ICNASA 2026

International Conference on Nanomaterials & Atomaterials Science and Applications

23 - 26 Nov 2026
Melbourne, Australia

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RMIT UNIVERSITY

CAN
CENTRE FOR ATOMATERIALS AND NANOMANUFACTURING



Welcome to ICNASA 2026

Womin Djeka (Welcome)!

We are thrilled to invite you to the 2026 International Conference on Nanomaterial and Atomaterial Science and Applications (ICNASA), hosted by the Centre for Atomaterials and Nanomanufacturing (CAN) at RMIT University, Melbourne, from November 23–26, 2026. As the world's first conference dedicated to atomaterials and an annual event since 2019, ICNASA responds to the rapid emergence of atomic-scale science, whose impact now spans multiple disciplines; our aim is to establish a global atomaterial community and advance these technologies to benefit society. This dynamic event brings together global leaders in micro/nano/atomic materials, catalysis, energy storage, optoelectronics, and beyond.

Having hosted a cumulative total of over 2,500 attendees from academia, industry, government, and organizations worldwide, ICNASA serves as a hub for groundbreaking innovations, offering a rich platform for researchers, industry professionals, and students to exchange ideas and collaborate on cutting-edge advancements.

In addition to insightful keynotes and presentations, the conference will feature an Industry Exhibition, including live demonstrations of the latest nanomanufacturing technologies. These sessions are designed to foster partnerships between academia and industry, presenting novel pathways for research commercialisation and societal impact.

ICNASA is not just a conference; it's a gateway to innovation and collaboration. With attendees spanning academia, industry, and government, the event promotes interdisciplinary exchange and creates value for all—whether you're an established researcher, an early career scholar, a student, or an industry leader.

Early Career Researcher (ECR) Awards, Travel Awards, and Poster Awards will be announced at the conclusion of Day 2, following a dedicated panel discussion.

We look forward to welcoming you to Melbourne and embarking together on this exciting journey of discovery and innovation.

Dist. Prof. Baohua Jia, Dist. Prof. Calum Drummond and Dist. Prof. Tianyi Ma
On behalf of the ICNASA 2026 Organising Committee



Chair Members



Dist. Prof. Baohua Jia

Chair

Distinguished Professor Baohua Jia is a Fellow of Australian Academy of Technological Sciences and Technologies (FTSE), a Future Fellow of Australian Research Council and Founding Director of Centre for Atomaterials and Nanomanufacturing (CAN) at RMIT University, Australia. Professor Jia is an elected Fellow of Optica (OSA) and an elected Fellow of Institute of Materials, Minerals and Mining (IoM3). Since 2019, Professor Jia has been serving as the Australian Research Council College of Expert. She has won many awards, including the 2023 Royal Society of Chemistry (RSC) Environment, Sustainability and Energy Horizon Prize: John Jeyes Prize, 2017 finalist of the Australian Prime Minister's Science Award.



Dist. Prof. Calum Drummond

Co-Chair

Distinguished Professor Drummond has a strong interest and passion for the commercialisation of research outcomes. He joined RMIT University in 2014 from CSIRO where he was Group Executive for Manufacturing, Materials and Minerals comprising 1300 researchers and research support staff and an annual budget of $250 million. Immediately prior to this CSIRO Group Executive appointment, he was Chief of CSIRO Materials Science and Engineering (CMSE), CSIRO's largest division. Prior to becoming a Chief, Calum was seconded from CSIRO to be the inaugural Vice President Research at CAP-XX, an Intel portfolio company. CAP-XX develops supercapacitors for consumer electronic products. In 2006, CAP-XX listed on the London AIM.



Dist. Prof. Tianyi Ma

Co-Chair

Tianyi Ma is RMIT University's Distinguished Professor. He is an Australian Research Council (ARC) Future Fellow, Fellow of the Royal Society of Chemistry (RSC), and a Clarivate Highly Cited Researcher in both Chemistry and Materials Science since 2020. He is Director of ARC Industrial Transformation Hub for Intelligent Energy Efficiency in Future Protected Cropping (E2Crop), and Research Director of Centre for Atomaterials and Nanomanufacturing (CAN). He has >400 publications in top-tier journals with an H-index of 95 and >40,000 citations, and acknowledged by many awards such as 2024 Prime Minister's Prize for Science - the Malcolm McIntosh Prize for Physical Scientist of the Year, Australian Academy of Science's Le Févre Medal.



Steering Committee



Prof. Warwick Bowen

University of Queensland, Australia. Director of the Australian Research Council Centre of Excellence in Quantum Biotechnology, and leads the Quantum Optics Laboratory at University of Queensland.



Prof. Lei Jiang

Suzhou Institute for Advanced Research, University of Science and Technology of China. Academician of the Chinese Academy of Sciences; also elected to TWAS, US NAE, Australian Academy of Science, and Academia Europaea.



Prof. Paul Mulvaney

University of Melbourne, Australia. Director of the ARC Centre of Excellence in Exciton Science, Fellow of the Australian Academy of Science, Fellow of the Royal Society of Chemistry.



Prof. Zhipei Sun

Aalto university, Finland. Head of the Photonics Research Group at the Department of Electronics and Nanoengineering of Aalto University, Fellow Member of The Optical Society.



Steering Committee



Prof. Anatoly Zayats

King's College London, United Kingdom. Head of the Photonics & Nanotechnology Group at King's College London, Fellow of the Institute of Physics, the Optical Society of America, SPIE and the Royal Society of Chemistry.



Prof. Laura Na Liu

University of Stuttgart, Germany. Director of the 2. Physics Institute, Fellow of Optical Society of America (2020), Fellow of the Royal Society of Chemistry (2023), Fellow of American Physical Society (2023).



Prof. Yalin Lu

University of Science and Technology of China, China. Distinguished Chair Professor, Director of the Anhui Laboratory of Advanced Photon Science and Technology, and former Director of the National Synchrotron Radiation Laboratory.



Theme Chairs

Theme 1: Optics, Photonics and Optoelectronics



Prof. Dongchen Qi
Queensland University of Technology



Prof. Feng Chen
Shandong University



A/Prof. Han Lin
RMIT University

Theme 2: Solar Energy Harvesting and Photo Detection



Dr. Xiaoming Wen
RMIT University



Dr. Meng Zhang
University of New South Wales

Theme 3: Advanced Characterisation and Simulation Techniques



Dr. Xiaoning Li
RMIT University



Dr. Keng-Te Lin
RMIT University



Theme Chairs

Theme 4: Emerging Materials for Diagnostics and Therapeutics



A/Prof. Maggie Zhai
RMIT University



A/Prof. Lei Bao
RMIT University



Dr. Haitao Yu
RMIT University

Theme 5: Sustainable Energy Storage and Applications



Dr. Yameng Fan
RMIT University



Dr. Xiaomin Xu
Curtin University

Theme 6: Catalysis for Energy and Sustainability



Dr. Ali Zavabeti
RMIT University



Dr. Jingrun Ran
Adelaide University



Theme Chairs

Theme 7: Nano-/Atom-fabrication, Advanced Manufacturing & AI



Prof. Yulin Zhong
Griffith University



A/Prof. Nic Bao
RMIT University



Dr. Morgan Zhang
RMIT University

Theme 8: Critical Minerals, Resource Recovery & Circular Economy



Dr. Helena Wang
The University of Melbourne



A/Prof. Hamid Arandiyan
RMIT University



Dr. Doudou Zhang
Macquarie University



Local Organising Committee



Prof. Daniel Gomez



Prof. Gary Rosengarten



Dist. Prof. Rachel Caruso



Dr. Junlin Lu



Prof. Xavier Mulet



A/Prof. Han Lin



A/Prof. Joel Van Embden



Dr. Mehri Ghasemi



Dr. Li Gao



Dr. Xiaoming Wen



Dr. Mingdeng Luo



Dr. Xiaoning Li




Dr. Keng-Te Lin


Dr. Morgan Zhang


Dr. Shuaiyu Jiang


Dr. Yameng Fan


Dr. Wahyu Narulita Dewi


Dr. Lei Zhang


Dr. Wenbo Liu


Dr. Yibo Ma


Dr. Yang Fu


Dr. Jiahui Li


Dr. Linnan Jia


Dr. Haimei (Jane) Xu


Dr. Xiangyang Guo


Dr. Peng Li


Dr. Lingyu Huang


Dr. Yitong Li

Conference Venue

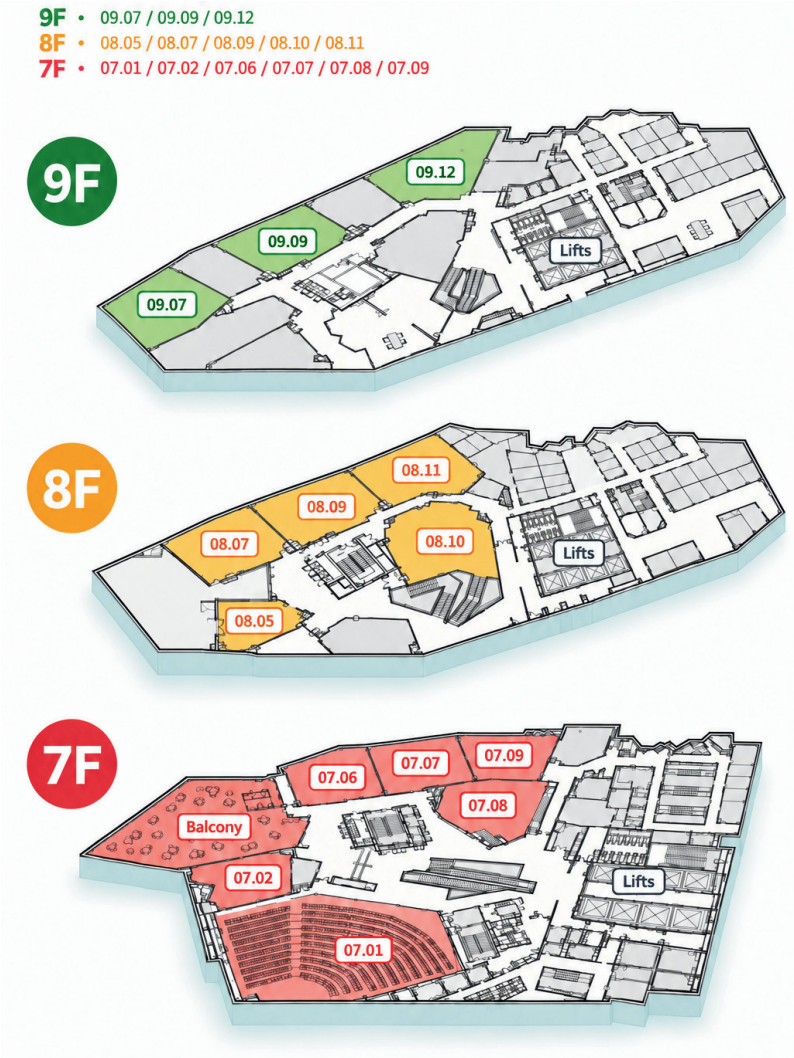
RMIT Building 80 (Swanston Academic Building)
445 Swanston Street, Melbourne VIC 3000, Australia





Conference Venue

RMIT Building 80 Level 7, 8 and 9




INTERNATIONAL CONFERENCE ON NANOMATERIALS &ATOMATERIALS SCIENCE AND APPLICATIONS 2026
CENTRE FOR ATOMATERIALS AND NANOMANUFACTURING






ICNASA
2024 International Conference on Nanomaterial and Atomaterial Science and Applications
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Day 0: Monday 23rd Nov 2026		
Time	**Events**	**Venue**
17:00-19:30	Registration Welcome reception	RMIT Building 80 Level 7 Foyer 445 Swanston Street, Melbourne, VIC 3000

	Plenary talk (40 mins include Q&A)	Keynote (25 mins include Q&A)	Invited oral (15 mins include Q&A)					
Time	**Day 1: Tuesday 24th Nov 2026**							**Venue**
08:35-08:40	**Welcome Speech**: Dist. Prof. Baohua Jia, RMIT University							080.07.001
08:40-08:50	**Opening Remarks**: **Prof. Catherine Itsiopoulos**, Deputy Vice-Chancellor STEM College and Vice-President, RMIT University							
08:50-09:00	**Photo Session**							080.07.001
09:00-09:40	**Prof. Kourosh Kalantar-Zadeh**, *Controlling of Liquid Metals on Demand in Soft Devices and Systems,* The University of Sydney					Chair: Prof. Xiwang Zhang		080.07.001
09:40-10:20	**Prof. Hua Zhang**, *Phase Engineering of Nanomaterials (PEN),* City University of Hong Kong							
10:20-10:50	Morning Tea (30 min, Poster Set Up, Venue: Foyer of B080.07)							
Morning Session	**Optics, Photonics and Optoelectronics**	**Solar Energy Harvesting and Photo Detection**	**Advanced Characterisation and Simulation Techniques**	**Emerging Materials for Diagnostics and Therapeutics**	**Sustainable Energy Storage and Applications**	**Catalysis for Energy and Sustainability**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI**	**Critical Minerals, Resource Recovery and Circular Economy**
Venue	**080.08.005**	**080.08.007**	**080.08.009**	**080.08.010**	**080.08. 011**	**080.09.007**	**080.09.009**	**080.09.012**
Chair	**Prof. Heike Ebendorff-Heidepriem** (Adelaide University)	**Dr. Lifeng Wang** (RMIT University)	**Dr. Xiaoning Li** (RMIT University)	**Dr. Haitao Yu** (RMIT University)	**Dr. Junnan Hao** (Adelaide University)	**Dr. Joshua Butson** (Curtin University)	**Dr. Qiran Cai** (Deakin University)	**Dr. Doudou Zhang** (Macquarie University)
10:50-11:15	**Prof. Dongchen Qi** *When Diamond Meets 2D: Engineering Diamond Surfaces for Diamondtronics* (Queensland University of Technology)	**Dr. Munkhbayar Batmunkh** *Understanding Carbon Based Perovskite Solar Cells* (Griffith University)	**Prof. Cordelia Selomulya** *Engineering Plant-Based Proteins for Sustainable Food Systems* (The University of New South Wales)	**Dr. Zihao Wang** *Patient-Specific Carotid Artery-on-Chip "Physical Twins" Reveal Flow-Dependent Thrombosis and Personalised Antithrombotic Response* (The University of Sydney)	**Dr. Dong Jun (DJ) Kim** *Wiring Proton Gradients for Energy Conversion via Light-Responsive Molecular Switches* (The University of New South Wales)	**A/Prof. Amgad Rezk** *MHz acoustics for nanomaterials synthesis and enhanced electrocatalysis* (RMIT University)	**Dr. Md Ataur Rahman** *Functional Materials and Intelligent Electronics for a Connected and Sustainable Future* (RMIT University)	**A/Prof. Hamid Arandiyan** *Nitric Acid Decomposition in Nickel-Cobalt Leaching* (RMIT University)

11:15-11:40	**Prof. Yang Tan** *RE-Doped Thin-Film Gain Media for Microcavity Lasers and Optical Amplifiers* (Shandong University)	**Prof. Xiaotao Hao** *Exciton and Charge-Carrier Dynamics in Organic Solar Cells Revealed by Ultrafast Spectroscopy* (Shandong University)	**A/Prof. Su Ying Quek** *Discovery of 2D Materials for Piezoelectronics, Non-Linear Optics and Exciton Condensation* (National University of Singapore)	**Dr. Jingqu Chen** *Compositional Engineering of Bioactive Metal–Organic Nanoparticles for Immune Modulation* (The University of Melbourne)	**Dr. Dmitrii Rakov** *Battery Electrolytes: From Molecules to Devices* (Adelaide University)	**Dr. Mengran Li** *Unlocking catalyst potentials in zero-gap membrane-electrode assemblies* (The University of Melbourne)	**Prof. Kuniharu Takei** *Laser-Induced Graphene-Based Smart Sensor System* (Hokkaido University)	**Dr. Siqi Huo** *Molecular and Structural Engineering of High-Performance Sustainable Polymers* (University of Southern Queensland)
11:40-12:05	**Prof. Zhanghua Han** *Coherent thermal emission generation enabled by nonlocal metasufaces* (Shandong Normal University)	**Dr. Jincheol Kim** *Advanced Manufacturing Strategies for Scalable Perovskite Solar Cells* (Macquarie University)	**A/Prof. Mark Edmonds** *Geometry-Engineered Quantum Materials: Twist, Strain and Stacking in 2D and Vertical Superlattices* (Monash University)	**Prof. Hang Ta** *Surface Coatings for the Prevention of Thrombosis and Bacterial Infections* (Griffith University)	**Dr. Yibo Ma** *Overcoming redox barriers in black phosphorus negative electrodes through lattice P–N engineering for fast-charging Li-ion batteries* (RMIT University)	**Dr. Jinqiang Zhang** *Photothermal catalysis for solar fuels production* (The University of Western Australia)	**Dr. Omid Mazaheri** *Metal–Phenolic Networks for Next Generation AgriTech* (The University of Melbourne)	**Prof. Huacheng Zhang** *Artificial ion channel membranes for efficient ion separation* (Monash University)
12:05-12:30	**A/Prof. Sudha Mokkapati** *Scalable Ternary-Solvent Growth of Ultrathin 2D Perovskite Crystals for Custom Optoelectronic Functionalities* (Monash University)	**Mr Kanishk Arunraj** *Copper tungstate photoanodes with enhanced solar water splitting performance* (RMIT University) Invited oral · 15 min	**Dr. Jiří Pavelec** *From Instrument Development to Atomistic Understanding of Single-Atom Catalysts* (TU Wien)	**Dr. Rong Xu** *Glucose-Responsive Nano Sugar with Kidney Tropism Enable Multi-Day Therapy in Diabetic Mice* (Monash University)		**Dr. Min Liu** *Advanced Membrane Engineering for Efficient CO_2 Electrolysis* (The University of Queensland)	**Prof. Dong Ruan** *Internal Interlaminar shear behaviour of additively manufactured continuous fibre-reinforced composites using MWCNT-coated filaments* (Swinburne University of Technology)	**Prof. Stefano Freguia** *Magneli-phase titanium suboxide ceramic electrodes for resource recovery from urban wastewater* (The University of Melbourne)
12:30-13:30	Lunch/Poster (60 min, Venue: Foyer of B080.07)							
After-noon Session 1	**Optics, Photonics and Optoelectronics**	**Solar Energy Harvesting and Photo Detection**	**Advanced Characterisation and Simulation Techniques**	**Emerging Materials for Diagnostics and Therapeutics**	**Sustainable Energy Storage and Applications**	**Catalysis for Energy and Sustainability**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI**	**Critical Minerals, Resource Recovery and Circular Economy**
Venue	**080.08.005**	**080.08.007**	**080.08.009**	**080.08.010**	**080.08.011**	**080.09.007**	**080.09.009**	**080.09.012**
Chair	**Prof. Yang Tan** (Shandong University)	**Dr. Munkhbayar Batmunkh** (Griffith University)	**Dr. Jiří Pavelec** (TU Wien)	**A/Prof. Lei Bao** (RMIT University)	**Dr. Dmitrii Rakov** (Adelaide University)	**Dr. Mengran Li** (The University of Melbourne)	**Prof. Dong Ruan** (Swinburne University of Technology)	**A/Prof. Hamid Arandiyan** (RMIT University)

13:30-13:55	**Dr. Guiyuan Cao** *Graphene Metalens for Multi-functional Flat Optics* (RMIT University)	**Dr. Lifeng Wang** *Two-Dimensional Materials: From Controlled Growth to Solar Energy Harvesting and Conversion* (RMIT University)	**Prof. Kapil Chousalkar** *Nanomaterials for Salmonella Detection and Control in the Poultry Food Chain: Bridging Food Safety and Materials Science* (Adelaide University) Keynote· 25 min	**Prof. Bo Peng** *Biochips for Mitochondrial Function Sensing and Therapeutic Regulation* (Northwestern Polytechnical University)	**Dr. Junnan Hao** *Advanced aqueous Zn battery design with conversion-based cathodes* (Adelaide University)	**Dr. Joshua Butson** *Room Temperature Hydrogen Permeability of Metals and Thin-Film Ceramics* (Curtin University)	**Dr. Sina Jamali** *Stochastic Electrochemistry and Emerging Transduction Strategies in Biosensors and Bioelectronics* (Griffith University)	**Dr. Helena Wang** *Accelerating the Circular Economy for Lithium-Ion Batteries: Microwave- Enhanced Deep Eutectic Solvents for Critical Metal Recovery* (The University of Melbourne)
13:55-14:20	**A/Prof. Shengxi Huang** *Improving single photon emission from van der Waals materials via atomic engineering* (Rice University)	**Prof. David Tissue** *Innovative glasshouse films to reduce energy use and increase resource use efficiency and productivity* (Western Sydney University	**Prof. James McCoy** *How Geometry Shapes Matter* (RMIT University)	**Dr. Christina Cortez-Jugo** *Carrier-free Nanoparticle Platforms for Therapeutic Applications* (The University of Melbourne)	**Prof. Min Hong** *Phonon Engineering for High-Performance Thermoelectric Materials (University of Southern Queensland)*	**Prof. Long Ren** *Liquid Metal-Based Responsive Micro/Nanorobots: Development and Applications* (Shanghai University)	**Dr. Debjit Ghoshal** *Light-Activated Doping and Dedoping for Precision Manufacturing of Wafer-Scale 2D TMDCs* (Indian Institute of Technology Guwahati)	**Prof. Damien Giurco** *Strategic Minerals in a Circular Economy: An Australian Perspective* (The University of Melbourne)
14:20-14:45	**Prof. Liang Li** *Multifunctional Perovskite Photodetectors* (Soochow University)	**Ms Xinyue Xu** *Spectral Signatures of Singlet Fission Intermediates of Solid-State TIPS-Pentacene* (University of Melbourne) Invited oral · 15 min	**Prof. Jie Yang** *Graphene Origami Reinforced Nanocomposites* (RMIT University)	**A/Prof. Vi Khanh Truong** *Engineering adaptive liquid-metal biointerfaces through Predict–Design–Restore for coordinated host defence and regeneration* (Flinders University)	**Dr. Minkyung Kang** *Observing Phase Transitions in Confined Volumes* (The University of Sydney)	**Prof. Zichun Wang** *Tailoring high-performance and stable Ni catalysts for CO2 reforming of CH4* (Beijing University of Chemical Technology)	**Dr. Qiran Cai** *Thermal properties and applications of boron nitride nanosheets* (Deakin University)	**Dr. Hong Peng** *A Sustainable Process for Critical Metals Recovery from Mine Waste* (The University of Queensland)
14:45-15:10	**Dr. Quancheng Liu** *Measurement-induced photonic topological insulators* (Shandong University) Invited oral · 15 min	**Ms Solongo Purevdorj** *Interfacial Passivation for Efficient Hole Transporting Materials Free Carbon-Based Perovskite Solar Cells* (Griffith University) Invited oral · 15 min	**Dr. Pei Lay Yap** *Advancing the Characterisation Toolbox for Graphene-Based Materials* (Adelaide University)	**Dr. Nhiem Tran** *Lipid Self-Assembly: From Nanostructure to Therapeutic Function* (RMIT University)	**Dr. Tong Yang** *Ultra-Thin Hybrid Ion Exchange Interlayer for High Performance Aqueous Zn Metal Batteries* (Queensland University of Technology) Invited oral · 15 min	**Ms Jianan He** *Engineering Active Sites and Heterointerfaces on MXene for Efficient Electrocatalytic Water Splitting* (The University of Melbourne) Invited oral · 15 min	**Ms Mengrui Li** *Application-Tailored Low-Loss MnZn Ferrites for High-Frequency Magnetic Components: Toward Additive Manufacturing* (RMIT University) Invited oral · 15 min	**Prof. Yan Zhuge** *Turning Water Treatment Sludge into Self-healing Concrete* (Adelaide University)

15:10-15:35		**Dr. Weifei Fu** *Scalable Fabrication of Organic and Perovskite Solar Modules* (Zhejiang University) Invited oral · 15 min		**A/Prof. Behnam Akhavan** *Plasma Bio-engineering: From bioactive interfaces to advanced biofabrication* (University of Sydney)		**Dr. Feiyue Gao** *Designing Active Sites and Microenvironments for Durable Hydrogen Electrocatalysis* (Adelaide University) Invited oral · 15 min	**Ms Maryam Jamshidi** *ZnS-Mediated Multi-cation Exchange toward Compositionally Complex Metal Sulphide Nanomaterials* (The University of New South Wales) Invited oral · 15 min	**A/Prof. Hans Oskierski** *Refining of spodumene into lithium chemicals* (Murdoch University)	
15:35-16:00	Afternoon Tea (25 min, Venue: Foyer of B080.07)								
After-noon Session 2	**Optics, Photonics and Optoelectronics 1**	**Optics, Photonics and Optoelectronics 2**	**Solar Energy Harvesting and Photo Detection**	**Emerging Materials for Diagnostics and Therapeutics**	**Sustainable Energy Storage and Applications**	**Catalysis for Energy and Sustainability**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI**	**Critical Minerals, Resource Recovery and Circular Economy**	**ANMFC Challenge Presentations and Live Judging**
Venue	**080.08.005**	**080.08.009**	**080.08.007**	**080.08.010**	**080.08.011**	**080.09.007**	**080.09.009**	**080.09.012**	**080.06.005**
Chair	**Prof. Dongchen Qi** (Queensland University of Technology)	**A/Prof. Shengxi Huang** (Rice University)	**Dr. Jegadesan Subbiah** (The University of Melbourne)	**Dr. Rong Xu** (Monash University)	**Dr. Junnan Hao** (Adelaide University)	**Dr. Jinqiang Zhang** (The University of Western Australia)	**Dr. Md Ataur Rahman** (RMIT University)	**Dr. Helena Wang** (The University of Melbourne)	
16:00-16:25	**Prof. Xiaodong Huang** *Topology Optimization of Phononic and Photonic Crystal Structures* (Swinburne University of Technology)	**Prof. Heike Ebendorff-Heidepriem** *Controlling crystal particles in glass through microgravity, surface activation and dissolution kinetics to create new and advanced optical functionalities* (Adelaide University)	**A/Prof. James Hutchison** *Fluorescence brightening up to 150°C and seconds-long delayed fluorescence in dye-doped zeotypes* (The University of Melbourne)	**Prof. Kang Liang** *Engineering Nanozyme Selectivity through Materials Design and Mechanistic Control* (The University of New South Wales)	**Dr. Nana Wang** *Engineering Sulfur Reaction Pathways for High-Energy Metal Sulfur Batteries* (University of Technology Sydney)	**Prof. Jun-Jie Zhu** *Electrochemiluminescence Imaging for Analytical Application* (Nanjing University)	**A/Prof. Shiyang Tang** *Universal shrink-programmed droplet-to-bead fabrication of multimodal functional microbeads* (The University of New South Wales)	**Dr. Doudou Zhang** *Accelerating green hydrogen production through low-cost electrode development and scalable manufacturing* (Macquarie University)	**Australian Nano-Manufacturing Future Challenge (ANMFC)** Shortlisted young researchers and student teams (5 mins each) • Live judging • Selection of 3 winning teams **16:00-18:00**
16:25-16:50	**A/Prof. Han Lin** *Polymer Metasurface Radiative Cooling Film from Lab to Fab* (RMIT University)	**Prof. Jiangang Feng** *Self-Assembly Nanophotonic Sources* (University of Science and Technology of China)	**Dr. Jialiang Huang** *Cryogenic Cathodoluminescence Reveals Defect-State Regulation in Wide-Bandgap Kesterite Solar Cells* (The University of New South Wales)	**Dr. Helen (Xiaoxue) Xu** *Quantitative Evaluation of Surface-Modified Upconversion Nanoparticles for Targeted Cancer Imaging and Fluorescence-Guided Surgery* (University of Technology Sydney)	**Prof. Porun Liu** *Design of Sub-Nanoscale Active Sites for Energy Conversion Applications* (Griffith University)	**Prof. Michael Stockenhuber** *Guiding the Chaos: Tuning Catalyst Acid-Redox Synergy for Product Selectivity* (University of Technology Sydney)	**Prof. Son Lam Phung** Image Processing for Sensing and Assistive Navigation (University of Wollongong)	**Prof. Mohammad Zaki Mubarok** *From Metallurgical Residues to Critical-Metal Resources: Integrated Valorization of Bauxite Residue and Nickel HPAL Tailings* (Institut Teknologi Bandung)	

16:50-17:15	**Dr. Yuge Chen** *Topological phase transitions in cut-and-project binary chains: an arithmetic criterion from polarization* (Shanghai University) Invited oral · 15 min	**Ms Nahiya Mushtaq** *Liquid-Metal-Engineered Ultrathin 2D Ce–Ga Oxides for Broadband UV–NIR Negative Photodetection* (RMIT University) Invited oral · 15 min	**Prof. Dewei Chu** *Water-Driven Energy and Information Flow for Nano-Bio Intelligence* (The University of New South Wales)	**Dr. Hao Wang** *From shared receptors to nanomedicine: targeting pathogenic macrophages across chronic lung diseases* (RMIT University)	**A/Prof. Bin Luo** *Interfacial Engineering for Metal-Based Rechargeable Batteries* (The University of Queensland)	**Dr. Caiden J. Parker** *Electroacoustic Copper Restructuring for Highly Selective CO_2 Reduction to Methane* (RMIT University) Invited oral · 15 min	**A/Prof. Ylias Sabri** (RMIT University)	**Dr. Hanwei Yu** *Circular Resource Engineering: Electrochemical and Membrane Technologies for Critical Mineral and Nutrient Recovery* (University of Technology Sydney)	
17:15-17:30	**Dr. Mansi Goyal** *High-Performance Cellulose Photonic Films with Multifunctional Properties* (Queensland University of Technology)	**Ms Junbo Yang** *Three-dimensional asymmetric plasmonic metasurfaces supporting quasi-BIC resonances with tunable Q factors* (RMIT University)	**Dr. Junlin Lu** *Rethinking Exciton Dissociation in Two-Dimensional Perovskites: Beyond Edge State Mechanism* (RMIT University)		**Dr. Jhonatan Soto Puelles** *Molecular Insight into the Structure of Poly(Ionic Liquids) for Sodium Metal Battery Applications* (Deakin University)	**Dr. Yitong Li** *Zwitterionic carbamate interfaces unlock efficient "liquid" CO2 upgrading* (RMIT University) Invited oral · 15 min	**Prof. Jianxin Zhong** *Ultrafast Quantum Oscillations Beyond the Bloch Oscillation in Coupled Low-Dimensional Atomic Crystals* (Shanghai University) Keynote· 25 min	**Dr. Chen Zhao** *Bioinspired Metal–Organic Framework Channel Membranes for Selective and Gated Ion Transport* (RMIT University)	
18:00-20:30 Complementary dinner, all welcome but pre-registration required for catering purpose									

	Plenary talk (40 mins include Q&A)	Keynote (25 mins include Q&A)	Invited oral (15 mins include Q&A)						
Time	**Day 2: Wednesday 25th Nov 2026**								**GTALL – ICNASA 2026 Industry Forum** 8:30 am –5:30 pm Venue: 080.04.011 Connecting breakthrough science with industry, investment and global markets **Separate registration required**
09:00-09:40	**Dist. Prof. Sujeeva Setunge,** *Nanotechnology-Enabled Circular Construction: Enhancing Waste-Derived Materials for Sustainable Infrastructure*, RMIT University, (Venue: 080.07.001)						Chair: Dist. Prof. Tianyi Ma		
09:40-10:20	**Prof. Lei Jiang,** *Bioinspired Superwettability and Beyond: Ultralow Energy Consumption in High-Efficiency Bio-Synthesis, Energy Conversion, and Information Transmission,* University of Science and Technology of China (Venue: 080.07.001)								
10:20-10:50	**Youth STEM Showcase and Awards Ceremony** (Venue: 080.07.001) 5 teams: 3 ANMFC winners + Trinity Grammer STEM Racing Car + Biotech Future PPE team								
10:50-11:20	Morning Tea (30 min, Poster Set Up, Venue:080.07 foyer)								
Morning Session	**Optics, Photonics & Optoelectronics**	**Solar Energy Harvesting and Photo Detection**	**Advanced Characterisation and Simulation Techniques**	**Emerging Materials for Diagnostics and Therapeutics**	**Sustainable Energy Storage and Applications**	**Catalysis for Energy and Sustainability**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI**	**Critical Minerals, Resource Recovery and Circular Economy**	
Venue	**080.08.005**	**080.08.007**	**080.08.009**	**080.08.010**	**080.08.011**	**080.09.007**	**080.09.009**	**080.09.012**	
Chair	**A/Prof. Han Lin** (RMIT University)	**Dr. Meng Zhang** (The University of New South Wales)	**Dr. Xue Yan** (The University of Melbourne)	**Dr. Jieying Liang** (The University of New South Wales)	**A/Prof. Dipan Kundu** (The University of New South Wales)	**Dr. Ali Zavabeti** (RMIT University)	**Dr. Morgan Zhang** (RMIT University)	**Dr. Zhouzun Xie** (The University of New South Wales)	
11:20-11:45	**Prof. Feng Chen** *Femtosecond Laser Inscribed 3D Optical Chirality in YAG Crystal* (Shandong University)	**Dr. Wenxin Mao** *Photo-modulation of Ion Distribution in Metal Halide Perovskites* (Monash University)	**Dr. David Broadway** *Persistence and emergence of atomic optical defects at high pressure* (RMIT University)	**Dr. Chang Lei** *Nanotechnology-Enabled Advanced Omics: Unlocking Molecular Insights for Biomedical Research* (The University of Sydney)	**Dr. Xiaomin Xu** *Perovskite Oxide Electrocatalysts for Anion Exchange Membrane Water Electrolysis: From Materials Design to Device Performance* (Curtin University)	**A/Prof. Muxina Konarova** *Fewer Experiments, Better Predictions: Hybrid Kinetic-Machine Learning Models for Catalytic Conversion of Mixed Feedstocks* (The University of Queensland)	**Dr. Mohammad Ghasemian** *Liquid Metals Enabling the Fabrication and Doping of Advanced Transparent Conductive Materials* (The University of Sydney)	**Prof. Luke Henderson** *Engineering Interfaces, Creating Function: New Opportunities in Advanced Materials* (Deakin University)	
11:45-12:10	**Dr. Zhuo Wang** *Ultrafast laser-enabled big data storge* (Zhejiang University)	**Dr. Xiaoming Wen** *A Novel Photovoltaic Concept: The Lattice Battery Solar Cells* (RMIT University)	**Prof. Yalin Lu** *Precision Quantum Measurement: Challenges on New Light Sources* (University of Science and Technology of China)	**Dr. Wenyi Li** *Understanding Antimicrobial Peptides as Next-Generation Antibiotics* (La Trobe University)	**Ms Joyee Wong** *Graphene Oxide–Silica Microcapsules Containing Phase Change Materials for Thermal Energy Storage* (Monash University)	**Dr. Hangjuan Ren** *From Active Sites to an Active-Site Ecosystem: Making Operando Truly Operando* (Monash University)	**Prof. Mingzhu Li** *A Bioinspired Micro-nano Photonic Materials* (Technical Institute of Physics and Chemistry, CAS)	**Dr. Jingxiu Wang** *Selective Lithium Recovery from Spent Lithium-Ion Batteries via Stepwise Transition Metal Crystallization* (Adelaide University)	

12:10-12:35	**Dr. Linnan Jia** *2D materials for enhanced nonlinear optics in integrated waveguides* (RMIT University) Invited oral · 15 min	**Dr. Jegadesan Subbiah** *Molecular design and additive engineering for efficient organic solar cells* (The University of Melbourne)	**Dr. Henry Li** *AI4Science: From Accelerated Discovery to Agentic Discovery* (Adelaide University)	**Prof. Feng Wang** *Engineering Nano-Bio Interfaces: From Biomedical Nanotechnology to Plant Nanobiotechnology* (Hefei University of Technology)	**A/Prof. Nolene Byrne** *Hard Carbon Anodes for High-Performance Sodium-Ion Batteries: From Processing to Electrochemical Performance* (Deakin University)	**Dr. Jingrun Ran** *Atomic-Level Regulation on Photocatalyst for Energy-Related Reaction* (Adelaide University)	**Prof. Qunfeng Cheng** *Bioinspired MXene Nanocomposites* (University of Science and Technology of China)	**Prof. Ying (Ian) Chen** *Solid-state lithium-metal batteries need new materials innovation* (Deakin University)	**GTALL – ICNASA 2026 Industry Forum** 8:30 am –5:30 pm Venue: 080.04.011 Connecting breakthrough science with industry, investment and global markets **Separate registration required**
12:35-13:00		**Dr. Mehri Ghasemi** *Illumination-Conditioned States in Soft Metal Halide Perovskites: Beyond Static Recombination Physics* (RMIT University) Invited oral · 15 min		**Dr. Haiyan Li** *Engineering Small Extracellular Vesicles for Tissue Regeneration* (RMIT University)	**Prof. Zhanying Zhang** *Lignocellulose-Derived Hard Carbon for Sodium-Ion Battery Anodes* (Queensland University of Technology)	**Ms Anran Song** *Database-guided thermodynamic-kinetic regulation for PtNi-based intermetallic electrocatalysts* (Shanghai Jiao Tong University) Invited oral · 15 min	**Prof. Longqiu Li** *High-Precision 3D Printing of Micro/Nano Functional Devices: Materials, Processes, Equipment and Applications* (Harbin Institute of Technology)	**Dr. Tim Werner** *Sustainable critical mineral supply futures for Australia: Reconciling resource abundance with supply risks and transparency* (The University of Melbourne)	
13:00-14:00	Lunch/Poster Assessment (60 min, Venue：080.07 foyer)								
14:00-14:40	**Plenary Talk：Prof. Ying Tan,** *From Functional Materials to Intelligent Wearable Sensors: Design, Fabrication and Applications,* The University of Melbourne (Venue: 080.07.001)						Chair: Prof. Jie Yang		
After-noon Session 1	**Optics, Photonics and Optoelectronics**	**Solar Energy Harvesting and Photo Detection**	**Emerging Materials for Diagnostics and Therapeutics 1**	**Emerging Materials for Diagnostics and Therapeutics 2**	**Sustainable Energy Storage and Applications**	**Catalysis for Energy and Sustainability**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI**	**Critical Minerals, Resource Recovery and Circular Economy**	
Venue	**080.08.005**	**080.08.007**	**080.08.009**	**080.08.010**	**080.08.011**	**080.09.007**	**080.09.009**	**080.09.012**	
Chair	**Prof. Feng Chen** (Shandong University)	**Dr. Xiaoming Wen** (RMIT University)	**Dr. Chang Lei** (The University of Sydney)	**Dr. Haiyan Li** (RMIT University)	**Dr. Xiaomin Xu** (Curtin University)	**Dr. Jingrun Ran** (Adelaide University)	**A/Prof. Nic Bao** (RMIT University)	**Prof. Ying (Ian) Chen** (Deakin University)	
14:40-15:05	**Prof. Jinglai Duan** *Ion Track Technology-Based Optical Nanostructures* (Institute of Modern Physics, CAS)	**A/Prof. James Bullock** *Black Phosphorus Infrared Photodiodes* (The University of Melbourne)	**Dr. Qi (Hank) Han** *Decoding protein solution behaviours using synchrotron small-angle X-ray scattering and machine learning* (RMIT University)	**Prof. Fariba Dehghani** *Architected and Translatable Biomaterials for Regenerative Medicine and Medical Implants* (The University of Sydney)	**Dr. Qingbing Xia** *Interfacial Engineering and Mechanistic Characterisation for Next-Generation Sodium-Ion Batteries* (The University of Queensland)	**A/Prof. Jingwei Hou** *Conformal Glazing of Covalent Organic Frameworks: Hydrogen Sieving When Dry, Proton Conduction When Wet* (The University of Queensland)	**Prof. Yang Yang** *Advanced Manufacturing of Radio Frequency Electronics* (The University of Sydney)	**Dr. George Chen** *Ion Partitioning and Transport in Advanced Membrane Materials* (The University of Melbourne)	

15:05-15:30	**Prof. Xingyuan Xu** *Programmable Photonic Computing and Signal Processing* (Beijing University of Posts and Telecommunications)	**Dr. Meng Zhang** *Crystallization Engineering of Perovskite Thin Films for Photovoltaic Applications* (The University of New South Wales)	**Prof. Sophia Gu** *Redox by design: engineering nanomaterials for precision therapeutics* (The University of New South Wales)	**Dr. Jieying Liang** *Engineering Biocatalytic Nanomaterials for Precision Therapy and Biosensing* (The University of New South Wales)	**A/Prof. Dipan Kundu** *Balancing Transport and Interfacial Stability in Solid-State Battery Cathodes* (The University of New South Wales)	**Dr. Dechao Chen** *Colloidal Synthesis of Photocatalytic Quantum Dots Heterostructure* (University of Southern Queensland)	**Dr. Olga Zinovieva** *Can Individual Struts Serve as Surrogate Specimens for Additively Manufactured Titanium Microlattices?* (The University of New South Wales)	**Dr. Zhouzun Xie** *From Particles to Processes: Understanding Complex Particle–Fluid Systems Across Scales* (The University of New South Wales)	**GTALL – ICNASA 2026 Industry Forum** 8:30 am –5:30 pm Venue: 080.04.011 Connecting breakthrough science with industry, investment and global markets **Separate registration required**
15:30-15:55	**Prof. Xiaoke Yi** *Integrated Microwave Photonic Circuits for Signal Processing and Sensing* (The University of Sydney)	**Dr. Miaoqiang Lyu** *Lead-free Halide Perovskites for Optoelectronic Applications* (The University of Queensland)	**A/Prof. Keying Guo** *Molecular Bioelectronics for Precision Medicine: From Single-Molecule Sensing to Intelligent Diagnostics* (Guangdong Technion-Israel Institute of Technology)	**Dr. Changkui Fu** *Sulfoxide Polymers for Diagnostic and Therapeutic Applications* (The University of Queensland)	**Prof. Hongqi Sun** *Catalyst materials for photothermal catalysis* (The University of Western Australia)	**Dr. Mu Xiao** *Molten salt synthesis of heterogeneous catalysts for solar energy conversion: old chemistry for advanced materials* (The University of Queensland)	**Prof. Bilu Liu** *2D materials based homologous metal heteromaterials with chemically bonded metallic interface for stable high-current-density electrocatalysis* (Tsinghua University)	**Dr. Rumana Hossain** *Transforming Complex Wastes into High-Performance Nano- and Advanced Materials* (The University of New South Wales)	
15:55-16:20	**Dr. Xiangyang Guo** *Laser-nanoprinted broadband flat optics in liquid-metal-derived 2D tin oxide* (RMIT University) Invited oral · 15 min	**Mr Tai Wu** *Phosphonic Acid Functionalization of P3HT for Efficient and Stable Inverted Perovskite Solar Cells* (University of New South Wales) Invited oral · 15 min	**Dr. Linpeng Fan** *Programming Biomaterial Systems Across Scales for Regenerative Therapeutics and Biointegrated Sensing* (The University of Melbourne)	**Dr. David Ju** *From mRNA Vaccines to Cancer Immunotherapy: Translating Clinical Insights into mRNA Therapeutics* (La Trobe University)	**Ms Jingyi Luo** *Energy-Efficient Plasma Nitrogen Fixation via Ozone-Enhanced Electrodeless Bubble Discharge* (University of Sydney) Invited oral · 15 min		**Dr. Zhiyuan Huang** *Biomimetic Design and High-Precision Additive Manufacturing of Bioactive Dental Structures* (Harbin Institute of Technology) Invited oral · 15 min	**Prof. Akbar Rhamdhani** *Low-Carbon and Circular High-Temperature Recycling of End-of-Life Batteries* (Swinburne University of Technology)	
16:20-16:45	Afternoon Tea (25 min, Venue: 080.07 foyer)								
After-noon Session 2	**Optics, Photonics and Optoelectronics**	**Solar Energy Harvesting and Photo Detection**	**Advanced Characterisation and Simulation Techniques**	**Emerging Materials for Diagnostics and Therapeutics**	**Sustainable Energy Storage and Applications**	**Catalysis for Energy and Sustainability**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI**	**Critical Minerals, Resource Recovery and Circular Economy**	
Venue	**080.08.005**	**080.08.007**	**080.08.009**	**080.08.010**	**080.08.011**	**080.09.007**	**080.09.009**	**080.09.012**	
Chair	**Dr. Zhuo Wang** (Zhejiang University)	**Dr. Miaoqiang Lyu** (The University of Queensland)	**Dr. David Broadway** (RMIT University)	**A/Prof. Maggie Zhai** (RMIT University)	**Dr. Yameng Fan** (RMIT University)	**Dr. Hangjuan Ren** (Monash University)	**Dr. Olga Zinovieva** (The University of New South Wales)	**Dr. Jingxiu Wang** *Crystallization* (Adelaide University)	

16:45-17:10	**A/Prof. Bo Zhang** *Ultrafast Laser Micro-nanostructuring in Transparent Materials for On-chip Integrated Micro-spectrometers* (Zhejiang University)	**Dr. Dongxu He** *Towards Efficient and Stable Tin Halide Perovskite Photovoltaics* (The University of Queensland) Invited oral · 15 min	**Prof. Nikhil Medhekar** *Reconfigurable 2D Materials for Low-Energy Electronics* (Monash University)	**A/Prof. Ruirui Qiao** *3D Printing of Nanoparticle-Integrated Hydrogels* (The University of Queensland)	**Dr. Tianqi Zhang** *Electrifying Chemical Manufacturing for a Net-Zero Future: Plasma Reactive Systems from Molecules to Applications* (The University of Sydney)	**Dr. Ali Zavabeti** *Reactive Liquid-Metal Interfaces: From Atomaterials to Catalysis and Environmental Remediation* (RMIT University)	**Prof. Xiwang Zhang** *Confined Polymerisation: A New Strategy for High-performance Membranes* (The University of Queensland)	**Prof. George Franks** *Flocculation-flotation for improved recovery of fine critical minerals* (The University of Melbourne)	
17:10-17:35	**Mr Miao Liu** *Programmable radiative coupling in nanoelectromechanical quasi-BIC metasurfaces* (RMIT University) Invited oral · 15 min	**Ms Maduni M. Wijethilake** *Evaluation of a Light Diffusion Radiative Cooling Film for Energy-Efficient Protected Cropping* (RMIT University) Invited oral · 15 min	**Dr. Xue Yan** *Intertwined chirality and symmetry breaking in moiré domain-wall networks* (The University of Melbourne)	**A/Prof. Jiao Jiao Li** *Developing Regenerative Therapies for Bone and Joint Diseases* (University of Technology Sydney)	**Dr. Yufei Zhao** *Highly efficient electrocatalysts for energy conversion reactions* (University of Technology Sydney)	**Dr. Zhiliang Wang** (The University of Queensland)	**A/Prof. Nic Bao** *Topology Optimisation and Advanced Manufacturing for High-Performance Architectural Structures* (RMIT University)	**Prof. Qilin Wang** (University of Technology Sydney)	
17:35-18:00	**Dr. Yi-Hsun Chen** *Efficient light upconversion in few-layer transition metal dichalcogenides* (The University of Queensland) Invited oral · 15 min	**Ms Xihan Wu** *Artificial Chiral Microstructures for Manipulating Upconversion Emission* (RMIT University) Invited oral · 15 min		**Prof. Bingyang Shi** *Brain Targeted Drug Delivery and Therapy* (University of Technology Sydney)	**Mr Shengyong Gao** *Carbon-anchored functionalized single atoms for anode-free sodium batteries* (The University of Queensland) Invited oral · 15 min	**Dr. Yu Mao** *Theoretical Investigation of Integrated CO2 Capture and Electrochemical Reduction: Challenges and Opportunities* (The University of Auckland) Invited oral · 15 min	**Mr Chi-Chun Cheng** *Fab-Compatible Platform with 2D Integration and Monolithic 3D CMOS* (Nation Tsing Hua University)	**Dr. Chitra Sulkan** *Towards Sustainable NMC Recycling: Lower-Emission Reduction Pathways for Critical-Metal Recovery* (Swinburne University of Technology Invited oral · 15 min	
18:30-22:15 Conference Banquet and Awards for registered attendees **Dress code: Business Formal. Entry will be refused for non-compliance.** *(Venue: Athenaeum Club, Melbourne, 87 Collins St, Melbourne VIC 3000, Australia)*									

	Plenary talk (40 mins include Q&A)	Keynote (25 mins include Q&A)	Invited oral (15 mins include Q&A)					
Time	**Day 3: Thursday 26th Nov 2026**							**Venue**
09:00-09:40	**Prof. Hui-Ming Cheng,** Exploration of new 2D materials, Shenzhen Institutes of Advanced Technology, CAS					Chair: Dist. Prof. Baohua Jia		080.07.001
09:40-10:20	**Prof. Frank Caruso,** Engineering Nanoparticle Platforms for Precision Organ Targeting and Therapeutic Delivery, The University of Melbourne							
10:20-10:50	Morning Tea (30 min, Venue:080.07 foyer)							
Morning Session	**Optics, Photonics and Optoelectronics**	**Advanced Characterisation and Simulation Techniques**	**Emerging Materials for Diagnostics and Therapeutics**	**Sustainable Energy Storage and Applications**	**Catalysis for Energy and Sustainability**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI 1**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI 2**	**Critical Minerals, Resource Recovery and Circular Economy**
Venue	**080.08.005**	**080.08.007**	**080.08.009**	**080.08.010**	**080.08.011**	**080.09.007**	**080.09.009**	**080.09.012**
Chair	**Dr. Taimur Ahmed** (RMIT University)	**Dr. Henry Li** (Adelaide University)	**Dr. Haitao Yu** (RMIT University)	**Dr. Yufei Zhao** (University of Technology Sydney)	**Dr. Xin Mao** (Queensland University of Technology) & **Dr. Haimei Xu** (RMIT University)	**Dr. Ming Zhou** (Griffith University)	**Prof. Withawat Withayachumnankul** (Adelaide University)	**Dr. Chitra Sulkan** (Swinburne University of Technology
10:50-11:15	**Dr. Qingdong Ou** *2D Material Polaritonics and Optoelectronic Devices* (Macau University of Science and Technology)	**Dr. Anton Tadich** *The Soft X-ray Beamline at the Australian Synchrotron: Capabilities, research and future direction* (ANSTO)	**Prof. Jānis Ločs** *Synthesis and room/subzero temperature pressure-driven sintering of metastable calcium phosphates* (Riga Technical University)	**Prof. Huanyu Jin** *Electrocatalysis under Intermittent Conditions* (Shenzhen Institutes of Advanced Technology, CAS)	**Dr. Xiuwen Zhou** *Quantitative calculations of the photoluminescence quantum yield of organometallic emitters* (Queensland University of Technology)	**Prof. Chang Liu** *Highly conductive carbon nanotube fibers* (Institute of Metal Research, CAS)	**Prof. Bernard Rolfe** *Utilising Neural Networks and Neural Operators to Accelerate Forecasting of Precipitate Growth in Binary Alloys* (Deakin University	**Dr. Camille Jing Zhao** *The Role of Microbial Systems in Shaping the Future of Sustainable Mining* (The University of New South Wales)
11:15-11:40	**Prof. Zhong-Hua Chen** *Energy and resource sustainable technologies of greenhouse horticulture in Australia* (Adelaide University)	**Dr. Pria Ramkissoon** *Using Synchrotron X-ray Absorption Spectroscopy (XAS) to Study Any Material* (ANSTO)	**Dr. Brendan Dyett** *Dynamic Nanostructures in Lipid Nanoparticles: From Interfaces to mRNA Microneedle Delivery* (RMIT University)	**A/Prof. Bing Sun** *Developing High-Energy Electrode Materials for Metal–Air Batteries* (University of Technology Sydney)	**Dr. Haimei Xu** *Harnessing Solar Energy for Sustainable Catalysis: Photo-Driven Energy Production, Waste Valorisation and Environmental Remediation* (RMIT University)	**A/Prof. Hongwei Cheng** *Ion track technology for the design and fabrication of nanolattice mechanical metamaterials* (Institute of Modern Physics, CAS)	**Prof. Hua Wang** *Privacy in Data Publishing* (Victoria University)	**Dr. Sazzad Ahmad** *Hydrogen-Assisted Recovery of Critical Metals from NMC Black Mass: Thermodynamic Modelling and Experimental Validation* (Swinburne University of Technology)

11:40-12:05	**Prof. Liwei Chen** *Time-Resolved In Situ Imaging Reveals the Mechanism of Laser-Induced Nanoparticle Self-Deposition on Copper* (Xi'an Jiaotong University)	**Dr. Pablo Resendiz Vazquez** *Unveiling electronic Inhomogeneity in moiré-engineered two-dimensional semiconductors* (Monash University)	**Dr. Guochen Bao** *Lanthanide Luminescent Materials for sensing and therapeutic applications* (University of Technology Sydney)	**Dr. Yanqiu Lyu** *Solvent Coordination Engineering for Selective and Sustainable Battery Recycling* (Adelaide University)	**Dr. Xin Mao** *Molecular Design of MIL-53(Cu) for Selective Electrochemical CO_2 Reduction to C2 Products* (Queensland University of Technology)	**Prof. Yang Xiang** *AI Across the Lifecycle: Security, Safety, and Accountability* (Monash University)	**Dr. Naimeh Naseritaheri** *Interfacial Coupling in MoS2Hydrogen Evolution* (Monash University)	**Ms. Fatima Arshia** *Upcycling E-Waste-Derived Copper into Cu/Ni Foam Electrodes for High-Current-Density Glucose Electrooxidation to Formate* (The University of Hong Kong) Invited oral · 15 min
12:05-12:30		**Prof. Xiaodong Li** *Generalization, Ethics, and Governance in Using Large Language Models for Combinatorial Optimization* (RMIT University)	**Prof. Emma Kowal** *Indigenous knowledge and new materials: lessons from genomics for nano- and atomaterials science* (Deakin University)	**Dr. Jinqiang Zhang** *Refining structures of functional molecules for energy storage and conversion* (University of Technology Sydney)	**Ms. Zhirong Lang** *Promoting Ampere-Level Nitrate Reduction to Ammonia Through Designing Chiral Catalysts* (The University of Hong Kong) Invited oral · 15 min	**Mr Kang Liu** *Designing with Scent: Coffee-Ground Composite Filaments for 3D-Printed Multisensory Wall Skins* (RMIT University) Invited oral · 15 min	**Ms Lily Arrieta** *Hierarchical Ti–Ta Materials from Additive Manufacturing and Nanofabrication for Implant Applications* (RMIT University) Invited oral · 15 min	**Dr. Fei Li** *Carbon-based nanomaterials for selective gold extraction from e-waste* (The University of New South Wales) Invited oral · 15 min
12:30-14:20	Lunch (110 min, Venue: Foyer of B080.07)							
	13:10-14:20	Lunch with the Editors (Chair: Prof. Dongchen Qi; Venue: B080.07.001) 4 journal presentations (10 min each): **Wiley, npj Nanophotonics, Materials Reports: Energy, Scilight**. followed by a 30-min panel discussion.						
After-noon Session	**Optics, Photonics and Optoelectronics 1**	**Optics, Photonics and Optoelectronics 2**	**Emerging Materials for Diagnostics and Therapeutics 1**	**Emerging Materials for Diagnostics and Therapeutics 2**	**Sustainable Energy Storage, Advanced Materials and Applications**	**Nano-/Atom-fabrication, Advanced Manufacturing and AI**	**4th Scilight Seminar** on High-Quality Journal Development Venue: 080.06.005 **From 1:00 pm** Separate registration required	
Venue	**080.08.005**	**080.08.007**	**080.09.012**	**080.08.009**	**080.08.010**	**080.09.009**		
Chair	**Prof. Zhong-Hua Chen** (Adelaide University)	**Dr. Qingdong Ou** (Macau University of Science and Technology)	**Dr. Hao Wang** (RMIT University)	**Dr. Brendan Dyett** (RMIT University)	**Dr. Yanqiu Lyu** (Adelaide University)	**Prof. Hua Wang** (Victoria University)		
14:30-14:55	**Prof. Dongming Sun** *Novel Two-Dimensional Material-Based Optoelectronic Transistors for Intelligent Vision* (Institute of Metal Research, CAS)	**Prof. Qiaoliang Bao** *Transformation of confined-space photonics into industrial-level applications* (University of Shanghai for Science and Technology)	**Dr. Haitao Yu** *Fusogenic Lipid Cubosomes as Nanocarriers for Next-Generation Nanomedicine* (RMIT University)	**Dr. Kevin M. Koo** *Decentralized cancer liquid biopsy profiling within a clinical biosensor validation framework* (The University of Queensland)	**Prof. Dan Liu** *Advanced Nanocomposite Materials for Zinc-ion batteries* (RMIT University)	**Prof. Withawat Withayachumnankul** *Optically Controlled InGaAs Thin-Film Terahertz-Wave Modulator* (Adelaide University)		

14:55-15:20	**Dr. Taimur Ahmed** *Defect-Engineering in Low-dimensional Materials for Bioinspired Neuromorphic Vision Sensors* (RMIT University)	**Prof. Wenxin Wang** *Lattice Plasmon Nanolasing* (Harbin Engineering University)	**Dr. Fengtao Jiang** *Engineering Dynamic Tumor–Vascular Interfaces: Microfluidic Platforms for Cancer Metastasis and Mechanobiology* (The University of Sydney)	**Dr. Eric Gao** *Structure-Guided Engineering of Ionisable Lipid Nanoparticles for Targeted mRNA Delivery* (RMIT University)	**Ms. Huan Xu** *Dual descriptor screening identifies a molecular mediator for low concentration ether electrolytes in lithium metal batteries* (The University of Hong Kong) Invited oral · 15 min	**Dr. Ming Zhou** *Molecularly Imprinted Polymer-Functionalised Lateral-Flow Membrane for Highly Sensitive and Selective Per- And Polyfluoroalkyl Substances Detection in Water* (Griffith University)	**4th Scilight Seminar** on High-Quality Journal Development Venue: 080.06.005 **From 1:00 pm** Separate registration required
15:20-15:45	**Ms. Ransini Dahanayake** *From Fire Protection to Fire Detection: Graphene Metamaterial-Coated Cotton for Smart Fire Safety* (RMIT University) Invited oral · 15 min	**Dr. Bo Wu** *Laser-induced Plasmonic Nanostructures for Optical Storage in Disordered Crystals* (Shandong University) Invited oral · 15 min	**Dr. Abdulah Bawazeer** *Novel Responsive Lipid Nanoparticles for Multidrug-Resistant Organism Therapeutics* (RMIT University)	**Dr. Guocheng Fang** *Microfluidic laser-emission aqueous droplets for biomedical applications* (University of Technology Sydney)	**Dr. James D. Randall** *Engineering Multifunctional Carbon Fibre Materials for Structural Energy Storage and Organic Electrochemical Systems* (Deakin University) Invited oral · 15 min	**Prof. Haiping Du** *Programmable Electromechanical Networks for Intelligent and Energy-Efficient Vehicle Suspension Systems* (University of Wollongong)	
15:45-16:00			**Prof. Zhaogang Teng** (Nanjing University of Posts and Telecommunications) Keynote· 25 min	**Dr. Marco Cassani** *Decoding Cancer Mechanobiology to Improve Nanotherapeutic Delivery* (International Clinical Research Center of Brno)	**Mr Madhav Kumar Jha** *Interplay between reinforcement-induced microstructural heterogeneity and corrosion kinetics in TiB2 reinforced Mg-12.5Al-2Zn-1.5Ca nanocomposite* (Dr B R Ambedkar National Institute of Technology Jalandhar) Invited oral · 15 min	**Ms Zhihong Zhang** *Predicting Solvent-Dependent Molecular Gelation through Self-Assembly-Informed Machine Learning* (Deakin University) Invited oral · 15 min	
16:00-16:30	Closing Ceremony and Awards (Chair: Dist. Prof. Baohua Jia) (Venue: B080.07.001)						

ICNASA 2026 Plenary Speakers



Kourosh Kalantar-Zadeh is a Professor at the Faculty of Engineering at the University of Sydney. He was a professor of Chemical Engineering at UNSW, and prior to that a Professor of Electronic Engineering at RMIT. Professor Kalantar-Zadeh is involved in research in the fields of analytical chemistry, materials sciences, gastroenterology, electronics and sensors, and has co-authored of >550 highly cited scientific papers. He is a member of the editorial boards of journals including ACS Applied Nano Materials (associate editor), ACS Sensors, Advanced Materials Technologies, Nanoscale, Applied Surface Science and ACS Nano. Professor Kalantar-Zadeh is best known for his works on ingestible sensors, liquid metals and two-dimensional semiconductors. He led his group to the invention of an ingestible chemical sensor: human gas sensing capsule, one of the breakthroughs in the field of medical devices. Professor Kalantar-Zadeh has received several international awards for his scientific contributions including the 2017 IEEE Sensor Council Achievement, 2018 American Chemical Society Advances in Measurement Science Lectureship awards and 2020 Robert Boyle Prize of Royal Society of Chemistry.

Controlling of Liquid Metals on Demand in Soft Devices and Systems

Kourosh Kalantar-Zadeh[1]
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Abstract

Gallium and its alloys with post-transition and group-12 metals exist in the liquid state at or near room temperature, combining the transport properties of metallic conductors with the fluidity of liquids. This unique materials platform exhibits exceptionally low viscosity, high surface tension, and electrical and thermal conductivities comparable to those of conventional metals. In addition, gallium-based liquid metals possess negligible vapour pressure and relatively low toxicity, making them attractive for safe and practical integration into soft engineering systems. A defining characteristic of gallium-based liquid metals is the spontaneous formation of an atomically thin, self-limiting oxide layer upon exposure to oxygen. This dynamic oxide interface fundamentally governs wetting, adhesion, interfacial rheology, and mechanical stability, enabling reversible manipulation of liquid metal morphology through electrical, chemical, or mechanical stimuli. The ability to generate, remove, or restructure this oxide layer provides a powerful mechanism for on-demand displacement and reconfiguration of liquid metal within confined geometries.

Harnessing these interfacial phenomena has enabled a new class of soft, reconfigurable devices, including pumps, mixers, actuators, motors, displays, and continuous-flow reactors, in which liquid metal simultaneously serves as a structural, electrical, thermal, and fluidic component. Controlled liquid metal displacement offers a versatile strategy for dynamically routing electrical pathways, transporting fluids, and reconfiguring functional architectures without conventional rigid mechanical components.

This presentation will discuss the fundamental principles governing on-demand liquid metal displacement and demonstrate how these mechanisms can be exploited to engineer highly integrated soft devices and multifunctional systems. The combination of metallic conductivity, fluidic deformability, and programmable interfacial behaviour establishes gallium-based liquid metals as a compelling platform for next-generation soft robotics, microfluidics, adaptive electronics, displays and biomedical technologies.

ICNASA 2026 Plenary Speakers



Dr. Hua Zhang is the Herman Hu Chair Professor of Nanomaterials and Director of Hong Kong Institute for Clean Energy in City University of Hong Kong before he worked in Nanyang Technological University (NTU) from 2011 to 2019. He has published 600+ papers including Nature and Science. As at Sept. 2026, the total cited times are over 153,800 with H-index of 193 (Web of Science), and over 173,100 with H-index of 204 (Google Scholar). He is the co-Editor-in-Chief of SmartMat (2020-) and sits on the Advisory/Editorial Board of 30+ journals. In 2020, he was elected as a Foreign Fellow of the European Academy of Sciences (EurASc). He was listed in the "Highly Cited Researchers" in Materials Science (Clarivate Analytics/Thomson Reuters, 2014-2025 (12 consecutive years)), in Chemistry (Clarivate Analytics/Thomson Reuters, 2015-2025 (11 consecutive years)), and in Environment and Ecology (Clarivate Analytics, 2022). In 2015, he was listed in 19 “Hottest Researchers of Today” in the world in the World’s Most Influential Scientific Minds 2015 (Thomson Reuters, 2015). In 2014, he was listed in 17 “Hottest Reearchers of Today” and No. 1 in Materials and More in the world in the World’s Most Influential Scientific Minds 2014 (Thomson Reuters, 2014). He received numerous awards IUMRS-Frontier Materials Scientists Award (2023, IUMRS-ICFM), ACS Nano Lectureship Award (2015, American Chemical Society), etc.

Phase Engineering of Nanomaterials (PEN)

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Abstract

In this talk, I will summarize the recent research on phase engineering of nanomaterials (PEN) in my group, particularly focusing on the rational design and synthesis of novel nanomaterials with unconventional phases for various promising applications. For example, by using wet-chemical methods, for the first time, we have successfully prepared novel Au nanostructures (e.g., the hexagonal-close packed (hcp) 2H-Au nanosheets, 4H-Au nanoribbons, and 4H/fcc and fcc/2H/fcc heterophase Au nanorods), epitaxially grown metal nanostructures on the aforementioned unconventional Au nanostructures and 2H-Pd nanoparticles, and amorphous/crystalline heterophase Pd, PdCu, Rh and Rh alloy nanosheets. By using gas-solid reactions, metastable 1T'-phase group VI transition metal dichalcogenides (TMDs), e.g., WS2, WSe2, MoS2, MoSe2, WS2xSe2(1-x) and MoS2xSe2(1-x), have been prepared. Impressively, the 1T'-MoS2-supported single-atomically dispersed Pt (s-Pt) atoms with Pt loading up to 10 wt% exhibit superior performance in hydrogen evolution reaction. Importantly, 1T'-TMD monolayers can be stabilized on 4H-Au nanowires, which have been used for ultrasensitive SERS detection. Moreover, the salt-assisted 2H-to-1T' phase transformation of TMDs have been achieved, and the phase transformation of TMDs during our developed electrochemical Li-intercalation process has been observed. Impressively, the lithiation-induced amorphization of Pd3P2S8 has been achieved. Currently, my group focuses on the investigation of (crystal) phase-dependent physicochemical properties, functions and applications in catalysis, (opto-)electronic devices, clean energy, chemical and biosensors, surface enhanced Raman scattering, water remediation, photothermal therapy, etc., which we believe are quite unique and very important not only in fundamental studies, but also in future practical applications. Importantly, the concepts of phase engineering of nanomaterials (PEN), crystal-phase heterostructures, and heterophase materials are proposed.

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In her current role as Associate DVC (Research) at RMIT University, **Professor Sujeeva Setunge** provides strategic and executive leadership in research and innovation to a community of 1,200 researchers and 1,600 HDR students. Previously she held the positions of interim dean of Engineering, deputy dean research in Engineering, Head of Civil Engineering and Head of Environmental Engineering.

Professor Setunge is the director of Australian Research Council funded Industrial Transformation Research Hub Transformation of Reclaimed Waste Resources to Engineered Materials and Solutions for a circular Economy which is a $21 m collaboration of 33 industry partners, 9 Australian institutions , 4 international Universities and Australian research council. She leads multiple research projects in collaboration with industry and government to progress net zero agenda for Civil infrastructure incorporating advanced materials, materials modelling, circular economy, asset management and digital transformation. Professor Setunge is a fellow of Engineers Australia and a chartered professional Engineer.

Nanotechnology-Enabled Circular Construction: Enhancing Waste-Derived Materials for Sustainable Infrastructure

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Abstract

The transition towards sustainable and circular construction requires innovative approaches to transforming waste resources into high-performance engineering materials while reducing the environmental footprint of infrastructure. Nanotechnology offers promising opportunities to enhance the reactivity, microstructure and durability of construction materials incorporating industrial by-products, potentially enabling higher levels of resource substitution without compromising engineering performance.

Drawing on the research and industry led framework of the ARC Industrial Transformation Research Hub for Transformation of Reclaimed (Waste) Resources to Engineered Materials and Solutions for a Circular Economy (TREMS), led by RMIT University, the presentation will present opportunities to improve the performance of waste derived construction materials through nano technology. Attention is given to the potential roles of nano-silica, nano clay, graphene and other functional nanomaterials in modifying the micro and nano structure of the construction materials.

The presentation highlights research priorities and pathways for translating nanotechnology-enabled material innovations into practical construction applications through interdisciplinary collaboration and industry-led validation. Combining nanoscale engineering with circular resource recovery can help move the construction sector beyond conventional recycling towards high-value resource utilisation and the development of durable, lower-carbon infrastructure materials.

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Lei Jiang is a Professor at the Suzhou Institute for Advanced Research, University of Science and Technology of China. He is an academician of the Chinese Academy of Sciences, National Academy of Engineering (USA) and Australian Academy of Science. Prof. Lei Jiang has discovered and established the basic principle of the interfacial material systems with superwettability and extended them to successful innovative applications. His work has been followed by more than 1,400 research institutions in 100 countries around the world. He is the most original and influential scientist in the field of material science in China. Due to his contribution to the development of superwettability, he won the "TWAS Prize in Chemistry" in 2011, the Advanced Science and Technology Award of "THE HO LEUNG HO LEE FUNDATION" in 2013 and the "Outstanding Achievement Award" of the Chinese Academy of Sciences in 2014. In 2016, he won the "UNESCO Medals" for contributions to the development of nanoscience and nanotechnologies, and the "Nikkei Asia Prize". In 2017, he won the "Humboldt Research Award" in Germany. In 2018, he was awarded the "Qiu Shi Outstanding Scientist Award" and "Nano Research Award". In 2020, he won the "ACS Nano Lectureship Award". In 2022, he won Tan Kah Kee Science Award.

Bioinspired Superwettability and Beyond: Ultralow Energy Consumption in High-Efficiency Bio-Synthesis, Energy Conversion, and Information Transmission

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Abstract

Since 1998, through learning from nature, we have established superwetting interface materials and superwetting interface chemistry systems, leading and promoting the global development of this field and successfully achieving the technological transformation of many achievements. Since 2020, our research has focused on dynamic superwettability. We raise a crucial question in life science: how can life achieve ultralow energy consumption (UEC) in high-efficiency bio-synthesis, energy conversion, and information transmission? We believe that to achieve these UEC processes, ultralow resistivity matter transport must exist within nanochannels (such as ion and molecular channels), where the directional collective motion of ions or molecules, rather than traditional Newtonian diffusion, is essential. This directional collective motion of ions and molecules is considered as ionic/molecular superfluidity. Understanding the UEC feature of living systems can realize UEC in high-efficiency material synthesis, energy conversion, and information transmission in artificial systems. In the future, we anticipate that research on this issue of UEC in high-efficiency bio-synthesis, energy conversion, and information transmission will greatly expand the development of basic research fields, such as material growth, temperate synthesis, energy conversion, material separation, information carrier, and information model. It will further have a disruptive impact on future fields such as chemical synthesis, chemical engineering, materials manufacturing, energy resources, and information technology.

ICNASA 2026 Plenary Speakers



Dr. Ying Tan is a Professor of Mechanical Engineering at The University of Melbourne, Australia. She earned her bachelor's degree from Tianjin University, China, in 1995, and her PhD from the National University of Singapore in 2002. Following a postdoctoral fellowship at McMaster University, she joined The University of Melbourne in 2004. Dr. Tan has received numerous prestigious recognitions, including an Australian Postdoctoral Fellowship (2006–2008) and an ARC Future Fellowship (2009–2013). She currently serves on the ARC Collage of Experts (2024–2026) and holds several distinguished titles, including Fellow of IEEE (FIEEE), Fellow of Engineers Australia (FIEAust), and Fellow of the Asia-Pacific Artificial Intelligence Association. She is also a member of the IEEE Fellow Committee (2024–2025) and was recently elected Fellow of the Australian Academy of Technology and Engineering (ATSE, 2025), an honor recognizing her outstanding contributions to engineering and applied science in Australia. Her research spans intelligent systems, nonlinear systems, data-driven optimization, rehabilitation robotics, human motor learning, wearable sensors, and model-guided machine learning.

From Functional Materials to Intelligent Wearable Sensors: Design, Fabrication and Applications

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Abstract

Recent advances in materials and manufacturing technologies are creating exciting opportunities for wearable sensors that can continuously monitor human health and physical activities in a comfortable and non-invasive way. Unlike conventional sensors, which are often bulky, rigid, and uncomfortable for extended use, emerging flexible and skin-compatible sensors can closely follow body movements while collecting important physiological information. However, translating these technologies into practical devices remains challenging, particularly in achieving reliable measurements, long-term comfort, affordable manufacturing, and meaningful interpretation of the collected data. In this keynote, I will present our recent research on flexible wearable sensors for monitoring human muscle activities, highlighting the journey from materials and device fabrication to intelligent health monitoring. First, I will introduce electronic tattoo sensors that use ultrathin, flexible electrodes to conform closely to human skin, improving comfort and reducing motion-related interference while maintaining reliable measurements. I will then discuss inkjet-printed wearable sensors using conductive silver-based inks, offering customizable and potentially low-cost fabrication with reduced lead times and material waste compared with conventional manufacturing methods. Experimental studies demonstrate the advantages of these technologies in terms of comfort, wearability, and signal quality compared with conventional sensing devices. Beyond sensor development, I will explore how artificial intelligence and machine learning can transform muscle signals into useful information about muscle fatigue and physical conditions. By combining physiological measurements with individuals' perceptions of fatigue and assessments from healthcare professionals, our research aims to bridge the gap between sensor measurements and practical health evaluation. Finally, I will discuss future opportunities and challenges in integrating advanced materials, scalable manufacturing, wearable sensing, and artificial intelligence to develop intelligent and personalized monitoring technologies, with potential applications in healthcare, rehabilitation, sports, and human–machine interaction.

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Prof. Hui-Ming Cheng is the founding director and professor of the Institute of Technology for Carbon Neutrality, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences since 2021 and the founding director of the Advanced Carbon Research Division of Shenyang National Laboratory for Materials Science, Institute of Metal Research, CAS from 2001 to 2025. He is a member of CAS, a foreign member of Academia Europaea, and a member of TWAS. He is a Highly Cited Researcher in three fields of materials science, chemistry, and environment and ecology. He was Associate Editor of Science China Materials (2014-2022), the Editor-in-Chief of New Carbon Materials (1998-2014), the founding Editor-in-Chief (2014-2025 and honorary Editor-in-Chief (since 2026) of Energy Storage Materials. His research activities mainly focus on carbon nanotubes, graphene and other 2D materials, and energy materials and devices

Exploration of new 2D materials

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Abstract

Identification of two-dimensional (2D) materials in the monolayer limit has led to discoveries of new phenomena and unusual properties. In this lecture, I will report the CVD growth of large-area high-quality 2D ultrathin Mo2C crystals, and the growth of monolayer films of MoSi2N4 which does not exist in nature and exhibits semiconducting behavior, high strength, and excellent ambient stability. In addition to CVD, we also prepared high-quality special 2D materials by exfoliation method. On the other hand, I will introduce some interesting properties found from well-known 2D materials, including high ion conductivity, anomalously large magneto-birefringence effect, and near-room-temperature sintering behavior of 2D materials. These findings indicate a great promise of 2D materials.

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Frank Caruso is an elected Fellow of the Royal Society (UK), the Australian Academy of Science, and the Australian Academy of Technological Sciences and Engineering. He has an internationally recognised track record in materials engineering with >600 publications. He is an Executive Editor of the ACS journal Chemistry of Materials and an Editorial Advisory Board Member of 10 other scientific journals. He has held continuous fellowships (ARC Federation Fellowships, an ARC Laureate Fellowship, an NHMRC Senior Principal Research Fellowship, and an NHMRC Leadership Fellowship). He has received numerous awards, including the Leverhulme Medal (2019, Royal Society UK), The Batteard–Jordan Australian Polymer Medal (2018, Royal Australian Chemical Institute) and the Eureka Prize for Leadership in Science (2013). His pioneering multidisciplinary research in particle engineering has resulted in several breakthrough technologies that have been applied by industry towards the development of an FDA-approved pain-relief product Zorvolex, antimicrobial products, and particle products for application in diverse sectors (agriculture, health). He is the co-inventor of 41 patents and is co-founder of Messenger Bio Pty Ltd (2021), a company that focuses on mRNA technologies.

Engineering Nanoparticle Platforms for Precision Organ Targeting and Therapeutic Delivery

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Abstract

The clinical validation of mRNA-lipid nanoparticles has established nanoparticle-based delivery as a transformative therapeutic modality. However, current platforms exhibit limited versatility, requiring case-by-case optimisation for distinct therapeutic payloads. We present a biomaterial-based nanoparticle platform capable of encapsulating structurally and functionally diverse therapeutics—including small molecules, siRNA, mRNA, and proteins—within a single nanoparticle type. The nanoparticles maintain cargo bioactivity throughout encapsulation and storage, with controlled release kinetics triggered by physiological conditions. The nanoparticles leverage metal–ligand interactions to achieve selective organ accumulation, enabling targeted delivery while reducing systemic exposure and off-target effects. Encapsulation efficiency, cargo stability, release profiles, and biodistribution across multiple therapeutic modalities will be demonstrated. Proof-of-concept applications in oncology, genetic disease, and infectious disease models will be presented. This work establishes a generalised nanoparticle platform that decouples therapeutic selection from formulation design, expanding the therapeutic scope of nanoparticle-mediated delivery.



Theme 1

Optics, Photonics and Optoelectronics

Theme 1: Optics, Photonics and Optoelectronics

When Diamond Meets 2D: Engineering Diamond Surfaces for Diamondtronics

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Abstract: Despite being a bona-fide bulk insulator, diamond develops an intriguing two-dimensional (2D) p-type surface conductivity when its surface is terminated by hydrogen and exposed to appropriate surface acceptor layer as a result of the surface transfer doping process. Consequently, the surface of diamond presents a unique hole-based 2D electronic system for exploring some of the extraordinary quantum and spin transport properties. In particular, the 2D hole layer affords a surprisingly large, and gate tunable spin-orbit interaction giving rise to exotic quantum coherent spin transport properties. However, the integration of the diamond 2D hole system with high-κ dielectrics that both preserve the delicate quantum properties of the underlying 2D hole band and provide effective electrostatic control remains a challenge.

In this talk, I will describe our recent work on the engineering of the 2D hole conducting layer on diamond through van der Waals integration. We developed a facile liquid-metal printing strategy to transfer an ultrathin glassy Ga_2O_3 dielectric onto hydrogen-terminated diamond at low temperature, enabling efficient gate control while preserving the delicate surface conductivity of the diamond channel. More recently, by integrating a high-κ $SrTiO_3$ membrane with hydrogen-terminated diamond through van der Waals assembly, we realised a diamond p-type MOSFET with a record high hole mobility, a low subthreshold swing near the thermal limit, and a high on/off ratio, demonstrating a promising route towards diamond electronics for harsh-environment and quantum device applications. Lastly, the hydrogen-terminated surface of diamond affords an ultralow surface energy that allows the pick-and-place transfer of arbitrary metal electrode arrays for van der Waals device fabrication. This novel diamond-assisted electrode transfer technique enables us to realise van der Waals integration of wafer-scale prefabricated electrode arrays onto 2D materials, enabling scalable 2D electronics and optoelectronics.



Prof. Qi received his undergraduate degree in physics in Peking University in 2003 and his PhD degree in surface science from the National University of Singapore in 2009. In 2012, he joined the Institute of Materials Science and Engineering (IMRE) as a staff scientist working on organic electronic devices. He took up a faculty position as a lecturer in physics at La Trobe University in 2013. In 2017, Dr. Qi was awarded the prestigious ARC Future Fellowship to develop high-performance diamond surface electronics and quantum devices. In 2018, He joined the Queensland University of Technology as a Senior Lecturer and was promoted to Associate Professor in 2020. Dr. Qi served as the Acting Head of School, Chemistry and Physics during 2023-2024.

Dr. Qi's research interests lie in the area of experimental condensed matter physics and material physics, focusing on creating, understanding, and controlling at nanoscale the surfaces and interfaces of functional materials to develop new technologies and material platforms for the next-generation devices. Dr. Qi has published more than 200 articles in internationally refereed journals including Nature Nanotechnology, Nature Materials, Physical Review Letters, Journal of the American Chemical Society, and Advanced Materials, with an H-index of 61 (Google Scholar).

Theme 1: Optics, Photonics and Optoelectronics

RE-Doped Thin-Film Gain Media for Microcavity Lasers and Optical Amplifiers

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Abstract: Integrated photonic chips require high-performance active optical devices, including optical amplifiers and lasers, whose performance critically depends on the selection of laser gain media. Ideal gain media must simultaneously exhibit excellent laser gain characteristics and support optical-grade micro- and nanofabrication. While a wide range of laser gain materials are available, most face significant technical barriers when processed at micro- and nanoscales with sufficient optical quality. Rare-earth-doped garnet crystals, such as YAG and GGG, represent a class of well-recognized high-performance laser materials. They can be doped with various rare-earth elements, enabling laser emission across a broad spectral range from 1 μm to 2.9 μm. However, their superior chemical stability and high Mohs hardness make micro- and nanoscale optical processing extremely challenging, which has long limited their application in compact integrated photonic platforms. In this work, we present an ion implantation-enhanced etching method to overcome this long-standing bottleneck. Using this approach, we directly exfoliate functional structures including microcavities and ridge waveguides from bulk rare-earth-doped garnet crystals, and successfully demonstrate multiple microcavity lasers and optical amplifiers based on these exfoliated single-crystalline films. These free-standing structures can be transferred onto arbitrary substrates, showing great promise for heterogeneous integration with other integrated photonic components.



Yang Tan is a Professor and PhD supervisor at the School of Physics, Shandong University, China. He received his PhD degree in Physics from Shandong University (2011), and then conducted postdoctoral research at the University of Calgary (2011-2012), Canada. His research focuses on ion beam modification of functional materials, single-crystal thin film fabrication, and their applications in microcavity lasers, waveguide optical amplifiers and integrated photonic devices.

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Theme 1: Optics, Photonics and Optoelectronics

Coherent thermal emission generation enabled by nonlocal metasufaces

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Abstract: Traditional thermal radiation originates from the spontaneous emission of a vast number of thermally excited electric dipoles with distinct frequencies, orientations, and moments within a bulk material; thus, it inherently exhibits broadband, omnidirectional, and unpolarized characteristics. By coupling this incoherent spontaneous emission into nonlocal metasurfaces and launching it into free space, coherent infrared signals can be efficiently generated. In this talk, I will review our latest research progress on key physical mechanisms in nonlocal metasurfaces, including high-Q resonances, photonic flatbands, and chiral responses[1]. Leveraging these mechanisms, I will demonstrate schemes for achieving infrared radiation with high temporal and spatial coherence, highlighting the feasibility of utilizing an infrared lens to collect large-area infrared signals while maintaining their temporal coherence[2]. Additionally, I will introduce control methodologies for coherent thermal emission ranging from circular polarization[3] to full polarization states[4], and even structured light fields[5]. Finally, I will present the dynamic spectral tuning and chirality reversal of circularly polarized thermal emission[6]. By dynamically compensating for structural fabrication errors, this approach achieves a precise match between the thermal emission wavelength and the fingerprint absorption of chiral matter, thereby offering a novel technological pathway for the efficient identification of chiral substances.



Zhanghua Han is a Professor of Physics at Shandong Normal University, China, and he has long been dedicated to the research of high-Q resonance physical mechanisms and their applications in nonlocal metasurfaces. Over the past three years, with a focus on frontier directions such as high-Q modes and photonic flatbands in nonlocal metasurfaces, he has achieved a series of original, internationally impactful outcomes. His work has been widely published in prominent journals, including *Nature Communications* (4 papers), *Science Advances*, *Advanced Photonics*, *Opto-Electronic Advances*, *Laser & Photonics Reviews*, and *Nano Letters*.

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ICNASA 2026 Keynote & Oral Speakers

Theme 1: Optics, Photonics and Optoelectronics

Scalable Ternary-Solvent Growth of Ultrathin 2D Perovskite Crystals for Custom Optoelectronic Functionalities

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Abstract: Solution-phase synthesis of monolayer hybrid organic–inorganic perovskites (A2MX4) is fundamentally limited by rapid out-of-plane growth and aggregation, typically restricting flakes to small lateral dimensions. Here, we present a steric-engineering ternary-solvent growth strategy that suppresses out-of-plane crystal stacking and enables the synthesis of laterally extended monolayer and few-layer A2MX4 crystals with surface areas exceeding 1000 μm2. By employing long-chain alcohol cosolvents combined with long-chain amine additives, secondary solvation environments are reorganized to prolong edge-mediated precursor transport during annealing. This platform demonstrates broad compositional universality across various organic cations, metal centers, and halides. The exceptionally large lateral dimensions allow direct, solvent-free electrical contact fabrication via physical shadow masking, bypassing chemical damage inherent to conventional lithography. Planar devices fabricated from ultrathin channels demonstrate diverse, composition-dependent optoelectronic behavior: PEA2PbI4 channels yield ultra-low dark currents, and enhanced volume-normalized photosensitivity; conversely, lead-free PEA2MnCl4 devices exhibit reproducible negative photoconductance driven by localized Mn-centered excitation and defect-assisted photogating. Together, these results establish steric solvation control as a general paradigm for synthesizing scalable 2D hybrid perovskite monolayers and exploring tailored metal-halide optoelectronic phenomena.



As an innovator at the intersection of advanced materials and photonics, Sudha Mokkapati brings extensive expertise across semiconductors, quantum optics, and 2D materials. Her research drives key breakthroughs in energy-efficient optoelectronics, high-bandwidth optical interconnects, and electronic sensing. By bridging fundamental physics with practical device engineering, she continuously develops scalable technologies designed to address next-generation technological challenges.

Mokkapati's career is defined by a strong focus on translation and enterprise, applying novel sensing architectures toward accessible diagnostics. A recognized leader in research direction and technology transfer, she serves as a member of the Australian Research Council (ARC) College of Experts and is a Monash 70th Anniversary Fellow in the 'commercialisation and enterprise' category. This track record highlights a proven capacity to navigate the complete pipeline from lab-scale discovery to high-impact enterprise solutions.

Combining deep domain knowledge with strategic governance, Sudha actively builds cross-disciplinary frameworks that link academic research with industry application. Her work prioritizes translateable outcomes, converting complex optical and electronic phenomena into reliable, market-ready solutions while fostering high-performing team environments.

Theme 1: Optics, Photonics and Optoelectronics

Graphene Metalens for Multi-functional Flat Optics

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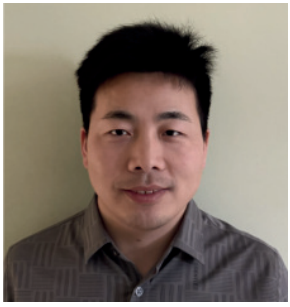
Abstract: Ultrathin flat lenses offer a compact and lightweight platform for optical wavefront control, opening new opportunities for miniaturized imaging systems. By combining tailored lens designs with the optical properties and laser pattern ability of graphene oxide (GO), graphene metalenses (GMLs) can be developed to realize diverse optical functions within a single ultrathin element.

Through the structure designs, GMLs can achieve varifocal imaging, multiwavelength achromatic imaging, multifocal imaging, and imaging at multiple magnifications [1-3], extending the capabilities of conventional single-focus lenses. The broadband optical response and mechanical flexibility of graphene-based materials [4] further support their use in compact and conformable optical devices. Their ultrathin geometry also offers opportunities for integration onto fibre tips and into on-chip optical systems, while laser nanoprinting provides flexibility in pattern design and device fabrication [5].

This talk presents the design principles and fabrication of GMLs, highlighting how lens geometry and material properties can be combined to achieve different imaging functions. Recent advances in broadband, multifocal, and multi-magnification imaging are discussed, together with the challenges and future prospects of GMLs for compact and integrated photonic systems.



Dr Guiyuan Cao is a Research Fellow at RMIT University and a recipient of the Australian Research Council Early Career Industry Fellowship. His research focuses on ultrathin flat optics, optical wavefront engineering, and laser nanofabrication for compact, multifunctional optical devices. His work on graphene metalenses has demonstrated multiwavelength achromatic focusing, multifocal imaging, and imaging at multiple magnifications, enabling diverse optical functions within a single ultrathin element. Dr Cao has published more than 40 peer-reviewed papers in journals including ACS Nano and Laser & Photonics Reviews. His current research includes compact snapshot hyperspectral imaging, alongside industry collaborations on laser nanoprinting systems and the translation of graphene metalenses into practical optical devices.

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Theme 1: Optics, Photonics and Optoelectronics

Improving single photon emission from van der Waals materials via atomic engineering

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Abstract: Designer van der Waals (vdW) materials offers enormous opportunities to tune material properties for various applications. Isolated, optically-active defects generated in vdW materials could lead to single photon emission. 2D vdW materials as host materials for single photon emission hold various advantages, such as high optical extraction efficiency from the atomically-thin layered materials, and readiness to integrate with on-chip photonic and electronic devices. However, single photon emission from 2D vdW materials typically suffers from low purity and lack of controllability, due to the sensitivity of these atomically-thin materials to external dielectric environments, surface defects and adsorbents, and strains and wrinkles introduced during material processing. This talk introduces our recent efforts to improve the single photon purity and controllability in vdW materials. We developed novel defect structures that can overcome several current issues, and explored their electronic structure and tunability in optical emission. Through a combination of approaches, including strain engineering, heterostacking, employing optical selection rules for excitation and detection, optimization of material synthesis and handling, we were able to achieve high purity (> 98%) for single photons emitted from 2D transition metal dichalcogenides (TMDs) at cryogenic temperature and in hBN at room temperature. This work provides deep insights into the electronic, spin, and valley properties of TMDs and hBN. It also paves the way towards the application of 2D vdW materials for quantum optical applications. The materials engineering approaches developed here can be applied to the optimization of other optical and quantum materials..

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Theme 1: Optics, Photonics and Optoelectronics

Multifunctional Perovskite Photodetectors

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Abstract: Perovskite, a flexible and versatile semiconductor material, exhibits remarkable optoelectronic properties, including a high light absorption coefficient, micrometer-scale carrier diffusion length, high mobility, and exceptional defect tolerance. These outstanding semiconductor characteristics have expanded the potential of perovskite materials beyond traditional photovoltaic applications.
My research group has been focused on advancing the preparation of materials, exploring physical properties, optimizing device structures, and integrating functional systems for various light-sensing applications.
In this report, I will present our progress in developing high-performance perovskite thin films for photodetectors with enhanced detectivity and rapid response times. These photodetectors serve as essential components for applications such as micro-spectrometers, multimodal hyperspectral imaging, and anti-noise, spatially coupled optical communication systems.



Liang Li is a Professor and Dean of the School of Physical Science and Technology at Soochow University, and Vice Chair of the Academic Committee of Soochow University. He is a recipient of the National Science Fund for Distinguished Young Scholars. He serves as Director of the Jiangsu Key Laboratory of Frontier Materials Physics and Devices and Director of the Suzhou Key Laboratory of Intelligent Photoelectric Perception. He is a Fellow of the Royal Society of Chemistry (RSC).
His research focuses primarily on optoelectronic information materials and new energy materials. He has published more than 300 research papers, including articles in Nature Materials, Nature Electronics, and Nature Sustainability, with over 30,000 citations. H-index is 100. He holds 25 granted invention patents and has edited one English-language monograph. He currently serves as Deputy Editor-in-Chief of Energy Materials and Devices, Associate Editor of Journal of Materials Science & Technology, Science Bulletin, and Nanomaterials, and Editorial Board Member of APL Electronic Devices, Fundamental Research, and other journals. He has served as Principal Investigator for major research programs including the Key Program, Original Exploration Program, National Science Fund for Distinguished Young Scholars, and Excellent Young Scientists Fund of the National Natural Science Foundation of China, as well as projects under the National Key R&D Program of the Ministry of Science and Technology. He has received a number of honors and awards, including the First Prize of the Science and Technology Award of the Chinese Materials Research Society.

Theme 1: Optics, Photonics and Optoelectronics

Measurement-induced photonic topological insulators

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Abstract: Measurement backaction offers an unconventional route to control dynamics beyond passive observation. We present a series of experiments in femtosecond-laser-written integrated photonic lattices that use segmented waveguides to emulate repeated stroboscopic measurements through the quantum-optical analogy. We first realize the optical Zeno effect and Zeno dynamics, where strong measurement backaction restricts light evolution to measurement-defined subspaces. By sequencing distinct projectors, we implement Zeno slicing, dynamically engineering the accessible Hilbert space and achieving deterministic node-to-node transport in a photonic lattice. Building on this measurement-control platform, we further show that repeated measurements can create rather than merely constrain collective phases. In a photonic Lieb lattice, an eight-step sequence of Zeno subspaces transforms an initially trivial lattice into an anomalous Floquet topological phase, characterized experimentally by an insulating bulk and robust unidirectional edge transport. The same framework enables programmable lattice operations, including beam splitting and controlled routing. Together, these results establish measurement backaction as a practical control resource in integrated photonics, connecting Zeno dynamics, Hilbert-space engineering, and topological transport, and opening a route to reconfigurable photonic devices inspired by monitored quantum systems.



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Theme 1: Optics, Photonics and Optoelectronics

Topology Optimization of Phononic and Photonic Crystal Structures

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Abstract: Phononic and photonic crystals enable precise control of elastic, acoustic and electromagnetic waves through their periodic microstructure, and their performance is governed by the wave dispersion relations they produce. Conventional design relies on intuition and trial-and-error parameter tuning, which restricts the accessible design space and rarely yields optimal solutions. Topology optimization offers a systematic alternative: it inverts the design process, so the crystal geometry is derived directly from the desired dispersion properties. This presentation reports recent advances in the topology optimization of phononic and photonic crystal structures, with emphasis on inverse design driven by target band-structure characteristics. Three classes of wave phenomena are considered. First, complete and maximized band gaps are designed for in-plane, out-of-plane and coupled elastic waves, as well as for transverse electric and transverse magnetic photonic modes. Second, topologically non-trivial band structures are engineered to realize topological insulators that support robust, backscattering-immune edge and interface states. Third, bound states in the continuum (BIC), which are localized modes with theoretically infinite quality factors embedded within the radiation continuum, are obtained by tailoring the crystal geometry. The examples show that topology optimization can discover non-intuitive crystal configurations with exotic wave-manipulation capabilities. This provides a unified, versatile framework for the next generation of waveguides, resonators, sensors and energy-harvesting devices.

Theme 1: Optics, Photonics and Optoelectronics

Controlling crystal particles in glass through microgravity, surface activation and dissolution kinetics to create new and advanced optical functionalities

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Abstract: This paper reviews progress in preventing or creating crystal particles in glass to tailor optical functionality of glass and optical fibres.
Inorganic non-metallic glass of high optical quality can transmit and guide light over long distances. Key to achieve high optical quality is the prevention of the formation of crystals during glass fabrication and fibre drawing. This is traditionally achieved through glass composition design and sufficiently fast cooling rate for the phase transition from a glass melt to a solid glass object. Another route is the processing of glass in microgravity conditions. Recently, ZBLAN glass fibres drawn in microgravity on the International Space Station (ISS) have shown 10 times lower loss compared to fibres drawn in unit-gravity conditions on Earth using ZBLAN preforms made under identical conditions [1].
On the other side, crystal nano- and micro-particles in glass can add unprecedented functionality to glass. A new technology of growing gold nanocrystals in-situ in glass has opened up unprecedented control of plasmonic tuning in tellurite glass [2]. A completely different approach is the doping of ex-situ made crystal particles to glass at different stages in the fabrication of glass and fibres. A prominent example is the demonstration of optical fibres with nitrogen vacancy centres containing diamond particles for remote and distributed magnetic field sensing in a robust platform [3]. This ex-situ doping technology was successfully expanded to rare earth doped crystal particles for testing a new laser platform paradigm with independent control of laser and glass transmission wavelength limits [4].



Heike Ebendorff-Heidepriem is Professor in Photonic Materials and Optical Fibres and Deputy Director of the Institute for Photonics, Advanced Sensing and Quantum Technologies (IPAS-QT) at Adelaide University. She is also Director of the Optofab Adelaide Hub at the Australian National Fabrication Facility (ANFF). She received the Ph.D. degree in 1994 at the University of Jena, Germany, where she continued until 2000. In 2001, she moved to the Optoelectronics Research Centre in Southampton, UK; and since 2005, she is with the University of Adelaide, which is since 2026 Adelaide University, Australia. In 2023, she was awarded a South Australian State Government Future Making Industry Fellowship and an ARC Laureate Industry Fellowship on “Breaking through the manufacturing ‘glass ceiling’ for ZBLAN glass fibres”. Since 2024, she is Chief Investigator at the ARC Centre of Excellence in Optical Microcombs for Breakthrough Science (COMBS). Her research focuses on the development of novel and advanced optical glasses and specialty optical fibres for science and industry applications

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Theme 1: Optics, Photonics and Optoelectronics

Polymer Metasurface Radiative Cooling Film from Lab to Fab

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Abstract: Radiative cooling is a zero-energy passive cooling strategy that uses the ~3 K outer space as a heat sink, combining high solar reflectivity with strong thermal emission through the 8–13 μm atmospheric window to cool objects below ambient temperature both day and night. With global thermal management costs reaching USD 44.75 billion in 2020, scalable cooling materials promise substantial energy and carbon savings. Among multilayer thin films, metamaterials, and polymers, polymer platforms uniquely combine large-scale production, low cost, and flexibility. Here we present a polymer metasurface radiative cooling film and its translation from lab to fab through roll-to-roll imprinting, producing prototypes approximately 50 cm in width continuously.[1] Under clear skies, the film achieves a temperature reduction of 8.5 °C and a cooling power of 129.8 W/m² in daytime, and 5.5 °C and 82 W/m² at night, while still delivering 59.5 and 48.1 W/m² on cloudy days and nights, respectively. We further demonstrate a range of applications, including a self-cooled 6.25 L water tank (5.5 °C reduction over 10 hours, 58.3–94.1 W/m²), radiative cooling covers for automobiles, a magnetically attachable film that cools stainless-steel plates by 15.2 °C under sunlight and reaches 259 W/m² at 70 °C,[2] a radiatively cooled thermoelectric generator for diurnal waste-heat harvesting, and smart films for protected cropping that reduce greenhouse energy consumption by 20.4% without affecting eggplant fruit quality. These results highlight the readiness of polymer metasurface films for industrial-scale deployment in energy-saving and decarbonization applications



Han Lin is an Associate Professor, Deputy Theme Leader and ARC Future Fellow in the School of Science and the Centre for Atomaterials and Nanomanufacturing at RMIT University, Melbourne. He received his PhD in physics from Swinburne University of Technology in 2013 after BSc and MSc degrees from Xiamen University. He has published more than 140 papers in leading journals, including Chemical Reviews, Nature Photonics, Nature Reviews Chemistry, Advanced Materials, Nature Communications and ACS Nano, which have attracted over 10,000 citations with an h-index of 50. Eight of his papers have featured as journal covers, and his Nature Photonics article is a Web of Science Highly Cited Paper. His research spans laser physics, photonic nanomaterials, graphene metamaterials and laser 3D nanoprinting for energy, imaging and sensing applications. His honors include the RMIT Vice-Chancellor's Award for Research Excellence (2024) and the Opto-Electronic Advances Best Paper Award (2022).

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Theme 1: Optics, Photonics and Optoelectronics

Self-Assembly Nanophotonic Sources

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Abstract: The advancement of integrated photonics relies on integrating multiple devices on-chip within a compact footprint—an objective traditionally pursued through complex CMOS nanofabrication. In particular, active nanophotonic devices require heterogeneous integration of multiple active materials for sustaining different functionalities, which is extremely challenging. Self-assembly, a ubiquitous strategy in biological systems for forming highly ordered structures, offers an alternative route to monolithic integration of high-quality nanostructures. In this talk, I will present self assembly approaches for fabricating resonant nanostructures from active photonic materials. The intrinsic symmetry of both the materials and the resonant architectures enables rich optical phenomena, including polarization-entangled photon-pair generation via spontaneous parametric down-conversion, spin–valley–locked lasing emission, and structured lasing from high-Q metasurfaces. Self-assembly methods such as capillary-bridge lithography and van der Waals (vdW) integration provide versatile platforms to incorporate emerging active materials—including vdW crystals and perovskites—into designed photonic structures. These approaches enable active nanophotonic functionalities for light emission, manipulation, and detection, and expand the potential of emerging quantum materials for integrated photonic devices

Theme 1: Optics, Photonics and Optoelectronics

Topological phase transitions in cut-and-project binary chains: an arithmetic criterion from polarization

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Abstract: Topological insulators in one dimension are usually introduced through the Su–Schrieffer–Heeger (SSH) model and its two-site unit cell. Here we show that a whole family of one-dimensional topological phases—and a surprisingly simple arithmetic law governing them—emerges from the cut-and-project (CP) construction, the same geometric method that generates quasicrystals and their periodic approximants. Cutting a square lattice along a rational slope α = p/q produces inversion-symmetric binary tight-binding chains, with two bond types t_A and t_B and n = p + q sites per unit cell, ranging from the SSH chain to long-period approximants of the Fibonacci chain. Combining tight-binding modeling with the modern theory of polarization, we map the "CP butterfly" that organizes the hierarchical spectra of these chains, and track their Zak phases, Wannier centers and electric polarization across the gap-closing point t_A = t_B. The Zak phase always jumps, but a genuine topological phase transition occurs if and only if n/gcd(M,n) is odd (M being the number of filled bands): the polarization then switches between 0 and P_q/2, where P_q = gcd(M,n)/n is a filling-dependent quantum of polarization. When the criterion fails, we construct an explicit inversion-symmetry-preserving adiabatic path—the "C-path"—that connects the two regimes without closing the gap, proving the absence of a transition. Open-boundary calculations confirm the bulk–boundary correspondence for the polarization quantum. Our criterion reduces the topological classification of one-dimensional inversion-symmetric binary insulators to the number theory of (n, M), independent of the detailed bond sequence, and opens a route to characterizing topological transitions in quasiperiodic chains and higher-dimensional cut-and-project materials.

Keywords: cut-and-project; topological phase transition; electric polarization; Zak phase; quasicrystal approximants

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Theme 1: Optics, Photonics and Optoelectronics

Liquid-Metal-Engineered Ultrathin 2D Ce–Ga Oxides for Broadband UV NIR Negative Photodetection

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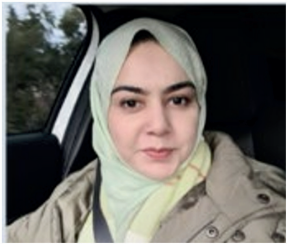
Abstract: Engineering two-dimensional (2D) ultrathin oxides through in situ control during growth provides a pathway to functional materials from nonlayered bulk systems that are unsuitable for conventional exfoliation. Here, liquid-metal chemistry is employed to synthesize ultrathin mixed oxides using liquid gallium as both solvent and growth medium. Cerium metal is dissolved into liquid gallium and subsequently oxidized at controlled temperatures at the metal–air interface, producing continuous and smooth nanoscale 2D oxides with a CeO_2-enriched surface. Temperature-dependent evolution of the surface oxide enables controlled incorporation of Ce into the nanoscale oxide structure while preserving its ultrathin morphology. The resulting Ce–Ga oxide nanosheets demonstrate broadband negative photodetection spanning the ultraviolet to near infrared (UV–NIR) spectral range from 365 to 1050 nm. Density functional theory (DFT) calculations indicate the formation of midgap electronic states that contribute to the observed broadband photo response. The negative photoconductivity is further associated with the photothermal/bolometric response of the ultrathin oxide, where nanoscale thickness and a high surface-to-volume ratio enhance light-induced resistance modulation. These results demonstrate that liquid-metal processing can enable surface-engineered 2D oxides from intrinsically nonlayered materials and provide a versatile platform for broadband optoelectronic devices.



Nahiya Mushtaq is a PhD researcher at RMIT University, Melbourne, Australia, working on liquid-metal-based synthesis of ultrathin mixed-oxide nanosheets for broadband optoelectronic and sensing applications. She holds a B.Tech. in Electronics and Communication Engineering and an M.Tech. in Nanotechnology, and has three years of experience as a Lecturer. Her research interests include two-dimensional oxide materials, Ce–Ga oxide systems, and broadband photodetection.

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Theme 1: Optics, Photonics and Optoelectronics

High-Performance Cellulose Photonic Films with Multifunctional Properties

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Abstract: Cellulose nanocrystal (CNC) based photonic materials generate structural color via interaction of light with their chiral nematic structure and offer a sustainable route for advanced optical applications. However, the practical implication of these materials is often limited by compromise between mechanical and optical properties associated with conventional plasticizers and strong dependence on substrate for color visibility. This study hypothesizes that integrating lignin as a functional substrate can simultaneously enhance mechanical robustness, optical visibility, and environmental responsiveness of CNC photonic films. Hence, a fully biobased lignin-CNC bilayer architecture was designed, where a CNC photonic layer was assembled onto lignin substrate to enable synergistic property enhancement. The resulting films preserved long-range chiral nematic ordering and exhibited vivid angle-dependent coloration, while lignin provided a built-in dark background for accurate optical visibility. Additionally, using lignin as substrate substantially improved thermal stability with maximum decomposition temperatures reaching 390-393°C. Glycerol-induced softening enabled tunable swelling, leading to reversible optical responses and humidity-driven actuation across variable relative humidity due to strain mismatch between layers. These findings demonstrate a robust, multifunctional strategy for overcoming key limitations of CNC photonic materials, advancing their potential in sustainable, responsive optical systems.



Dr Mansi Goyal is a Postdoctoral Research Fellow at Queensland University of Technology (QUT), Australia. Her research focuses on nanocellulose-based photonic materials for sensing and structural colour applications, bio-based nanomaterials, and the development of high-performance cellulose-based composites. Her work aims to develop sustainable, multifunctional materials with advanced optical, mechanical, and functional properties for emerging advanced material applications.

ICNASA 2026 Keynote & Oral Speakers

Theme 1: Optics, Photonics and Optoelectronics

Three-dimensional asymmetric plasmonic metasurfaces supporting quasi-BIC resonances with tunable Q factors

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Abstract: Symmetry-protected bound states in the continuum (BICs) enable perfectly confined optical modes, but tuning their transition into radiative quasi-BICs in plasmonic structures remains a fundamental challenge. While two-dimensional (2D) dielectric metasurfaces have successfully demonstrated symmetry-broken quasi-BICs, achieving robust geometric tuning in fully three-dimensional (3D) plasmonic platforms requires novel architectural approaches. Here, we theoretically propose and experimentally realize 3D asymmetric plasmonic metasurfaces that support tunable quasi-BIC resonances. The meta-atoms consist of vertically oriented gold-coated pillar pairs and a horizontal bar. By systematically adjusting the in-plane relative position of the horizontal bar, we introduce a controlled structural asymmetry. This geometric tuning explicitly breaks the lattice mirror symmetry that otherwise strictly decouples the out-of-plane electric dipole mode from the transverse free-space continuum, enabling a continuous transition from an ideal BIC dark state to a radiative quasi-BIC. We experimentally validate this geometry-driven resonance tuning through optical measurements. Furthermore, by explicitly modeling the angular spread introduced by the finite-aperture measurement setup, we reconcile our theoretical predictions with the observed spectra and clarify the influence of illumination angle on the resonance.



Junbo Yang received her master's degree from Shandong University in 2024 and is currently a PhD candidate at RMIT University under the supervision of Distinguished Professor Baohua Jia. Her research interests focus on nanophotonics.

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Theme 1: Optics, Photonics and Optoelectronics

Femtosecond Laser Inscribed 3D Optical Chirality in YAG Crystal

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Abstract: Chiral materials are of considerable interest in photonic integrated circuits, optical sensing, and quantum optics, owing to their distinctive capability for spin-state discrimination and spin–orbit angular momentum conversion. Despite this potential, realizing large-scale, tunable, and cost-effective chiral nanostructures within inorganic crystals remains a significant challenge. Metallic nanoparticles, widely utilized in photonics, provide a promising route: their localized surface plasmon resonance enhances near-field confinement, which amplifies the chiral-induced absorption contrast and simultaneously supports rapid, large-area, high-precision, and controllable in situ reconfiguration under external electromagnetic fields. Here, we report a strategy that employs femtosecond laser pulses to manipulate embedded nanoparticles within a yttrium aluminum garnet (YAG) host, yielding rotationally ordered nanoassemblies. The resulting laser-induced symmetry breaking endows these three-dimensional bulk nanostructures with chiral optical responses that are continuously tunable from the visible to the near-infrared and reproducibly achievable along two orthogonal orientations. These parametrically customizable chiral crystals offer broad applicability in photonics, including quantum technologies, and open an unexplored avenue for direct-write laser nanolithography.



Feng Chen is currently a Distinguished Professor at School of Physics, Shandong University, China. He received the PhD degree from Shandong University in 2002. From 2003 to 2005, he was an Alexander von Humboldt Research Fellow at Clausthal University of Technology, Germany. His research interests include fabrication of micro-nanoscale photonic structures, optical waveguides, lithium niobate thin films, ion beam modification of materials, ultrafast laser writing, plasmonics, nonlinear optics, topological photonics, etc. He has more than 500 papers published in peer-reviewed journals, 1 professional book, 5 book chapters, and holds 10 patents. He is a Fellow of Institute of Physics (IOP), OPTICA (formerly OSA), and SPIE. He also serves the Editor-in-Chief of Laser and Particle Beams, Editorial Board Member of Opto-Electronic Science, Deputy Editor of ChemPhysMater, a member of committees/subcommittees of CLEO, CLEO-Europe, etc.

Theme 1: Optics, Photonics and Optoelectronics

Ultrafast laser-enabled big data storge

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Abstract: Data storage has long underpinned the advancement of human civilization. The rapid proliferation of big data, artificial intelligence, and the Internet of Things has triggered an exponential surge in global data generation, which in turn has placed immense and growing demands on energy consumption for storage infrastructure. Optical data storage based on ultrafast-laser-induced micro/nanostructures offers compelling advantages including high storage density, long retention time, and robust stability. By exploiting nonlinear absorption processes driven by ultrafast pulses, information can be inscribed directly within the volume of a storage medium, facilitating true three-dimensional and multidimensional data recording. Nevertheless, the performance of currently reported optical storage remains insufficient to meet the practical requirements of the big-data era, such as the long-term, energy-efficient, and cost-effective preservation of massive datasets. We leverage the ultrahigh precision and spatial selectivity of ultrafast laser processing to propose a novel optical storage strategy based on single-pulse laser-induced microphase transitions in lithium niobate single crystals. We reveal the underlying material modification mechanism governed by intrapulse coupling dynamics during ultrafast laser irradiation. By employing a single ultrafast laser pulse to directly write three-dimensional, pixel-level, programmable structural colors capable of encoding multidimensional information, we achieve permanent, multidimensional archiving of big data. The resulting storage system demonstrates high read/write speeds, low error rates, high storage density, low energy consumption, and exceptional stability, offering a promising pathway toward next-generation data storage solutions.

Theme 1: Optics, Photonics and Optoelectronics

2D materials for enhanced nonlinear optics in integrated waveguides

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Abstract: Chip-scale integrated devices, with their compact footprint, low energy consumption, and cost-effectiveness enabled by large-scale manufacturing, have profoundly shaped modern technology[1]. Among them, nonlinear photonic devices are particularly critical, as they enable essential functions such as all-optical signal processing, frequency conversion, ultrafast optical switching, and on-chip light generation[2]. However, the weak intrinsic optical nonlinearities of conventional platforms, such as silicon photonics, significantly limit device performance and scalability. This challenge has driven the search for novel materials with stronger nonlinear responses to advance integrated photonics.

Two-dimensional (2D) materials, endowed with extraordinary properties such as ultrahigh carrier mobility, layer-dependent bandgaps, strong anisotropy, broadband and low optical dispersion, as well as excellent nonlinear optical responses, have thus emerged as promising candidates for the next generation of integrated nonlinear photonic device fabrication [1]. In this work, we focus on investigating the optical nonlinearities of novel 2D materials and exploring their potential in integrated nonlinear photonic devices. Ultrafast laser spectroscopy techniques, including Z-scan and pump–probe measurements, are employed to characterize the third-order optical responses of graphene oxide [1], BiOBr [2], $PdSe_2$ [3], and MXene [5] films. Furthermore, hybrid integrated devices incorporating these materials with enhance nonlinear photonic performances have been demonstrated, offering valuable insights into the design and fabrication of high-performance nonlinear photonic platforms for future applications.



Dr. Linnan Jia is a Research Assistant at the Centre for Atomaterials and Nanomanufacturing, School of Science, RMIT University. He earned his PhD from the Optical Sciences Centre of Swinburne University of Technology in 2022. His research focuses on 2D materials, nonlinear optics, and integrated photonic devices.

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Theme 1: Optics, Photonics and Optoelectronics

Ion Track Technology-Based Optical Nanostructures

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Abstract: Swift heavy ions deposit enormous electronic energy densities in solids, leading to the formation of latent ion tracks that provide a unique platform for investigating radiation–matter interactions under extreme conditions. Beyond their fundamental scientific significance, ion tracks have emerged as an enabling tool for the template-fabrication of new nanostructures and some of them exhibit interesting optical properties. As one of the major heavy-ion accelerator facilities in Asia, the Heavy Ion Research Facility in Lanzhou (HIRFL) has served as a versatile platform for ion-track research over the past decades. Leveraging the capabilities of HIRFL, extensive efforts have been devoted to both the fundamental understanding of ion-track formation and the development of interdisciplinary applications.

In this presentation, recent research activities of ion track-template fabrication of nanostructures with HIRFL will be reviewed, covering fabrication and optical properties of some structures Emphasis will be placed on the fundamentals of ion tracks and optical nanostructures, illustrating the expanding role of heavy-ion accelerators in fostering interdisciplinary innovation. Perspectives on future opportunities for ion-track science and technology will also be presented.



Professor Jinglai Duan is a Distinguished Professor and Director of the Materials Research Center at the Institute of Modern Physics (IMP), Chinese Academy of Sciences (CAS). He is a recipient of the National Science Fund for Distinguished Young Scholars of China. Prof. Duan has struggled to understand the science of ion tracks in solids, including ion-solid interactions, fine structure of ion tracks, and fabrication of novel functional nanostructures based on ion tracks. He proposed a novel light-absorption mechanism and, based on it, invented the world's blackest ultra-black material – the ion track membrane ultra-black material with an absorbance of 99.99%. Using ion tracks, he "wove" quasi-nanolattice mechanical metamaterials with the highest energy absorption capacity reported at that time (Nat. Commun., 2023, 14, 1243). He and his team independently designed and built an advanced irradiation facility for mass-production of ion track membranes, achieving a daily production capacity of hundred thousand square meters for membrane commercialization. Prof. Duan has published more than 100 journal papers, holds dozens of patents. He has delivered tens of invited talks at prestigious venues including the Xiangshan Science Conferences and international conferences on ion beam materials. He is the recipient of the First Prize of Gansu Provincial Science and Technology Progress Award and the First Prize of Gansu Provincial Patent Award. He serves on the editorial boards of international journals and is a fellow of multiple scientific societies. His work has been recognized for combining fundamental irradiation physics with impactful industrial applications.

ICNASA 2026 Keynote & Oral Speakers

Theme 1: Optics, Photonics and Optoelectronics

Programmable Photonic Computing and Signal Processing

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Abstract: Photonic computing offers a physical route to processing wideband information through optical parallelism and programmable signal transformations. This talk reviews our research on microcomb-enabled computing, programmable photonic integrated circuits and physical learning, connecting devices and architectures with applications in signal processing and artificial intelligence. I will first introduce broadband microwave photonic processing and time–wavelength interleaving, including a convolutional accelerator operating at 11 trillion operations per second and optical neural networks [1]. I will then discuss complex-valued convolution, tensor and reconfigurable convolutional operators, and the integration of microcomb sources with on-chip spectral programming. A central theme is making photonic hardware observable and controllable: reference-assisted amplitude and phase recovery enables self-calibration despite fabrication errors and thermal crosstalk [2], while output-driven learning adapts the processor directly to a task. These methods support parallel optical convolution streaming [3] and real-time complex-valued radio-frequency blind source separation. Finally, I will present recent progress towards reusable photonic representations and electro-optic generative computing, alongside ongoing work on multiscale transforms. The talk will examine how optical bandwidth, multiplexing, calibration and learning jointly determine useful computational performance, with emphasis on the transition from individual optical operators to programmable systems for communications, sensing and intelligent information processing.



Xingyuan Xu is a Professor in the School of Electronic Engineering at Beijing University of Posts and Telecommunications. He received his PhD from Swinburne University of Technology in 2020 and was a Research Fellow at Monash University before joining BUPT in 2022. His research focuses on photonic computing, programmable integrated photonics and optical communications signal processing. His work includes microcomb-based optical neural networks, self-calibrating photonic circuits and hardware learning.

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Theme 1: Optics, Photonics and Optoelectronics

Integrated Microwave Photonic Circuits for Signal Processing and Sensing

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Abstract: Integrated microwave photonic circuits, increasingly enhanced by artificial intelligence, offer powerful capabilities for advanced signal processing and sensing. Recent advances include microresonator-based devices for high-resolution interrogation, athermal and noise-resilient operation, multiparameter and wide-range sensing, and silicon carbide integration for expanded functionalities. Emerging nanophotonic neural networks further extend these capabilities towards ultrafast, energy-efficient AI processing.

Theme 1: Optics, Photonics and Optoelectronics

Laser-nanoprinted broadband flat optics in liquid-metal-derived 2D tin oxide

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Abstract: Two-dimensional (2D) metal oxides grown at liquid-metal (LM) interfaces offer a scalable route to ultrathin, transparent, and chemically tunable materials for next-generation optoelectronics. Yet their translation into functional flat optics remains constrained by a central challenge: a continuous few-nanometer film cannot shape light unless its optical phase and amplitude are spatially programmed. Conventional routes rely on multi-step nanolithography to define subwavelength structures, but these processes are costly, slow, and often incompatible with fragile LM-derived oxides. Here, we demonstrate a scalable, lithography-free strategy, converting LM-printed 2D SnOx directly into broadband flat micro-optics using femtosecond (fs) laser nanoprinting. Localized laser irradiation interacts uniquely with the naturally stratified printed SnOx, inducing nanoscale thinning, progressive oxidation, and the generation of densely distributed SnOx nanoparticles. Operating in the Rayleigh-scattering regime, these subwavelength scatterers produce an amplitude-dominated modulation of the local complex transmission, accompanied by a smaller phase variation, which is exploited to build binary diffractive elements. By spatially encoding these laser-induced structures, we fabricate planar diffractive SnOx micro-lenses with broadband focusing and subwavelength-resolution imaging across visible spectrum, capable of programmable 1D and 2D diffraction gratings. Our results establish LM-derived oxides as scalable platform for integrating ultrathin, customizable and broadband flat optics without conventional nanolithography.

Xiangyang Guo is a Postdoctoral Research Fellow at RMIT University, Melbourne, Australia. He received his PhD in Electronic and Telecommunications Engineering from RMIT University in 2024. His research focuses on advanced functional materials, two-dimensional materials, laser micro/nanofabrication, and optoelectronic devices.

His research interests include the synthesis and characterisation of liquid-metal-derived two-dimensional materials, laser–matter interactions, piezoelectric materials, flexible sensors, and nanophotonic devices. He has expertise in femtosecond laser processing, thin-film fabrication, micro/nanofabrication, and advanced materials characterisation. His work aims to develop innovative material-processing strategies and integrate functional materials into next-generation sensing and photonic technologies.

ICNASA 2026 Keynote & Oral Speakers

Theme 1: Optics, Photonics and Optoelectronics

Ultrafast Laser Micro-nanostructuring in Transparent Materials for On-chip Integrated Micro-spectrometers

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Abstract: Miniaturized spectral encoding devices are vital for spectroscopic applications, such as light analysis, spectral imaging, optical sensing, and measurement. Despite recent advances, a microscale optical dispersion solution capable of delivering numerous spectral responses without applying external stimuli remains elusive. Here, we developed a minimalist self-organization approach to address this challenge. This strategy employs ultrafast laser-induced micro-structures in transparent substrates to create localized optical dispersion. These dispersive structures function over a broad bandwidth, occupy an ultra-compact footprint, and are independent of viewing angle. We demonstrate the potential of these structures in on-chip spectral analysis and microscopic spectral imaging applications. Our method establishes an effective route for versatile, high-resolution, and cost-efficient integrated spectroscopic systems.



Zhang Bo, received undergraduate training in Mechanical Engineering from Sichuan University and got a Ph. D. from Zhejiang University in 2021, now works as an associate Professor at the College of Optical Science and Engineering in Zhejiang University (ZJU). From 2021 to 2025, he worked as a postdoctoral researcher in the State Key Laboratory of Extreme Photonics and Instrumentation at Zhejiang University (ZJU). At present, he is mainly engaged in the research of ultrafast laser-matter interaction mechanisms and their applications, including high-density optical data storage, multi-dimensional optical modulation, and integrated micro-spectrometers.
In recent years, he has published more than 20 SCI academic papers in Nature Electronics, Nature Communications, Light: Science & Applications, Advanced Materials, ACS Nnano, and other journals. He was selected for the 2023 National Postdoctoral Researcher Funding Program. He is responsible for the National Key Research Plan, the National Natural Science Foundation of China, and other projects.

Theme 1: Optics, Photonics and Optoelectronics

Programmable radiative coupling in nanoelectromechanical quasi-BIC metasurfaces

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Abstract: Active metasurfaces primarily tune resonant spectra through resonance-frequency shifts or internal-loss modulation, while radiative loss remains largely untuned despite its fundamental role in balancing incident-light coupling, local-field enhancement, and far-field visibility. Bound states in the continuum provide a distinctive platform for quantitative engineering of radiative loss through symmetry breaking, but fabrication-fixed asymmetry locks the operating point. Here we experimentally demonstrate a transdimensional mechanism for radiative-coupling control via nanoelectromechanical geometric evolution. Electrostatically driven out-of-plane deformation transforms a planar quasi-BIC into transdimensional quasi-BIC configurations, rendering radiative coupling voltage-programmable. We reversibly drive the metasurface from overcoupling through critical coupling to undercoupling without increasing non-radiative dissipation, while continuously tuning radiative loss, resonance wavelength, and reflectance, with distinct TD-qBIC states stably maintained under corresponding biases. The integrated device draws sub-microampere steady-state current, maintains repeatable modulation over 800 cycles, and switches within a 10-ms acquisition interval. Building on this platform, we provide a conceptual demonstration of a programmable mid-infrared radiative-loss modulator, with discrete voltages addressing resolvable radiative-loss states and calibrated states sequenced with user-defined order and dwell times. Such programmable radiative-loss control mitigates the state-retention and integration limitations of optical-pump-based approaches, making radiative coupling a programmable operating-state variable and offering prospects for infrared spectroscopy and sensing, thermophotonics, and nonlinear photonics.



Miao Liu received his master's degree from Shandong University in 2024 and is currently a PhD candidate at RMIT University under the supervision of Distinguished Professor Baohua Jia. His research interests focus on nanophotonics.

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Theme 1: Optics, Photonics and Optoelectronics

Efficient light upconversion in few-layer transition metal dichalcogenides

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Abstract: Materials capable of light upconversion—transforming low-energy photons into higher-energy ones—are pivotal in advancing optoelectronics, energy solutions, nanophotonics, and photocatalysis. However, the discovery in various materials pays little attention on few-layer transition metal dichalcogenides, primarily due to their indirect bandgaps and weaker light-mater interactions. Here, we report a pronounced upconversion photoluminescence in few-layer transition metal dichalcogenides. This joint theory-experiment study attributes the upconversion photoluminescence to a resonant exciton-exciton annihilation involving a pair of dark excitons with opposite momenta, followed by the spontaneous emission of upconverted bright excitons, which can have a high upconversion efficiency. Additionally, the upconversion photoluminescence is generic in MoS_2, $MoSe_2$, WS_2, and WSe_2, showing a high tuneability from green to ultraviolet light (2.34–3.1 eV)[1]. The findings pave the way for further exploration of light upconversion regarding fundamental properties and device applications in two-dimensional semiconductors.



Dr Yi-Hsun Chen is a Postdoctoral Research Fellow in the School of Mathematics and Physics at The University of Queensland. His research spans condensed-matter physics, quantum materials, and quantum technologies, with particular interests in exciton physics, two-dimensional materials, and superconducting quantum circuits. His work focuses on understanding the fundamental optical and electronic transport properties of quantum materials

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Theme 1: Optics, Photonics and Optoelectronics

2D Material Polaritonics and Optoelectronic Devices

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Abstract: Manipulating light at the nanoscale and developing low-loss on-chip photonic and optoelectronic devices are the focus of research in the field of nanophotonics. The key issue is how to achieve high confinement and propagation control of light in the 2D plane. Polaritons, hybrid light-matter waves, enable nanoscale control of light. Particularly large polariton field confinement and low losses have been found in graphene and 2D van der Waals materials.
In this talk, I will present our recent progress in manipulating anisotropic polaritons in 2D materials [1]. Firstly, by fabricating twisted α-MoO3 bilayers [2] and van der Waals heterostructures, we experimentally observe photonic magic angles and tunable topological transitions of phonon polaritons. Such polaritonic topological transition and canalization can be used for super-resolution imaging [3]. Secondly, via photonic structure engineering, we demonstrate unidirectional diffraction of hyperbolic polaritons [4], low-symmetry Bloch modes in hyperbolic polaritonic crystals [5], and low-temperature hyperbolic phonon polaritonics [6]. Lastly, we show recent progress on designing on-chip optoelectronic nanocircuit by integrating 2D materials with nanophotonic metasurfaces [7].



Dr. Qingdong Ou is an Assistant Professor at the Macao Institute of Material Science and Engineering (MIMSE), Macau University of Science and Technology. His research primarily focuses on 2D materials, near-field optics, and optoelectronic devices. He obtained his Ph.D. from Monash University, Australia, in 2019. He has published over 100 papers in prestigious journals, including Nature, Nature Photonics, Nature Synthesis, Nature Communications, Science Advances, and Advanced Materials. His achievement on photonic magic angles of 2D materials was selected as Physics World Top 10 Breakthroughs of 2020. He received fundings from the National Natural Science Foundation of China, and the Science and Technology Development Fund, Macau SAR. He was previously an Australian Research Council DECRA Fellow. He has been nominated for the Asian Young Scientist Fellowship and the Australian Prime Minister's Prizes for Science. His academic honors also include the Second Prize of the Natural Science Award from the Ministry of Education of China, and the Monash University Vice-Chancellor's Award for Research Excellence.

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Theme 1: Optics, Photonics and Optoelectronics

Energy and resource sustainable technologies of greenhouse horticulture in Australia

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Abstract: Global greenhouse horticulture faces dual challenges from intensifying climate volatility and urgent need to reduce energy and resource inputs. We demonstrate that innovative greenhouse covers play a pivotal role in buffering climate impacts and cutting operational costs. In capsicum cultivation under projected Intergovernmental Panel on Climate Change (IPCC) pathways, advanced cover materials provide a significant boost to energy efficiency by mitigating extreme temperature spikes and reducing cooling demands. These advanced materials optimize greenhouse microclimates by lowering cooling energy expenditure and drop average fertigation use by up to 24.2%. Although crop yield reductions can occur due to restricted light transmission, economic modelling confirms high viability when paired with fan-pad cooling systems, achieving an advantageous benefit-cost ratio through the structure's lifespan. New generation of films can reduce energy cost while maintain and even increase yield of capsicum. Optimizing liquid nutrient delivery is vital for cleaner production and resource efficiency. Our research across multiple vegetables reveals that traditional, high-input irrigation schedules often lead to resource waste without adding yield value. integrating these optimized fertigation levels with transitional or fully renewable energy supply scenarios enables the avoidance of up to 95% of operational climate control greenhouse gas emissions. Collectively, these findings highlight the importance of a synergistic approach to modern greenhouse horticulture by integrating advanced covering technologies with precise, genotype-specific, and reduced-input fertigation strategies.

Professor Zhong-Hua Chen is a leading plant scientist at Adelaide University's School of Agriculture, Food and Wine and an Adjuct Professor at Westen Sydney University. His pioneering research focuses on stomatal regulation, multi-omics, and abiotic stress tolerance to future-proof global crops against climate change. He serves as Deputy Program Lead for CRC Future Food Systems and a Chief Investigator for major national hubs in protected cropping and sustainable horticulture. He was a recipient of many research awards including Minister for Agriculture, Forestry and Fisheries Award, ARC DECRA, ARC Future Fellow, and Clarivate Highly Cited Researcher.

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Theme 1: Optics, Photonics and Optoelectronics

Time-Resolved In Situ Imaging Reveals the Mechanism of Laser-Induced Nanoparticle Self-Deposition on Copper

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Abstract: Laser-induced nanoparticle (NP) formation involves highly transient interactions among plasma, shock waves, molten material, and vapor, making its underlying mechanism difficult to resolve. Here, we directly visualize the dynamic self-deposition of NPs on copper during nanosecond laser ablation using a combined in situ observation system integrating ultrashort-exposure imaging and pump–probe microscopy. The temporal evolution of the plasma plume, shock wave, and moltenmetal spatter was systematically correlated. The shock wave initially propagated faster than the plasma plume, while molten copper subsequently rose from the irradiated surface and approached the high-temperature region of the plume. The spatial agreement between the top of the molten spatter and the lower boundary of the plume indicates direct plume–spatter interaction. The ejected molten material undergoes evaporation and fragmentation within this region, contributing to NP formation. As the plume cools and dissipates, the generated NPs are released and finally deposited around the laser-irradiated area. These observations provide a time-resolved physical picture of laser-induced NP self-deposition and offer insights into controlling laser-generated surface nanostructures.

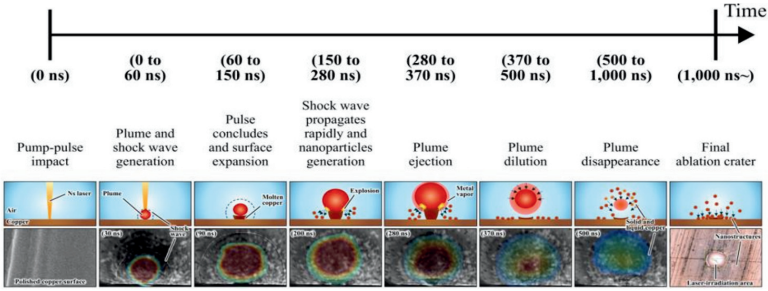

Figure 1. Mechanism of nanoparticle self-deposition during nanosecond laser ablation of copper.



Liwei Chen is engaged in research on laser materials processing and advanced manufacturing. His research interests include ultrafast laser–matter interaction, laser micro/nanofabrication, additive manufacturing, and in situ characterization of dynamic processes. His work focuses on understanding fundamental mechanisms in laser processing and developing advanced manufacturing approaches with improved precision, stability, and controllability.

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Theme 1: Optics, Photonics and Optoelectronics

Novel Two-Dimensional Material-Based Optoelectronic Transistors for Intelligent Vision

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Abstract: To meet the growing demands for low-power, highly sensitive, and intelligent machine vision, we have developed novel optoelectronic transistors and photon-controlled devices based on two-dimensional materials. Inspired by the adaptive mechanisms of biological vision, new device concepts based on dual-capacitor charge coupling, photo-controlled barrier modulation, and photosensitive heterostructures have been demonstrated. The dual-capacitor phototransistor enables both static and dynamic vision sensing, achieving high infrared sensitivity and ultralow-power dynamic vision detection. A photon-controlled diode further enables optical control of the rectification state, together with multifunctional photomemory and optical signal processing. In addition, a bioinspired phototransistor with tunable sensitivity enables highly sensitive detection of low-contrast targets while effectively suppressing noise. These results demonstrate the potential of two-dimensional-material-based optoelectronic transistors for integrating light sensing, signal preprocessing, and memory, providing new opportunities for low-power and intelligent machine vision systems.



Dongming Sun is the Director and a Professor at the Energy Information Materials and Devices Research Department, Institute of Metal Research, Chinese Academy of Sciences (CAS). He is a recipient of the National Science Fund for Distinguished Young Scholars and a Ph.D. supervisor at the School of Materials Science and Engineering, University of Science and Technology of China. He previously worked as a postdoctoral researcher at Tokyo Institute of Technology and Nagoya University in Japan. His research focuses on advanced semiconductor and optoelectronic devices, with particular interests in (1) carbon-based electronic devices; (2) semiconductor devices based on low-dimensional materials; (3) flexible electronic devices; and (4) thermoelectric cooling devices. His work aims to develop novel materials, device architectures, and technologies for next-generation electronics and intelligent information systems.

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Theme 1: Optics, Photonics and Optoelectronics

Transformation of confined-space photonics into industrial-level applications

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Abstract: Our research interests are mainly focused on the light-matter interactions in the forms of nonlinear light absorption, light coupling into 2D materials and wave-guiding, polaritonic manipulation as well as the transformation of confined-space photonics into industrial-level applications. This talk will give an overview of photonic and optoelectronic applications based on these optical phenomena in 2D materials.[1-4] To overcome the limit light absorption in graphene and obtain large nonlinear optical modulation, we developed a serial of new saturable absorbers based on graphene heterostructures and other 2D materials.[5,6] To enhance the light modulations associated with plasmonic or polaritonic excitation, graphene and other 2D materials were reconstructed into patterns, in-plane or vertical heterostructure, and 3D network. [7-9] We not only observed anisotropic and ultra-low-loss polariton in the natural vdW material α-MoO3, but also demonstrated how the interlayer twist magic angle was applied to delicately manipulate the polaritonic transformation in α-MoO_3 thin slabs.[10,11] As the demonstration of principle of concept, industry level ultrafast laser was built and direct laser writing was used to reconstruct 2D materials into flat optical devices such as Fresnel lens, grating and meta-hologram.[12-13] Recently, a biaxial van der Waals canalization lens was fabricated for non-destructive nanoelectronic circuit imaging and inspection with a record high resolution.[14-16] Lastly, we will show off our latest progress on the commercialization of industrial-scale laser processing of battery electrodes as well as semiconductor components.



Dr. Qiaoliang Bao received his Ph. D degree from the Department of Physics, Wuhan University in 2007. Dr. Bao served as a postdoctoral fellow at Nanyang Technological University and the National University of Singapore from 2007 to 2012. He was awarded the ARC DECRA in 2012 and Future Fellowship in 2016. From 2012 to 2019, he held positions as Senior Lecturer and later Associate Professor at Monash University. During this period, he also served as one of the lead Chief Investigators of the ARC Centre of Excellence FLEET. With over 280 refereed journal publications, Dr. Bao has accumulated more than 56,000 citations and achieved an H-index of 107 (Google Scholar). He has been recognized as a Highly Cited Researcher (HiCi) by Clarivate Analytics from 2018 to 2024 and one of the World's Top 2% Scientists by Standford/Elsevier from 2021 to 2026. His research focuses on confined-space light–matter interactions, including nonlinear absorption in 2D materials, light coupling into 2D structures, polaritons in van der Waals crystals, and transformation optics via laser writing. In 2021, he founded a spin-off company dedicated to advancing industrial-scale precision laser processing of soft or hard and brittle functional materials.

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Theme 1: Optics, Photonics and Optoelectronics

Defect-Engineering in Low-dimensional Materials for Bioinspired Neuromorphic Vision Sensors

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Abstract: Bioinspired neuromorphic vision sensors, mimicking a biological retina, revolutionise edge computing by streamlining data processing and reducing energy consumption.[1] By emulating retinal photoreceptor and bipolar cells, these sensors convert light into electrical signals, extracting image features in a simple on/off framework. The dynamic photoresponse mimics information flow in bipolar cells by amplifying target signals through positive responses while suppressing irrelevant features through negative responses.

Two-dimensional black phosphorus (BP) exhibits broadband photodetection due to its high hole mobility and direct bandgap.[2] However, its tendency to spontaneously oxidise under ambient condition creates defects, altering its optoelectronic characteristics.[3] Interestingly, we have exploited defect engineering in two-dimensional materials as a pathway to create new functionalities for optoelectronic neuromorphic applications. Our research utilises self-propagating defects in BP to generate unique wavelength selective bipolar photoresponse.[4,5] We observed a defect-induced photoresponse in BP devices, where optical excitation with nonpolarized 365 nm light reduces conductivity (i.e., generating a negative photoresponse), while exciting the same device with 280 nm light increases conductivity (i.e., generating positive photoresponse). This opposing photoresponse, without applying an alternating-polarity bias at gate terminal of the device, enables the realisation of bioinspired neuromorphic vision sensors. By harnessing the defect-engineered photoresponse of BP, we can mimic photoreceptor and bipolar cells in the biological retina, unlocking efficient in-sensor memory and data processing for applications like feature extraction, pattern recognition, and motion tracking. This breakthrough paves the way for innovative neuromorphic vision sensors, transforming robotics, security, and automation.



Dr Taimur Ahmed is a Lecturer of Electronic Engineering at the RMIT University of Australia. He completed his PhD in 2018 from RMIT University and was awarded the Victoria Fellowship 2020 in Physical Sciences. His work focuses on low-dimensional materials and bio-inspired nanodevices for neuromorphic and sensing applications. Dr Ahmed has authored more than 70 high-impact journal articles, holds five international patents and his research outcomes have been featured widely in international electronic and print media. He has established new device concepts in electronic memory and atomically thin optoelectronic synapses that integrate sensing, memory and computation at the material level, advancing the development of scalable hardware for next-generation artificial vision and neuromorphic systems.

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Theme 1: Optics, Photonics and Optoelectronics

Low-dimensional antimonide and optoelectronic devices

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Abstract: Low-dimensional semiconductor optoelectronic materials are the core of the research on next-generation information materials. The construction of one-dimensional GaSb nanowires, on the one hand, is able to develop the next-generation high-performance room temperature infrared detectors. On the other hand, it can fabricate the new integrated circuits. Many research groups are devoted to the development of high-performance GaSb nanowire optoelectronic devices. However, the performance of the devices is still confined to low hole mobility. First, the "surfactant effect" of the antimony element would cause serious disordered radial growth, resulting in uncontrollable diameter of GaSb nanowires, rich surface states and low mobility. Next, GaSb nanowires have rich crystal structures and different polarities., contributing to uncontrollable carrier scattering, carrier concentration and uniformity of mobility. In the end, the association between mobility and photodetection performance is still unknown experimentally. To solve these scientific difficulties, Zai-xing Yang conducts the researches based on "precisely controlling the surfactant effect of antimony element", "regulating carrier transport properties" and "regulating the surface state of nanowires" for a long term. In a word, he aims to solve the physical problems during the settlement of low-dimensionalizing antimonide into nanowire structures and strives to lead the development of a next-generation ultrafast infrared detection technology and high-speed integrated circuits.



Zai-xing Yang is a full professor of School of Physics at Shandong University, China. His research interest mainly focuses on the controlled fabrication of low-dimensional semiconductors for electronic and optoelectronic device applications, including field-effect-transistors, CMOS invertors, photodetectors, and photovoltaic devices. He has published 112 SCI papers so far, including Nat. Commun., PNAS, Nano Lett., ACS Nano, Adv. Funct. Mater. and so on.

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ICNASA 2026 Keynote & Oral Speakers

Theme 1: Optics, Photonics and Optoelectronics

Laser-induced Plasmonic Nanostructures for Optical Storage in Disordered Crystals

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Abstract: Heterostructured nanointerfaces, formed by integrating ordered nanoparticles with non-plasmonic functional materials, hold substantial potential for a wide range of applications. However, their development remains constrained by the absence of flexible and scalable fabrication methods. In this study, we present a two-step top-down approach for constructing plasmonic architectures within neodymium-doped disordered crystals, enabling optical data inscription and encryption. The fabrication process begins with ion implantation to introduce nanoparticle precursors into the subsurface region of the crystal. Subsequently, femtosecond laser-induced nonlinear near-field optical forces drive the redistribution of these nanoparticles along the laser propagation path, leading to the formation of ordered three-dimensional nanoshell structures. By precisely tuning the laser irradiation power, the resonance modes of the hybrid system can be modulated, thereby enabling controlled upconversion luminescence in rare-earth-ion-based plasmonic structures. This method supports versatile multifunctional optical applications, including data storage, encryption, and fluorescence/photoluminescence readout. Overall, this work establishes a general strategy for tailoring plasmon-enhanced optical responses in rare-earth-doped crystalline materials, offering promising prospects for optoelectronic applications as well as passive and active optical control.



Bo Wu received his Ph.D. degree from Shandong University in 2025. After his Ph.D., he worked as a postdoctoral researcher in the State Key Laboratory of Crystalline Materials, School of Physics, Shandong University. He has been awarded the China Postdoctoral Science Foundation and Shandong Postdoctoral Science Foundation. His research interests include femtosecond laser micro/nano fabricated structures, ultrafast dynamics of ultrafast laser interaction with dielectric materials, and non-hermitian topological laser systems.

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Theme 1: Optics, Photonics and Optoelectronics

Plasmonic modified photoresponse in ferroelectrics

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Abstract: Ferroelectric photodetectors have attracted growing interest in recent years owing to their self-powered operation, robust environmental stability, and inherent polarization-driven photoresponse, making them particularly attractive for applications in optical communication, remote sensing, and smart imaging systems. However, their spectral response is often constrained by the intrinsic bandgap of ferroelectric materials, and the relatively slow thermal diffusion dynamics typically limit the achievable response speed. This work uses low-energy ion implantation to construct a plasmonic-ferroelectric hybrid structure in dielectric/ferroelectric substrates, leading to a substantial enhancement of the pyroelectric response. The implanted metal ions aggregate into embedded plasmonic nanoparticles within the crystal lattice, and the resulting localized surface plasmon resonance strongly confines the incident optical field to the near-surface region. This field localization promotes efficient local photothermal conversion, which in turn triggers a transient temperature modulation of the ferroelectric matrix and gives rise to a pronounced pyroelectric polarization change. Benefiting from this synergistic mechanism, the detector delivers an ultrabroadband response from 261 to 4000 nm and a fast rise time of 39.7 μs, among the quickest reported so far, while maintaining stable performance over more than one year. High-resolution imaging tests further demonstrate its capability for contour feature recognition, pointing to the promise of ion beam techniques in future optical sensing and imaging systems. From a broader perspective, this study validates ion implantation as a nuclear-physics-based approach that enables controllable engineering of light-matter interactions, offering a viable pathway toward high-performance photodetectors



Xiaoli Sun was born in Shandong province, China, in 1993. She received the degrees of Bachelor of Science and Doctor of Science (PhD) from Shandong Normal University in 2015 and Shandong University in 2020, respectively. After she finished her doctoral dissertation she stayed at Shandong University as a L Supervisor of master's students. She is currently a Professor and a Supervisor of master's students at School of Physics, Shandong University, China.

Her principal research interest lies on the study of material modification induced by electron energy loss and nuclear energy loss, as well as the fabrication of the novel metallic composite nanoparticles and their application in optical field. She has more than 50 papers published in peer-reviewed journals including Adv. Funct. Mater., ACS Nano, Small and Adv. Opt. Mater.

Theme 2

Solar Energy Harvesting and Photo Detection

Theme 2 : Solar Energy Harvesting and Photo Detection

Understanding Carbon Based Perovskite Solar Cells

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Abstract: Metal halide perovskites have revolutionized the conventional perception of excellent semiconductors due to their unique electronic, chemical, physical and optical properties, which have opened doors for many applications. A classic example of perovskites' applications is photovoltaic solar cells, which convert sunlight directly into electricity. Despite the great advancements, the commercialization of perovskite solar cell technology is limited due to the issues associated with the stability of perovskite in ambient conditions and heat. Carbon back electrode-based hole transporting materials free (HTM-free) and metal-free perovskite solar cells gained much interest due to their low manufacturing cost and excellent stability. Although carbon-based perovskite solar cells have been around for a while and studied over a decade, the efficiency and stability trends over time in different testing conditions remained to be further explored. In this talk, I will present our recent work focused on understanding the efficiency and stability changes of carbon-based perovskite solar cells in various testing conditions and will discuss their kinetics.



Dr. Batmunkh received his PhD degree from the School of Chemical Engineering at the University of Adelaide in 2017. Dr. Batmunkh is currently an Australian Research Council (ARC) Future Fellow (2026-2030) in the School of Environment and Science at Griffith University and leads an active independent research group working on functional materials, solar cells, detectors and their integrated systems. He is a former ARC DECRA fellow (2022-2025). Dr Batmunkh is a QLD 2025 Young Tall Poppy.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Exciton and Charge-Carrier Dynamics in Organic Solar Cells Revealed by Ultrafast Spectroscopy

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Abstract: Organic solar cells convert light into electricity through a sequence of elementary steps, from exciton formation and diffusion to dissociation and charge transport. The microscopic mechanisms behind these steps still govern efficiency and stability. This talk presents our recent studies using femtosecond transient absorption and time-resolved microscopy to resolve these processes in photoactive blends. We show that sonication-induced J-aggregation in non-halogenated solvents strengthens π-π stacking, delocalizes excitons, and suppresses molecular vibration, accelerating charge separation. Modulated insulator dilution suppresses exciton-vibration coupling and extends exciton diffusion, and a critical-length criterion links local carrier hopping to macroscopic transport in thick films, supporting 19% efficiency. On stability, we identify radical generation in polymer donors as the main cause of photo-degradation, and we show that an effective-elastomer-density parameter governs the interplay among morphology, carrier dynamics, and mechanical response in stretchable blends. We further demonstrate that external electric fields reorient acceptor dipole moments, improving photoconversion in organic photovoltaics. These results deepen the mechanistic understanding of photoconversion and degradation in organic semiconductors and guide the design of more efficient, stable devices.



Hao Xiaotao is a Professor at Shandong University. He is a Fellow of the Institute of Physics and a Fellow of the Royal Society of Chemistry. He has been awarded Distinguished Taishan Scholar of Shandong Province. His research focuses on organic semiconductor physics, organic photovoltaic and photodetector devices, as well as ultrafast spectroscopy and microscopy. He has published over 300 papers in journals including Advanced Materials, Science Advances, Nature Communications and National Science Review with more than 19,000 citations and an h-index of 69. He holds 10 patents, and has delivered over 60 keynote and invited talks at domestic and international conferences. He currently serves as Regional Vice President of the Thin Films Society, Standing Director of multiple academic societies, Associate Editor of Chinese Journal of Chemistry and Editorial Board Member of ChemPhysMater. He served on organizing committees of several major international conferences and held academic positions in Shandong Physical Society. His honors include the Shandong Provincial Natural Science Award, Asia-Oceania Photochemistry Association Award, and multiple prestigious teaching awards.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Advanced Manufacturing Strategies for Scalable Perovskite Solar Cells

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Abstract: The transition of perovskite solar cells from laboratory-scale demonstrations to practical photovoltaic technologies requires advanced manufacturing strategies that integrate efficiency, stability, reproducibility and sustainability. This work presents a manufacturing-oriented approach to perovskite solar cell development, focusing on how materials chemistry, process design, characterisation and data-driven optimisation can be combined to improve device performance and manufacturability. Rather than treating materials development, device fabrication and performance analysis as separate steps, this approach links them within a unified framework for understanding and controlling the key factors that govern film formation, interfacial quality, process reliability and long-term stability.

Particular emphasis is placed on sustainable solution processing, scalable fabrication and processaware characterisation as essential components of next-generation perovskite manufacturing. Advanced analytical methods provide feedback on material quality, device behaviour and degradation pathways, while machine-learning-assisted analysis offers new opportunities to accelerate optimisation, identify critical processing parameters and strengthen process control. By connecting fundamental materials understanding with practical manufacturing requirements, this work highlights how advanced manufacturing can support the development of high-performance, reliable and scalable perovskite photovoltaic technologies.



Dr. Jincheol Kim is a Research Fellow at the School of Engineering, Macquarie University, and a Visiting Fellow at UNSW's School of Materials Science and Engineering. He received his Ph.D. from UNSW, specialising in large-area perovskite solar cells. His research covers organic–inorganic hybrid materials, solution chemistry, and scalable thin-film manufacturing. He currently leads a commercialisation project on green solvent-based perovskite modules and previously led tandem device development at the Korea Electronics Technology Institute. Dr. Kim is actively leading international collaborative research between Korea and Australia and has contributed to multiple national research programs. His work bridges materials science and device engineering, advancing stable and high-efficiency solar technologies.

Theme 2 : Solar Energy Harvesting and Photo Detection

Copper tungstate photoanodes with enhanced solar water splitting performance

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Abstract: Ternary metal oxides have attracted growing interest as alternative photoanode materials for photoelectrochemical (PEC) water splitting, offering a broader compositional and electronic design space than their binary counterparts. Among these, copper tungstate ($CuWO_4$) stands out for its chemical stability, favourable bandgap and promising theoretical performance, yet its fundamental chemistry and the levers available to control it remain comparatively underexplored, a gap we have addressed both experimentally and through a recent review of the field.

Here, we present a comprehensive investigation into the fabrication, fundamental chemistry, and performance optimisation of $CuWO_4$ photoanodes, employing two complementary deposition routes, spin coating and ultrasonic spray pyrolysis, to build a holistic understanding of the structure-property relationships governing this material. Through systematic control of solution chemistry, we reveal the interconnected roles of solvent composition and citric acid complexation in dictating precursor reactivity, film porosity and uniformity.

Spectroscopic analysis further uncovers an intrinsic and unusual electronic feature of $CuWO_4$: copper adopts an oxidation state exceeding +2, consistent with Cu3+ character, compensated by a corresponding reduction in the effective oxidation state of tungsten below +6. This subtle internal charge redistribution, observed consistently across distinct fabrication routes, points to a fundamental structural feature of the material rather than an artefact of any single synthesis method.

Extending this understanding, we demonstrate how deliberate intervention, through reductive annealing, aliovalent doping at both the Cu and W lattice sites, surface stoichiometry correction, and molecular cocatalyst integration, can be used to systematically tune the defect landscape, charge transport and interfacial reactivity of CuWO4. Each strategy is examined not only for its effect on PEC performance, but also for the mechanistic insight it offers into the underlying material chemistry.

This research positions copper tungstate as a rich and instructive platform for exploring structure-property relationships in ternary metal oxide photoanodes, offering both practical fabrication strategies and fundamental chemical insights to guide the broader design of next-generation PEC materials.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Two-Dimensional Materials: From Controlled Growth to Solar Energy Harvesting and Conversion

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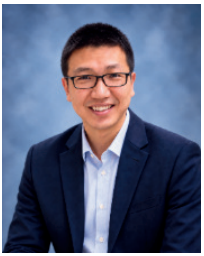
Abstract: Two-dimensional (2D) materials provide a useful platform for tuning electronic, optical, thermal and transport properties through control of their structure, composition and interfaces. Here, we present our work on the controlled synthesis and interface engineering of 2D materials, with a focus on how growth, phase transformation and interfacial structure affect energy and mass transport.

Our studies include the controlled growth and etching of monolayer hexagonal boron nitride (h-BN), as well as the conversion of layered transition-metal chalcogenides into ultrathin transition-metal nitrides and chalcogenide-nitride heterostructures. Control over nucleation, phase conversion and interface formation allows the morphology, crystal phase and interfacial structure of these 2D systems to be tuned.

The resulting materials show tunable optical, electronic and thermal properties and have been explored for photothermal energy conversion, solar-driven water evaporation, and ion and water transport. In these systems, the interfaces play an important role in regulating heat transfer, charge transport and interactions between water and the material surface.

These studies demonstrate that combining controlled synthesis with phase and interface engineering provides a practical route to tune energy and mass transport in 2D materials and related heterostructures.



Dr Lifeng Wang is an ARC Future Fellow and Research Fellow in the School of Science at RMIT University. His research focuses on the controlled synthesis of two-dimensional materials, transition-metal nitrides and heterostructures, interface engineering, and their applications in energy conversion, water transport and functional materials.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Innovative glasshouse films to reduce energy use and increase resource use efficiency and productivity

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Abstract: The Smart Glasshouse Films project is testing two glasshouse films to reduce energy use, increase resource use efficiency and improve crop performance in protected cropping. One film shifts green and yellow light to red light (Light Shifting Film; LLEAF, Sydney) to increase photosynthesis and productivity, while the other film is a radiative cooling film (RCF) developed by Innofocus (Melbourne) to reduce energy use. Unlike conventional heat-blocking materials, the radiative cooling film doesn't reduce light transmission. Instead, it lets heat escape more efficiently through the atmosphere's 'radiative cooling window' (the 8–13 µm wavelength range), keeping glasshouses cooler while maintaining high light levels for crop growth. This project is a collaboration between Western Sydney University, RMIT, glasshouse film producer Innofocus, SME partner LLEAF, and grower-owned research and development corporation Hort Innovation. These films retrofit existing glasshouse structures rather than requiring new builds, so they offer growers a lower-cost pathway to reduce energy costs and emissions, while maintaining or increasing yield and quality. Current efforts are focused on detailed energy use, nutrient and water use, return-on-investment, quality of produce and productivity, and the development of a digital twin at RMIT and Western Sydney University. A major objective of the project is to demonstrate a practical, near-term technology pathway for reducing the protected cropping sector's energy footprint.

Distinguhed Professor **David Tissue** is a plant physiologist working on crop and native plants. His research focuses on plant response to variable environments, including temperature, nutrients, water and extreme climate events. He is the Director of the National Vegetable Protected Cropping Centre where this research is conducted.

Theme 2 : Solar Energy Harvesting and Photo Detection

Spectral Signatures of Singlet Fission Intermediates of Solid-State TIPS-Pentacene

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Abstract: TIPS-pentacene has been extensively researched over the past decade in terms of its photophysical properties due to its high initial singlet fission (SF) quantum yield (~100% $S_0S_1 \rightarrow {}^1(TT)$ conversion efficiency [1]), excellent photostability, and good solubility in a range of solvents. These properties make this molecule highly competitive for photovoltaic and optoelectronic applications. While the excited-state dynamics of TIPS-pentacene have been well characterised in solutions, nanoparticles, and films with varying morphologies, inconsistencies still exist in the analysis of ultrafast transient absorption data. In most cases, the extracted kinetic parameters and species-associated spectra depend on the model selected, while overlapping spectral features in the visible probe range create significant difficulties in resolving the dynamic mixtures of ${}^1(TT)$, ${}^1(T\ldots T)$, and separated triplet (T) states, with forward SF and reverse triplet–triplet annihilation (TTA) occurring simultaneously. In this work, we utilise the extended spectral information provided by the mid-infrared probe to facilitate the distinction of excited-state absorption features associated with the two different triplet-pair states and the free triplet. A complete kinetic scheme is used to analyse the transient absorption data obtained across multiple spectral regions, incorporating all reversible steps and additional non-radiative decay pathways from the correlated triplet-pair ${}^1(TT)$ state. This comprehensive experimental and global analysis scheme is applied to spin-cast TIPS-pentacene films with different morphologies (as-cast, thermally annealed, and solvent-annealed). We find that the formation of crystalline structures suppresses the decorrelation of the ${}^1(TT)$ state, while morphological disorder, as a consequence of domain-boundary formation, greatly hinders the spatial separation of the ${}^1(T\ldots T)$ state into free triplets.



Xinyue Xu is a PhD candidate in Chemistry, supervised by Prof. Trevor Smith and Dr Christopher Hall at the Ultrafast Microspectroscopy Laboratory at the University of Melbourne (UoM). She completed a BSc and an MSc, majoring in Physics and Chemistry, respectively, at UoM. Her current research focuses on the development and application of advanced ultrafast spectroscopic techniques, including temperature- and magnetic-field-dependent transient absorption and transient infrared spectroscopy, to study photovoltaic and singlet-fission materials.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Interfacial Passivation for Efficient Hole Transporting Materials Free Carbon-Based Perovskite Solar Cells

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Abstract: Perovskite solar cells (PSCs) have attracted considerable attention as a next-generation photovoltaic technology owing to their high-power conversion efficiency (PCE) over the past decade.[1] Despite their high photovoltaic performances, they suffer from long-term stability in ambient conditions, while also using precious metal (e.g. Au) and organic hole transporting materials. Carbon-based electrodes are promising candidates because of their low cost, hydrophobic nature, and excellent chemical inertness, which can contribute to enhanced device stability.[2] However, hole-transport-layer (HTL) free carbon-based PSCs still suffer from relatively poor efficiency mainly due to severe interfacial charge recombination at the perovskite/carbon interface.

In this work, a 4-fluorobenzylammonium bromide (4-FBABr) interfacial passivation layer is introduced onto the perovskite surface to improve the performance of HTL-free carbon-electrode PSCs. The optimised 4-FBABr-passivated device achieved a champion PCE of 17.14%, with V_{oc} of 1.04 V, J_{sc} of 23.33 mA cm^{-2}, and FF of 70.27%. In contrast, the reference carbon-based device showed a PCE of 15.37%, with Voc of 1.03 V, Jsc of 23.27 mA cm^{-2}, and an FF of 63.98%. Importantly, both the passivated and control devices showed no degradation in the performance after one month of storage in ambient conditions. Electrochemical impedance spectroscopy measurements further confirmed the beneficial role of 4-FBABr passivation, as the passivated device exhibited a significantly higher recombination resistance of 78 kΩ compared to 33 kΩ for the control device. This increased recombination resistance indicates that the 4-FBABr layer effectively suppresses non-radiative recombination at the perovskite/carbon interface and the enhanced fill factor.



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Theme 2 : Solar Energy Harvesting and Photo Detection

Scalable Fabrication of Organic and Perovskite Solar Modules

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Abstract: Scaling solution-processed organic and perovskite photovoltaics requires effective control of film formation, interfaces and processing conditions. This presentation introduces our recent progress towards efficient solar modules through coating-process regulation, interface engineering and flexible manufacturing. For organic photovoltaics, solid additives improve film uniformity and suppress excessive acceptor aggregation during blade coating, reducing efficiency losses upon scale-up. Solvent-bath thermal annealing enables processing in air while preserving device performance, yielding a certified module efficiency of 16.75% over a 19.84 cm^2 aperture area. A modular roll-to-roll platform enables independent optimization of slot-die coating and laser patterning. For perovskite photovoltaics, bimolecular amine vapour passivation and molecular contact engineering improve interface quality and device stability. Buried-interface crystallinity control further enables blade-coated modules with 25.36% efficiency over an 18 cm^2 aperture area. These advances link materials and interface engineering with scalable fabrication of organic and perovskite solar modules.



Weifei Fu received his B.S. and Ph.D. degrees from Zhejiang University in 2010 and 2015, respectively. He conducted postdoctoral research with Prof. Alex K.-Y. Jen at the University of Washington and Prof. Michael Saliba at TU Darmstadt. He is currently a researcher at Zhejiang University-Hangzhou Global Scientific and Technological Innovation Center. His research focuses on the scalable manufacturing of large-area organic and perovskite photovoltaics.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Fluorescence brightening up to 150°C and seconds-long delayed fluorescence in dye-doped zeotypes

Yazhuo Wang[1], Rebeca Sola-Llano[2], Luis Gómez-Hortigüela[3], Joaquín Pérez-Pariente[3], Jialu Li[4], Virginia Martínez-Martínez[2], and James A. Hutchison[1,*]

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Abstract: Ultra-tight confinement of dyes in nanocavities can lead to drastic changes in photophysical behaviour. In this work, we show that confinement of acridine dyes within rigid inorganic zeotype hosts enables ultralong-lived delayed fluorescence in air and pronounced fluorescence brightening at temperatures up to 150°C, despite the intrinsically inefficient delayed fluorescence properties of the non-encapsulated chromophores. Acridine orange (AO) and acridine yellow (AY) will be focused on, and their incorporation into the micropores (6.5 × 4.0 Å) of a Mg-doped aluminophosphate zeolite analogue. The combination of spatial confinement, and local dye-host interactions, suppresses aggregation, restricts molecular motion, and mitigates collisional and oxygen quenching. Time-resolved spectroscopy reveals visible room-temperature delayed fluorescence over several seconds (Fig. 1). Thermally activated delayed fluorescence (TADF) is the likely mechanism, despite a very large energetic barrier (>0.3 eV). A pronounced fluorescence brightening from ambient temperature up to 150 °C in air highlights the potential of these materials for optical thermometry and high-temperature luminescent applications.

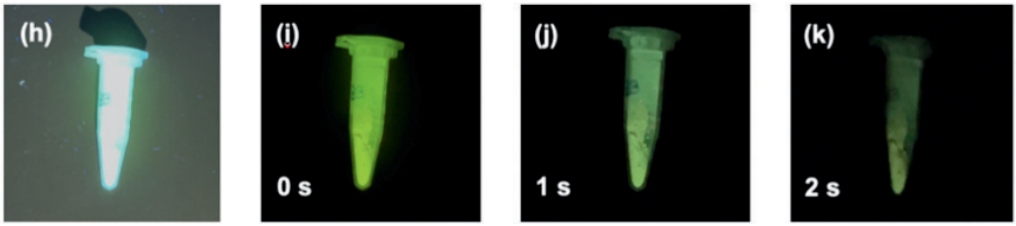

Figure1: *Photographs of the delayed fluorescence of an acridine yellow guest/ Mg-doped aluminophosphate zeolite analogue host, for several seconds after UV flashlight irradiation.*



James Hutchison is a physical chemist with research interests in light-to-chemical energy conversion and trace molecular optical sensing using nanomaterials. He has held ARC fellowships (Future Fellow, DECRA), CNRS tenure (Chargé de Recherche, Première Classe), and was a CI on the ARC Centre of Excellence in Exciton Science. He has made foundational contributions to the field of Polaritonic Chemistry, the study of the physicochemical properties of hybrid light-matter states, and is a co-founder of QDT Ink Pty Ltd, a start-up developing shortwave infrared optoelectronics using Quantum Dots. He is currently an Associate Professor at the School of Chemistry, University of Melbourne.

Theme 2 : Solar Energy Harvesting and Photo Detection

Cryogenic Cathodoluminescence Reveals Defect-State Regulation in Wide-Bandgap Kesterite Solar Cells

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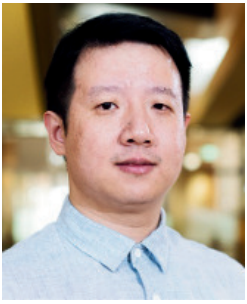
Abstract: Wide-bandgap Cu_2ZnSnS_4 (CZTS) is an attractive earth-abundant absorber for tandem photovoltaic applications, but its performance is limited by substantial open-circuit voltage losses associated with compositional inhomogeneity, secondary-phase formation and defect-mediated recombination [1]. Here, we present a characterization-led investigation of how precursor chemistry influences the early-stage evolution and optoelectronic properties of CZTS absorbers. Cryogenic cathodoluminescence (cryo-CL) measurements at 85 K reveal a pronounced injection-dependent evolution of the emission spectra. Both reference and optimized absorbers exhibit two emission components, indicating contributions from distinct recombination pathways [2]. However, the optimized absorber displays a stronger high-energy emission component and detectable luminescence at lower electron-beam excitation currents, consistent with reduced non-radiative recombination. Its emission peak also shifts more rapidly with increasing injection level, suggesting a lower density of localized states that become progressively filled as the carrier generation rate increases. To correlate these optical signatures with the underlying material properties, Raman spectroscopy, X-ray photoelectron spectroscopy, time-of-flight secondary-ion mass spectrometry, transmission electron microscopy with energy-dispersive X-ray mapping, and time-resolved photoluminescence were employed. The combined results indicate that precursor modification suppresses Cu out-diffusion and the formation of Cu–S-rich secondary phases, thereby maintaining a more uniform local chemical environment during crystallization. The cryo-CL response provides important insight into the relationship between early-stage local chemistry, defect-state distribution, carrier localization and radiative recombination. This work demonstrates the potential of cryo-CL, supported by complementary multiscale characterization, for resolving defect-mediated voltage losses and guiding the development of high-performance wide-bandgap multi-nary photovoltaic materials.



Dr Jialiang Huang is a Senior Lecturer and Research Fellow at UNSW specialising in thin-film solar-cell technology. His research focuses on micro-to-atomic-scale materials characterisation and efficiency optimisation of emerging photovoltaic devices, contributing to several world-record efficiencies. He employs advanced electrical and microstructural characterisation techniques to identify efficiency-limiting mechanisms, bridging fundamental materials understanding with practical device applications. Dr Huang has authored more than 110 high-impact publications, which have received over 7,800 citations, and has an H-index of 44. He holds three patents in chalcogenide photovoltaics and has a Field-Weighted Citation Impact of 3.21. Most of his publications appear in Q1 journals, including Nature Energy, Nature Photonics, Advanced Energy Materials and Advanced Materials, with seven recognised among ESI Top 1% highly cited papers. He has served as Lead CI and CI on projects securing more than $10 million in competitive research funding. He has also established extensive national and international collaborations, supervised multiple PhD students and presented his research at leading international conferences.

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ICNASA 2026 Keynote & Oral Speakers

Theme 2 : Solar Energy Harvesting and Photo Detection

Water-Driven Energy and Information Flow for Nano-Bio Intelligence

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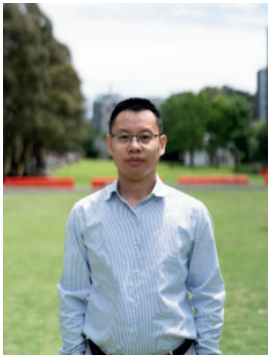
Abstract: Nature relies on water not only as the medium of life but also as a dynamic carrier of both energy and information. Inspired by biological systems, this presentation introduces a new nano-bio intelligence paradigm based on water-driven energy and information flow, where ionic transport and ion–electron coupling simultaneously enable energy harvesting, sensing, memory, and intelligent signal processing within a unified materials platform.

This talk presents our recent advances in nanoionic materials and devices that bridge the traditionally separate functions of power generation and information processing. Long-lasting moisture electric generators continuously harvest electricity from ambient humidity, providing sustainable power for battery-free systems. Nanoionic synaptic devices exploit ion migration and interfacial ion-electron coupling to emulate biological synaptic plasticity with ultralow energy consumption, enabling adaptive learning and neuromorphic perception. By integrating moisture energy harvesting, wearable sensors, stretchable energy storage, and neuromorphic processors, we establish self-powered intelligent systems capable of continuous physiological monitoring and autonomous decision-making.

These studies establish a unified framework in which water actively orchestrates both energy and information flow through nanoionic materials. By integrating energy harvesting, sensing, memory, and computation into a single ion-mediated platform, this work opens new opportunities for sustainable nano-bio intelligence in wearable healthcare, autonomous robotics, and next-generation Internet of Things technologies.



Chu is a full professor and ARC Mid-career Industry Fellow at School of Materials Science and Engineering, UNSW Sydney. His research is focused on water enabled energy conversion, storage, and information storage materials for wearable devices.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Rethinking Exciton Dissociation in Two-Dimensional Perovskites: Beyond Edge State Mechanism

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Abstract: Although two-dimensional (2D) perovskites are widely regarded as strongly excitonic materials, persistent free carrier signatures observed experimentally remain difficult to reconcile with this picture. The commonly invoked edge-state-assisted dissociation mechanism provides a possible explanation, but it is fundamentally limited by exciton diffusion. Here, we re-examine exciton dissociation in 2D perovskites and show that the widely invoked edge-state-assisted mechanism is fundamentally constrained by exciton diffusion and cannot readily account for dominant free carrier behavior in typical micron-scale crystals or ultrafast free carrier generation on picosecond timescales. These observations suggest the presence of an intrinsic dissociation pathway operating throughout the bulk. We propose that nonequilibrium lattice energetics, described within a lattice energy reservoir (LER) framework, provide a plausible driving force for intrinsic exciton dissociation. Experimental evidence for long lived lattice energy storage further supports the physical basis of this picture. A dual channel framework is proposed in which intrinsic lattice energy driven and extrinsic edge-state-assisted pathways coexist, offering a unified perspective on exciton dissociation in 2D perovskites.



Dr Junlin Lu received his PhD from RMIT University. His research interests focus on understanding the optoelectronic properties and carrier dynamics of semiconductor materials, particularly metal halide perovskites and photocatalytic materials, using a range of advanced optical characterisation techniques. His expertise includes steady-state and time-dependent photoluminescence (PL) spectroscopy, time-resolved photoluminescence (TRPL) spectroscopy, and transient absorption (TA)spectroscopy, with a particular interest in photoexcited carrier dynamics and recombination processes.

Theme 2 : Solar Energy Harvesting and Photo Detection

Photo-modulation of Ion Distribution in Metal Halide Perovskites

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Abstract: Metal halide perovskites (MHPs) have emerged as leading semiconductors for the next generation of solar cells, light-emitting devices, and photodetectors. A critical requirement for many optoelectronic applications is the ability to tune the semiconductor bandgap. In MHPs, this is achieved by controlling the halide ratio, resulting in composition-dependent mixed-halide perovskite species. However, bandgap instability—driven by light-induced phase segregation—presents a major challenge for their future commercialization.

This talk will present our recent findings on the microscopic mechanisms of how photoexcitation impacts the distribution of halide species within single-crystalline mixed-halide perovskite microplatelets.
Key topics include:

- **Insight into Segregation Domains**: Utilizing a combination of widefield narrowband fluorescence imaging and time-resolved fluorescence spectroscopy to uncover the nature of light-induced halide segregation domains. [1]
- **Reversibility and Bandgap Control**: Demonstrating that photoinduced halide segregation can be completely reversed at sufficiently high illumination intensities. This enables precise control over the optical bandgap of a mixed-halide perovskite single crystal by optimizing the photogenerated carrier density. [2]
- **Mechanisms in 2D Perovskites**: A detailed discussion on light-induced distributions in layered 2D perovskite materials. Through hyperspectral imaging, in situ X-ray diffraction, and first-principles calculations, we uncover a mechanism of structurally encoded, site-selective photoisomerization rather than halide segregation. This discovery offers a new strategy for reconfigurable optoelectronic devices, non-volatile optical memory, and quantum photonics. [3]

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Theme 2 : Solar Energy Harvesting and Photo Detection

A Novel Photovoltaic Concept: The Lattice Battery Solar Cells

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Centre for Atomaterials and Nanomanufacturing (CAN), RMIT University, Australia

Abstract: Halide perovskites exhibit a range of unique optoelectronic properties that defy conventional semiconductor theory. Their exotic electron dynamics span from femtoseconds to hours, and the underlying physical origins of these phenomena remain a fundamental challenge. The Lattice Energy Reservoir (LER) theory explains how electron-lattice synergistic interactions[1], specifically the storage of phonon energy and its subsequent delayed feedback, fundamentally alter electron dynamics across these timescales.

Building upon the LER theoretical framework, we propose a novel photovoltaic concept: the Lattice Battery Solar Cell. Unlike conventional photovoltaics, which rely on a single energy conversion pathway, this design establishes an additional energy conversion channel by facilitating the storage of phonon energy in the lattice and its delayed feedback into the electronic system. This approach fundamentally eliminates energy losses associated with hot phonons and the non-absorption of sub-bandgap photons, thus a theoretical efficiency exceeding 70%, far surpassing the Shockley–Queisser limit[2]. Furthermore, its simple structure and intrinsic high stability position it as a highly competitive candidate for next-generation photovoltaic technology.



Dr Xiaoming Wen received his Bachelor's and Master's degrees from Zhejiang University and PhD from Swinburne University of Technology in 2007. He worked at the Department of Physics at Yunnan University, serving as a professor and deputy department head. He performed research at the University of Melbourne, University of New South Wales etc. on ultrafast spectroscopy and photophysics of advanced materials. Currently a Senior Research Fellow at RMIT University. He established the theory of lattice energy storage reservoirs and proposed the novel photovoltaic concept of lattice energy storage solar cells.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Molecular design and additive engineering for efficient organic solar cells

Jegadesan Subbiah

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Abstract: Organic solar cells (OSCs) are a promising technology for renewable solar energy conversion because of their solution processability, lightweight nature, flexibility, and roll-to-roll production. Novel molecular design of organic semiconducting materials and nanoscale morphology optimisation of bulk-heterojunction (BHJ) layers have led to OSC efficiencies greater than 20%. The most critical factor in rationally designing donor materials and material combinations suited for efficient OPVs is controlling absorption properties, band gap, HOMO–LUMO energy levels, solid-state packing, transport, material composition, and device processing conditions. Recently, we reported the design and synthesis of new semiconducting small-molecule materials for organic photovoltaic (OPV) devices with efficiencies over 17%. Here, we studied the effect of side-chain engineering and molecular additives on the OPV device performance. Significant efforts have been made to develop morphology optimisation methodologies to realise the full potential of photoactive materials. In this work, we have also employed a fluorine-functionalised solid additive to modulate donor-acceptor phase separation of a photoactive layer based on the semiconducting polymer (PM6) and non-fullerene acceptor (BTP-eC9). Due to the halogen bonding interaction between the additive and photoactive materials, the volatilisation of solid additives from the photoactive layer induces BHJ nanostructure rearrangement, giving larger crystalline sizes and better charge separation and transport properties in devices, resulting in the efficiency of OSC based on the photoactive layer blend (PM6: BTP-eC9) significantly increasing. In this talk, we will discuss our recent work on molecular design, additive engineering, and device optimisation approaches used to achieve high-performance OPV devices.



Dr Jegadesan Subbiah is a Senior Research Fellow at Bio21 Institute, University of Melbourne (UOM). He received his PhD in Materials Chemistry from the National University of Singapore and conducted postdoctoral research at NUS Singapore and the University of Florida, USA. His research interests include organic and perovskite solar cells, device physics of thin-film photovoltaics, nanomaterials, Renewable energy conversion and storage, solar-rechargeable batteries, and interface engineering of organic semiconductors and electrodes. Dr Jegadesan has made a significant impact in his field, with more than 120 peer-reviewed journal publications and an h-index of 42. He serves as an Editorial Board member for various scientific journals, including Scientific Reports (Nature Springer), the International Journal of Photoenergy, the Interdisciplinary Journal of Chemistry, and the Solid and Open Journal of Organic Polymer Materials. He is also a Member of the Royal Society of Chemistry (MRSC), the American Chemical Society (ACS, USA), the Materials Research Society (MRS, USA), and the Melbourne University Chemical Society (MUCS), Australia.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Illumination-Conditioned States in Soft Metal Halide Perovskites: Beyond Static Recombination Physics

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Abstract: Metal halide perovskites (MHPs) combine exceptional optoelectronic properties with an unusual susceptibility to illumination-induced changes in their electronic, ionic and structural states.[1, 2]

Yet their photophysical behaviour is still commonly interpreted using recombination pathways and material parameters that are effectively treated as static. This raises a fundamental question: does illumination simply generate carriers within an existing energetic landscape, or progressively modify the state of the semiconductor itself?

Here, we investigate how the photophysical state of MHPs evolves under sustained excitation using steady-state, excitation-power-dependent and time-resolved photoluminescence measurements. Continuous illumination progressively modifies emission intensity and recombination dynamics, accompanied by systematic evolution of the photoluminescence power-law exponent, β. Rather than behaving as a fixed signature of conventional carrier-population recombination regimes, β depends on excitation conditions and illumination history. Illumination-dark cycling further reveals partial retention of the modified photoluminescence response after excitation is removed, providing evidence that the material retains information about its prior excitation state. These observations reveal an illumination-conditioned, non-equilibrium photophysical state arising from coupling between electronic excitation and slower lattice, structural and ionic degrees of freedom.[3, 4] This framework connects photobrightening, persistent intermediate photoluminescence superlinearity, memory effects and evolving recombination dynamics within a common physical picture. More broadly, understanding how excitation energy is redistributed, retained and dissipated in soft semiconductor lattices provides a pathway towards controlling their dynamic optoelectronic response and operational stability.



Dr Mehri Ghasemi is a Research Associate at RMIT University, Australia, with a multidisciplinary background in materials science, nanotechnology and optoelectronics. Her research focuses on understanding and controlling the fundamental processes that govern the performance and stability of emerging functional materials, with particular expertise in metal halide perovskites, quantum dots and advanced optoelectronic materials. Her work spans materials development, photophysics and nanoscale characterization, with an increasing focus on non-equilibrium phenomena in soft semiconductors. She has authored more than 30 peer-reviewed publications and contributed to research across energy conversion, nanomaterials and next-generation optoelectronic technologies.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Black Phosphorus Infrared Photodiodes

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Abstract: Bulk black phosphorus (bP) has shown promise in short- to mid-wave infrared (IR) photodiodes, particularly paired with molybdenum disulfide electron contacts. Bulk bP photodiodes, with absorbers in the intermediate thickness range (10-500 nm), balance strong absorption out to λ = 4 μm, with high dynamic resistance area product R_0A, allowing demonstrations of photodiodes yielding room temperature specific detectives of $D^* \approx 10^{10}$ Jones in the mid-wave IR region. In this talk, I will present our work on a range of novel IR devices and demonstrations based on black phosphorus including computational imaging using refractive microlens integrated bP/MoS_2 photodiodes (Figure 1a and b); power generation from bP/MoS_2 thermoradiative diodes (Figure 1c); and imaging arrays based on printed bP photodetectors (Figure 1d and e).

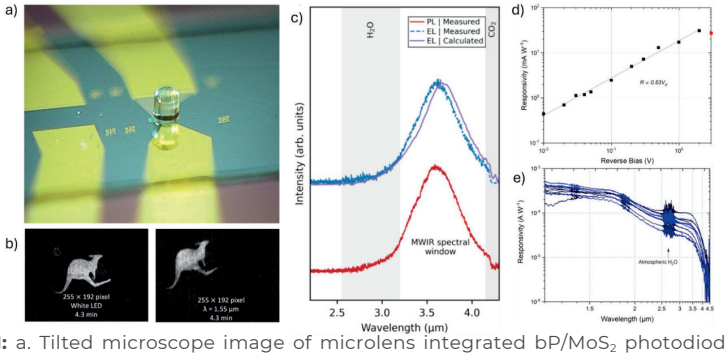

Figure1: a. Tilted microscope image of microlens integrated bP/MoS_2 photodiode. b. Computational images taken using microlens enhanced bP/MoS_2 photodiodes under visible (left) and infrared (right) illumination. c. Photoluminescence (PL) and electroluminescence (EL) of bP/MoS_2 thermoradiative diode. d. Bias dependent responsivity of ink-based bP/InO_x pixels under λ = 1.5 μm light. e. Image of ink-based bP/InO_x pixel array. Figures modified from *Vedaraj, V. V., et al., Small, e75405. 2026; Sun, J., et al., Under Review, 2026; Corletto, A., et al., In prep, 2026.*



Associate Professor James Bullock completed his PhD in Engineering, as an Australian Renewable Energy Agency Fellow, at the Australian National University. Following that he was a postdoctoral researcher in the Electrical Engineering and Computer Sciences department at Berkeley and an affiliate in the Materials Sciences Division at the Lawrence Berkeley National Laboratory. James now heads the Electronic Materials and Devices (EMaD) group in the Electrical and Electronic Engineering Department at the University of Melbourne. This group focuses on the design and fabrication of next-generation optoelectronic devices.

Theme 1: Optics, Photonics and Optoelectronics

Crystallization Engineering of Perovskite Thin Films for Photovoltaic Applications

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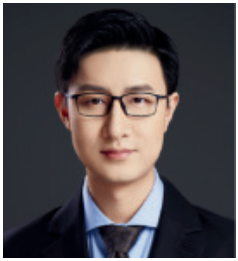
Abstract: Metal halide perovskites have emerged as one of the most promising candidates for next-generation photovoltaics. In particular, wide-bandgap perovskites hold great potential for applications in perovskite/silicon tandem solar cells. However, achieving high-quality wide-bandgap perovskite films with reliable processing remains challenging, especially under ambient conditions. In this talk, I will discuss our recent advances in controlling the crystallization process of metal halide perovskites for photovoltaic applications. Through systematic investigation of the crystallization pathway of narrow-bandgap perovskites, we revealed that the regulation of intermediate phases plays a critical role in determining the final film quality and defines the processing requirements for high-performance devices. Based on this understanding, we further extended the crystallization control strategy to wide-bandgap perovskites, enabling the reliable fabrication of high-quality films under ambient conditions. As a result, wide-bandgap perovskite solar cells prepared in air achieved a certified efficiency of 23.0%. Beyond intermediate phase regulation, we further explored the impact of crystallographic orientation on the stability of perovskite devices. We found that two-dimensional passivation layers formed on the (111) crystal plane exhibit superior stability compared with those formed on the (100) plane, showing minimal degradation during the thermal lamination process of encapsulation. By engineering the crystallization process, highly (111)-oriented wide-bandgap perovskite films were successfully obtained, leading to devices with an efficiency of 23.3%. These findings highlight the importance of crystallization engineering, including phase evolution and crystal orientation control, for advancing efficient and stable perovskite photovoltaics.



Dr. Meng Zhang is Senior Lecturer and a ARC Future Fellow at University of New South Wales. He obtained his PhD at the University of Queensland in 2016, and was promoted as a full professor in Southwest Petroleum University in 2019. His research is focused on materials engineering for metal halide perovskite thin films and solar cells for over 13 years.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Lead-free Halide Perovskites for Optoelectronic Applications

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Abstract: Metal halide perovskites have attracted tremendous research attention in the past decades due to their rapid progress and breakthroughs as one of the most promising photovoltaic technologies. This family of materials have superior properties, such as solution-processability, easy fabrication with high crystallinity, highly tunable optical bandgaps, high defect tolerance, high light-absorption coefficient and large carrier lifetime, which enable them as very promising candidate for the next-generation high-performance optoelectronic applications. However, serious concerns on the use of toxic lead as well as the instability of these perovskites in indoor conditions have inspired increasing efforts towards developing non-toxic and stable metal halide perovskite and perovskite-inspired alternative materials. Herein, we focus on the rational design of low-toxicity metal halide perovskites and explore their potential applications, with a particular focus on indoor light energy conversion and artificial synapses. Owing to the outstanding light absorption capability of these materials under weak light conditions, we demonstrate that low-toxicity perovskites can be ideal candidates for the next-generation indoor photovoltaics for powering off-the-grid Internet-of-Things electronics. Solution and vacuum evaporation methods were developed for high-quality thin-film processing, which in turn led to enhanced power conversion efficiencies in the indoor photovoltaic devices. In addition, the unique ionic and optoelectronic properties also enable them as promising semiconductors for the emerging artificial synapses and neuromorphic computing devices. Low-toxicity metal halide perovskites hold great promise for these emerging optoelectronic applications, and we demonstrate that additive engineering in the perovskite precursor can regulate the thin-film fabrication process as well as the resultant film properties, which is critical in achieving high-performance optoelectronic devices.



Dr Miaoqiang Lyu is an ARC Future Fellow and Group Leader in the School of Chemical Engineering at The University of Queensland, Australia. His research focuses on the design and applications of advanced optoelectronic materials, particularly lead-free halide perovskite semiconductors for indoor photovoltaics, solar cells, phototransistors and X-ray detectors. His research also advances research of printed energy storage devices for applications in wearable and IoT electronics. Dr Lyu has published 96 peer-reviewed articles, accumulating over 11,700 citations and an h-index of 45.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Phosphonic Acid Functionalization of P3HT for Efficient and Stable Inverted Perovskite Solar Cells

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Abstract: Developing hole-transport materials (HTMs) that simultaneously enable high efficiency, long-term stability, and scalable manufacturing remains a major challenge for inverted perovskite solar cells (PSCs). Although poly(3-hexylthiophene) (P3HT) possesses excellent intrinsic thermal and ultraviolet stability, its application in high-performance PSCs has been hindered by poor interfacial contact and limited charge-transport efficiency.
Here, we report a phosphonic-acid-functionalized P3HT derivative, poly(3-(6-(phosphonic acid)hexyl)thiophene) (P3HT-PA), which spontaneously assembles on oxide electrodes to form an ultrathin hole-transport layer. The phosphonic acid groups provide strong chemical anchoring to metal oxides, while favorable interactions between the thiophene backbone and perovskite absorber facilitate efficient charge extraction and suppress interfacial recombination. The self-assembled ultrathin architecture further minimizes transport limitations commonly associated with conventional P3HT films, eliminating the need for dopant incorporation while preserving the intrinsic stability of the polymer.
As a result, inverted PSCs employing P3HT-PA achieve a certified power conversion efficiency (PCE) of 26.74%, with a champion efficiency of 26.95%. The devices retain more than 90% of their initial performance after 1,600 h of maximum power point tracking. Importantly, the material is compatible with large-scale manufacturing, enabling perovskite solar modules with an active area of 668 cm^2 to deliver a champion efficiency of 20.11%.



Tai Wu is a PhD candidate at UNSW Sydney. His research focuses on perovskite solar cells, spanning functional material design and interface engineering, as well as perovskite crystal orientation engineering for high-performance photovoltaic devices.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Towards Efficient and Stable Tin Halide Perovskite Photovoltaics

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Abstract: Tin halide perovskites (THPs) are promising lead-free photovoltaic materials owing to their ideal bandgaps and excellent optoelectronic properties. However, their performance and stability remain limited by rapid crystallization, defect formation and, particularly for inorganic CsSnI3, intrinsic phase instability. Here, we demonstrate that rational engineering of two-dimensional/three-dimensional (2D/3D) heterostructures can regulate THP crystallization from precursor colloids to crystal growth. For $FASnI_3$-based THPs, we identify a nucleation kinetic mismatch between 2D and 3D phases arising from distinct colloidal aggregation behaviours. Incorporating small Cs+ cations educes the aggregation barrier and promotes mixed 2D/3D colloidal clusters, synchronizing their nucleation and producing homogeneous heterostructures with improved crystallinity and orientation. The resulting solar cells achieve a PCE of 17.13% (certified 16.65%) and retain 92% of their initial efficiency after 1,500 h of continuous one-sun illumination.[1] Extending this concept to all-inorganic $CsSnI_3$, lattice-matched PEA-based 2D templates direct the oriented growth of γ-$CsSnI_3$ while suppressing octahedral tilting and the undesirable γ-to-δ phase transition. The optimized devices deliver a PCE of 15.27% with a 0.90 V open-circuit voltage and retain over 95% of their initial efficiency after 1,280 h of maximum-power-point operation.[2] Together, these studies establish nucleation synchronization and lattice-matched template growth as complementary strategies for efficient and durable lead-free photovoltaics.

Dr Dongxu He is a PostDoc researcher in the School of Chemical Engineering at UQ, working on eco-friendly perovskite photovoltaics. His research focuses on high-quality, lead-free tin-based perovskite solar cells for both outdoor and indoor applications.

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Theme 2 : Solar Energy Harvesting and Photo Detection

Evaluation of a Light Diffusion Radiative Cooling Film for Energy-Efficient Protected Cropping

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Abstract: Greenhouse cooling is essential for maintaining crop productivity and quality during warm conditions, but conventional air conditioning increases energy demand and operating costs. This study evaluated a light-diffusion radiative-cooling (LD-RC) film as a passive thermal management strategy under large-scale protected cropping conditions. Four identical glasshouses (approximately 4 m × 8 m × 3 m) with an area of 28 m2 (each) in commercial farming settings were operated simultaneously under four treatments: fully active climate control, fully active climate control with LD-RC film integrated, semi-active control, and semi-active control with LD-RC film integrated. Air temperature, relative humidity and photosynthetically active radiation were monitored continuously. Total energy consumption, irrigation water use, lettuce survival, growth, yield, and nutrition quality were assessed. In addition to its cooling function, the LD-RC film converted direct solar radiation into diffuse light, creating a more uniform light environment and improving light penetration within the lettuce canopy. This distribution reduces excessive irradiance on upper leaves while increasing light availability to shaded leaves, supporting more efficient canopy-level photosynthesis. Compared with the corresponding traditional glasshouses, the LD-RC treatments provided annual energy savings of 14.6% and increased lettuce yield by 19.8%, while maintaining a more stable crop-zone microclimate. The LD-RC produced more uniform lettuce growth across the greenhouse. Plant-width coefficient variation decreased from 0.16 to 0.07 in summer and from 0.15 to 0.08 in winter, proving it's capable of producing more consistent lettuce growth across the greenhouse in all positions. These findings demonstrate that LD-RC films can complement active greenhouse cooling while improving the light environment and productivity of lettuce cultivation. This scalable material strategy offers a promising pathway towards more energy-efficient, productive and climate-resilient protected cropping.



Maduni Wijethilake is a PhD Student at RMIT University in Melbourne, Australia, researching light diffusion radiative cooling film for self-sustainable, energy-efficient protected cropping, focusing on energy efficiency, and evaluating nutritional and growth benefits. She holds a BEng (Hons) in Electrical and Electronic Engineering from the University of Sunderland, UK, and a Postgraduate Diploma in Industrial Automation from the University of Moratuwa, Sri Lanka. Maduni brings 5 years of valuable experience in building energy management and energy efficiency systems to her industrial-scale commercial projects while she works in design engineer at Eco33 Private Limited, bridging theoretical innovation and practical applications.

Theme 2 : Solar Energy Harvesting and Photo Detection

Artificial Chiral Microstructures for Manipulating Upconversion Emission

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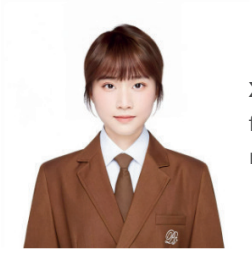
Abstract: Circularly polarized light provides an additional degree of freedom for optical information encoding, communication, and sensing. Conventional generation of circularly polarized light relies on bulky polarization optics, limiting compact integration. Circularly polarized luminescence (CPL) enables the direct generation of circularly polarized light at the emission source. Although many organic materials have been developed to produce CPL by combining chiral units with luminophores, they often suffer from low luminescence dissymmetry factors. Artificial chiral photonic structures therefore provide a promising alternative for enhancing polarization-selective emission by engineering the optical environment around emitters. Here, we integrate upconversion nanoparticles (UCNPs) with chiral microstructures fabricated by two-photon polymerization to manipulate upconversion emission. Under near-infrared excitation, the UCNP emission couples to the local chiral electromagnetic environment created by the microstructures. By varying the emitter placement, we investigate how the spatial overlap between the emitters and this local optical environment influences polarization-selective emission. Electromagnetic simulations and optical measurements consistently show that stronger emitter–environment coupling leads to enhanced circular-polarization selectivity. These results highlight emitter placement as a key factor in tailoring chiral emission and provide a practical route toward compact circularly polarized light sources.



Xihan Wu is a PhD candidate at RMIT University. Her research focuses on microoptics, laser microfabrication, and upconversion materials.

Theme 3

Advanced Characterisation and Simulation Techniques

Theme 3 : Advanced Characterisation and Simulation Techniques

Engineering Plant-Based Proteins for Sustainable Food Systems

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Abstract: Achieving sustainable food systems requires not only alternative ingredients, but also the ability to engineer structure and functionality that meet performance and consumer expectations. Plant-based proteins offer significant potential, however, translating them into high-functioning food products remains a key scientific and technological challenge.[1] This talk presents a multiscale engineering framework linking molecular interactions to macroscopic functionality in plant-based foods. Advances in protein and colloid engineering enable control of interfacial behaviour to stabilise emulsions,[2] enhance encapsulation of sensitive compounds,[3,4] and improve physicochemical stability through tailored protein–phenolic interactions.[5] These strategies support robust and efficient food formulations during processing and storage. At the product level, structured emulsion gels integrated within dual-network matrices provide tunable thermal and mechanical properties.[6-7] Such systems can reproduce the melting, texture, and stability of conventional foods, enabling the development of high-performance plant-based analogues.[8-9] By integrating materials design, advanced characterisation, and scalable processing strategies, our work demonstrates how the understanding of structure and functionality of plant-based proteins can accelerate innovation in sustainable food systems. This approach provides a pathway to develop functional, resource-efficient, and scalable food solutions to support future global demand.



Prof. Cordelia Selomulya is the Head of School of Chemical Engineering, UNSW Sydney, and the Research and Commercialisation Director of the Future Food Systems CRC. At UNSW Sydney, Cordelia has continued to lead a research team addressing grand challenges at the interface of particle engineering and science, with a focus on functional particles and structures for applications in smart drying, protein functionality, encapsulation, and advanced food systems.

She is a Fellow of the Australian Academy of Technology and Engineering (ATSE), a Fellow of the Institution of Chemical Engineers (IChemE), a Fellow of the Institute of Food Technologists (IFT), and serves as Executive Editor for Advanced Powder Technology and Regional Editor of Particuology.

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Theme 3 : Advanced Characterisation and Simulation Techniques

Discovery of 2D Materials for Piezoelectronics, Non-Linear Optics and Exciton Condensation

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Abstract: The role of computation as a third pillar of science (alongside theory and experiment) has become increasingly significant in recent years. In this work, we employ first principles calculations – calculations with no empirical parameters but with well-defined approximations, to accelerate the discovery of materials with superior target properties. Starting with density functional theory (DFT) calculations for materials screening of material databases compiled as part of the Materials Genome project, we further perform many-body GW-BSE calculations for the optical properties of selected systems. Our high-throughput search for 2D materials with high piezoelectric stress coefficients identified $NbOI_2$ to be optimal among 109 2D piezoelectrics.[1] The material was synthesized, and the large piezoelectric coefficients were verified experimentally by our collaborators [1], and thereafter we continued to study the non-linear optical properties of these materials [2,3]. The system exhibits giant second harmonic generation (SHG) [2], and we show that excitonic effects are required to explain the shapes of the polar SHG plots from experiments [3]. In more recent work, we have also searched for 2D materials that can host long-lived excitons with high exciton condensation temperatures. The Bose-Einstein condensation (BEC) of excitons can potentially lead to long-range coherence at much higher temperatures than that found in superconductivity, due to the larger energy scales involved. We have previously predicted BEC temperatures of 50-100 K for ZnPc molecules on MoS_2 monolayers.[4] Here, we identify a few 2D materials with long-lived low-energy excitons with BEC temperatures of room temperature and above.



Quek Su Ying is an Associate Professor in the Department of Physics at the Faculty of Science of the National University of Singapore (NUS). She leads a computation and theory group to predict the properties of emerging materials. After receiving her Bachelor's degree in Mathematics, she completed her PhD degree in Applied Physics in Harvard University, and pursued postdoctoral studies in Lawrence Berkeley National Laboratory. She started her independent career in the Agency for Science Technology and Research in Singapore, before joining NUS in 2013. Her work involves unravelling the awesome secrets of nature through first principles calculations.

Together with her team of talented students and research fellows, she has published more than 90 articles which have been cited more than 10,000 times. She is also a founding member of the leadership team at NUS College, the honours college of NUS, where she serves as Vice Dean (Outreach).

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Theme 3 : Advanced Characterisation and Simulation Techniques

Geometry-Engineered Quantum Materials: Twist, Strain and Stacking in 2D and Vertical Superlattices

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Abstract: Moiré superlattices have transformed our ability to engineer quantum matter. By introducing twist, lattice mismatch, or strain into van der Waals heterostructures, we can create metamaterials whose behaviour simply does not exist in the individual layers. In marginally twisted semiconductors, this design freedom produces ferroelectric moiré domains with alternating polarization - and theory tells us that the domain walls should host an in-plane component forming networks of topological merons and antimerons.

In the first part of this talk, I'll show how angle-resolved piezoresponse force microscopy lets us observes these textures directly. By rotating the probe relative to the moiré lattice, we can map the in-plane polarization and reveal Bloch-type and Néel-type merons and provide experimental confirmation of these topological polar nanostructures. This gives us a powerful diagnostic for distinguishing twist-driven from strain-driven moiré architectures.[1]

Then I will shift perspective - from twisted bilayers to vertical superlattices. Using angle-resolved photoemission spectroscopy and density functional theory, we find that even a single superlattice unit, just six to eight TMD layers thick, can host coherently delocalized electronic bands across lattice-mismatched interfaces. These asymmetric stacks stabilise semimetallic phases and topological surface states that simply do not exist in the parent materials.[2]

Together, these results show that whether we twist, strain, or vertically stack, we now have unprecedented control over polarization textures and topological electronic structure. This convergence of moiré engineering and intermediate-layer design opens new pathways for exploring how geometry, stacking, and topology intertwine in next-generation quantum devices.



Dr Mark Edmonds is an ARC Future Fellow and Associate Professor in the School of Physics and Astronomy at Monash University. Since receiving his ARC DECRA in 2016, he has established a research program in quantum and atomically thin materials, with a particular focus on magnetic and 2D topological insulators, and moiré quantum systems. His laboratory integrates advanced thin-film growth and 2D material stacking with state-of-the-art spectroscopic and microscopy capabilities, to uncover new electronic phases and enable pathways toward ultra-low-energy electronic and quantum technologies.

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Theme 3 : Advanced Characterisation and Simulation Techniques

From Instrument Development to Atomistic Understanding of Single-Atom Catalysts

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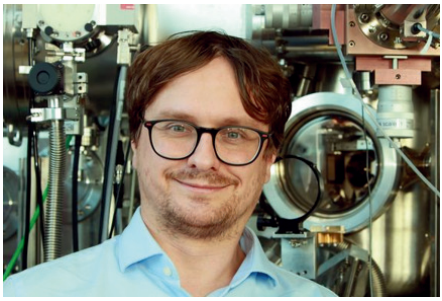
Abstract: Single-atom catalysts (SACs) offer a route to use precious metals more efficiently while creating active sites with defined local environments. However, their chemistry remains difficult to probe. Structural heterogeneity in powder catalysts complicates spectroscopic assignments and comparisons with theory, while the low site densities and limited surface areas of single-crystal models produce inherently weak spectroscopic signals.

This presentation will describe how a surface-science approach based on well-defined model catalysts and purpose-built instrumentation can address these limitations. The central focus is a homebuilt infrared reflection absorption spectroscopy (IRAS) instrument designed to detect adsorbates at dilute single-atom sites under ultrahigh-vacuum conditions. Results from IRAS, temperature-programmed desorption, photoelectron spectroscopy, and scanning probe microscopy are compared directly with density functional theory calculations to determine the local structure, adsorption energetics, and oxidation state of the active sites.

Systematic studies of CO adsorption on oxide-supported Rh and Pt single-atom systems highlight the complexity of spectral assignment. IRAS titration experiments reveal multiple carbonyl species whose vibrational frequencies depend on metal coordination, support structure, adsorbate coverage, pressure, and preparation history. Individual infrared bands therefore cannot always be assigned reliably from their frequencies alone. Model catalysts with controlled atomic structures, examined using complementary techniques, enable carbonyl species to be identified and provide experimental benchmarks for testing theoretical calculations.

These benchmarks connect infrared signatures with local adsorption environments and enable reliable interpretation of spectra from structurally complex, technologically relevant powder catalysts.



Jiří Pavelec is a Senior Scientist at the Institute of Applied Physics, TU Wien, specializing in the development of instruments for quantitative desorption measurements, high-sensitivity infrared spectroscopy, and surface studies at realistic pressures. Working with Gareth Parkinson, he applies these methods to atomically defined models of single-atom catalysts. He studied Engineering Physics at Brno University of Technology and completed his PhD at TU Wien under Ulrike Diebold in 2019. He was recently awarded an ERC Starting Grant for a robotic platform designed to generate reliable experimental data for computational catalyst design.

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Theme 3 : Advanced Characterisation and Simulation Techniques

Nanomaterials for Salmonella Detection and Control in the Poultry Food Chain:
Bridging Food Safety and Materials Science

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Abstract: Non Typhoidal Salmonella (NTS) is one of the most significant foodborne pathogens affecting public health in Australia and worldwide. NTS is a major food safety concern for both the egg and chicken meat industries. Contaminated poultry products are important vehicles for the transmission of Salmonella to humans. Salmonella serovars such as, Salmonella Enteritidis and Salmonella Typhimurium are commonly associated with poultry product related outbreaks. Current Salmonella diagnostics rely heavily on bacteriological culture and molecular diagnostic methods. These techniques can be labour-intensive, costly, time-consuming and less suited for rapid detection of low-level contamination within complex environmental and food matrices.

Previous studies demonstrated that residual shed dust in poultry shed, wild birds, grading floor equipment and processing facilities can contribute to the persistence and spread of Salmonella. Freshly laid warm eggs may facilitate bacterial penetration through eggshell pores and biofilm formation on processing and grading equipment can enable Salmonella survival. As a result, there is a need for routine surveillance tools capable of rapid, sensitive and in field detection methods.

This presentation will explore the possible application of nanomaterials, for the development of diagnostic and control tools for Salmonella in poultry farm environments. The advanced surface coatings with antimicrobial compounds could reduce bacterial persistence in the food chain. Nano-enabled delivery systems can be used to deliver poultry vaccines and probiotics to reduce intestinal colonisation of Salmonella in poultry. The integration of veterinary microbiology and materials science represents a promising interdisciplinary approach for producing safer poultry products and enhance public health outcomes.

Theme 3 : Advanced Characterisation and Simulation Techniques

How Geometry Shapes Matter

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Abstract: Many nanoscale technologies, including nanoparticle sintering, nanowire evolution, thin-film dewetting, and surface smoothing, are governed by the motion of interfaces driven by surface energy. The classical continuum description of this mechanism is the surface-diffusion model introduced by W. W. Mullins, leading to a fourth-order geometric evolution law.

In this talk, I will explain how Mullins' model arises from fundamental principles of energy dissipation and mass transport, highlighting the distinction between mean-curvature flow and surface diffusion. I will discuss classical results on thermal grooving, self-similar solutions, and stability, before turning to modern developments including axisymmetric surface diffusion, nanowire instability, and equilibrium geometries such as cylinders and unduloids.

Finally, I will describe recent work on these and related geometric flows, illustrating how the Mullins model fits into a broader hierarchy of geometric diffusion equations relevant to modern nanotechnology and materials science.

ICNASA 2026 Keynote & Oral Speakers

Theme 3 : Advanced Characterisation and Simulation Techniques

Graphene Origami Reinforced Nanocomposites

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Abstract: Graphene has attracted considerable interest due to its exceptional mechanical, thermal, electrical, and optical properties, making it a promising material for a wide range of engineering applications [1]. Building upon these intrinsic advantages, origami engineering introduces an additional dimension of structural design by transforming two-dimensional graphene sheets into three-dimensional folded architectures. The resulting graphene origami structures exhibit distinctive deformation behavior and highly tunable properties [2]. These characteristics can be further exploited by incorporating graphene origami into nanocomposites, offering new opportunities to enhance their performance and tailor their properties.

This work aims to review and summarize recent advances in graphene origami and its reinforced nanocomposites, with particular emphasis on their mechanical and thermal properties. The effects of origami configurations on the physical properties of graphene origami are critically examined, followed by an assessment of recent developments in polymer and metal nanocomposites reinforced with graphene origami. Future research directions are also discussed, highlighting how advances in fabrication, multiscale modelling, and artificial intelligence-assisted design could support the further development and practical application of graphene origami and its reinforced nanocomposites. Collectively, these advances highlight the potential of graphene origami for engineering next-generation materials with tailored properties.



Professor Jie Yang is a Distinguished Professor in the School of Engineering at RMIT University, Australia. His research interests include advanced composite structures, nanocomposites, structural stability and dynamics, smart structures and control, and nano/micro-mechanics. He has authored over 440 journal publications, which have received over 35,000 Google Scholar citations with h-index 102. He was recognized as a Highly Cited Researcher (Cross-Field) by Clarivate Analytics for five consecutive years from 2019 to 2023 and in 2025. He was also named by Australian Research Magazine as the Global Field Leader in Mechanical Engineering in 2020 and Australia's Research Field Leader in Mechanical Engineering from 2019 to 2023, Structural Engineering in 2021, and Acoustics & Sound in 2023. Prof Yang is awarded Nishino Medal in 2026 and currently serves as the Lead Editor-in-Chief of Engineering Structures and an editorial board member of several international journals, including Mechanics of Advanced Materials and Structures, Thin-Walled Structures, and International Journal of Structural Stability and Dynamics, etc.

Theme 3 : Advanced Characterisation and Simulation Techniques

Advancing the Characterisation Toolbox for Graphene-Based Materials

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Abstract: Graphene-related materials (GRMs), particularly graphene oxide (GO) and functionalised graphene materials, critically rely on their surface and basal-plane functional groups to dictate their performance in downstream applications. Despite significant advances in graphene research, commercialisation remains limited by a critical metrology gap. Without reliable bulk-scale methods to quantify chemical functionality, manufacturers cannot consistently control production processes or ensure batch-to-batch reproducibility, undermining confidence across the graphene value chain.

This keynote presents an integrated, industrially accessible analytical toolbox for the quantitative characterisation of GRMs, built upon three complementary and scalable techniques: thermogravimetric analysis (TGA), titration, and Raman spectroscopy. First, we demonstrate how TGA can be transformed from a routine analytical method into a globally validated metrology standard for quality assurance, enabling robust verification of GRMs and reliable detection of counterfeit graphene products.[1,2,3,4,5] We further show that derivative thermogravimetric (DTG) analysis provides molecular fingerprints capable of identifying and quantifying oxygen-, nitrogen-, and sulfur-containing functional groups.[3] Second, we present quantitative approaches for measuring surface functional groups by combining potentiometric Boehm titrations with catalyst-assisted acid titrations.[6,7] Finally, we demonstrate how sample preparation influences the structural characteristics of GRMs, using both confocal and widefield Raman spectroscopy to establish robust structural metrics for industrial quality control.

Ultimately, these complementary methodologies establish a practical, low-cost, and high-throughput analytical framework for the standardised characterisation of GRMs. By bridging the gap between laboratory research and industrial manufacturing, this toolbox enables reliable verification of batch-to-batch consistency, supports international standardisation efforts, and accelerates the translation of graphene technologies into commercial applications.



Dr Pei Lay Yap is a Postdoctoral Research Fellow in the School of Chemical Engineering at the Adelaide University, specialising in advanced materials and measurement science for sustainable applications, including water purification and carbon capture. She received her PhD in Chemical Engineering and Advanced Materials from the University of Adelaide in 2020 and has been recognised with prestigious awards, including the 2021 RACI Cornforth Medal and the 2024 NMI Measurement Achievement Encouragement Award. She has led and contributed to international interlaboratory comparison (ILC) studies involving 61 organisations, supporting the development of ISO/TS 21356-1 and ISO/TS 23359 for standardised graphene characterisation. Her work bridges materials science, measurement, standardisation and industrial quality assurance, accelerating the translation of emerging materials into reliable and sustainable technologies.

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Theme 3 : Advanced Characterisation and Simulation Techniques

Persistence and emergence of atomic optical defects at high pressure

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Abstract: Quantum sensing under extreme conditions offers a powerful route to interrogate materials where conventional probes fail. Extending quantum sensing techniques into the gigapascal pressure regime promises new insight into phase transitions, emergent order, and critical phenomena in correlated materials. To date, most experimental efforts have focused on spin defects in diamond, whose remarkable sensitivity has captured broad interest [1,2]. However, at elevated pressures these defects often suffer from degradation of their quantum coherence and optical addressability, ultimately limiting their performance and applicability in high-pressure environments.

In this talk, I will present a new strategy for quantum sensing at extreme pressures based on optically active spin pairs hosted in hexagonal boron nitride (hBN) [3]. Using a combination of high-pressure spectroscopy and spin-resolved measurements, we demonstrate that the key spin properties of these defects are, to first order, insensitive to applied pressure. Crucially, their optical transitions remain stable and well-defined up to at least 20 GPa, in stark contrast to many existing solid-state quantum sensors [4,5].

Beyond their robustness within the hexagonal phase, we show that these spin defects persist across the structural transition of hBN into the wurtzite phase. This survival across a major crystallographic transformation opens the door to truly in situ quantum sensing through pressure-driven phase transitions. Taken together, these results establish hBN spin pairs as a promising and versatile platform for quantum sensing under extreme conditions, and suggest new opportunities for probing phenomena deep within the high-pressure phase space of quantum materials.



David Broadway is an experimental quantum physicist whose research interests include quantum sensing and optics, 2D electronics and magnetics, novel condensed mater systems, and other related fields. He obtained his Ph.D. from the University of Melbourne in 2020 on quantum sensing with Nitrogen-vacancy centres in diamond. He was then a post-doctoral researcher at the University of Basel Switzerland in the group of Patrick Maletinksy focused on cryogenic scanning nitrogen-vacancy magnetometry of 2D magnetic van der Waals materials. In 2023 he joined the team at RMIT as an ARC DECRA fellow and has continued his research into low-dimensional condensed matter systems and optical quantum defects.

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Theme 3 : Advanced Characterisation and Simulation Techniques

Precision Quantum Measurement: Challenges on New Light Sources

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Abstract: Collective oscillations or random motions of single quantum quantities including charge, spin and momentum, normally names as quasi-particles in quantum materials or quantum effects, are crucial to many potential applications such as quantum information, catalysis, energy material, etc. Such effects are normally localized at the nano-to-atomic scale, with their responses ranging from femtosecond to picosecond, and with their responsive energies from microwave to X-ray frequencies. It has been a long endeavour effort to develop new measurement methods down to the quantum level covering the spectrum, However, suitable light sources are still heavily limited by their bulkiness, operation inconvenience, energy coverage, etc.

In this talk, the past effort on developing compact and cost-effective light sources will be introduced. Solutions to developing new precision quantum measurement are then discussed. Finally, a future of the construction plane of a new ultrafast terahertz near-field system will be given.



Yalin Lu received his Ph.D in Physics from Nanjing University, Nanjing, China, in 1991, and is now a distinguished professor at the University of Science and technology of China (USTC) and a distinguished researcher at the Hefei National Lab (HFNL). Dr. Lu is the recipient of China National Award for Natural Science (first class) in 2006, is the Member of International Eurasian Academy of Sciences and the Correspondence Member of Slovenia Academy of Engineering. He was the Director of National Synchrotron Radiation Laboratory of China (2014-2019), and currently serves as the Director of Anhui Laboratory of Advanced Photon Science and Technology, and the Director of the Engineering Technology Division at HFNL. His research focuses on quantum functional materials, nanophotonics, new energy materials and THz technologies. He is highly noted for the past inventions on transparent electro-optical PMN-PT ceramics, quasi-phase matched PPLN crystal, nonlinear microwave scanning tip microscope, quantum functional complex oxides, and terahertz compact FEL. Dr. Lu has ~ 600 publications, ~ 120 US and Chinese patents and applications, and 6 books/chapters.

Theme 3 : Advanced Characterisation and Simulation Techniques

AI4Science: From Accelerated Discovery to Agentic Discovery

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Abstract: AI4Science has traditionally been driven by accelerated discovery, where machine learning models are used to rapidly screen molecules, materials, and catalytic systems. In this talk, I will first discuss my work on accelerating scientific discovery through improved molecular representations, advanced learning algorithms, and large-scale datasets. I will then introduce our recent work on uncertainty quantification for molecular vector properties, with a particular focus on equivariant uncertainty estimation for atomic forces. This work aims to make molecular machine learning models more reliable by ensuring that both predictions and uncertainty estimates respect the underlying 3D geometric symmetries of physical systems.

Building on these efforts, I will discuss a broader transition from accelerated discovery to agentic scientific discovery. In particular, I will highlight our recent work that enables large language models to understand and reason over molecular simulation trajectories, opening up new opportunities for AI systems to actively interpret, steer, and improve computational scientific workflows.

Henry Li is a Postdoctoral Research Fellow at the Responsible AI Research Center, Australian Institute for Machine Learning (AIML), Adelaide University. His research sits at the cutting edge of AI4Science, with a focus on materials discovery, drug design, and the emerging field of agentic scientific discovery. He has demonstrated world-class expertise in AI-driven science, notably winning the 2023 Open Catalyst Challenge hosted by Meta AI Research and receiving second prize in the Tencent Alchemy Contest. He has published over 20 peer-reviewed papers in high-impact journals such as Nature Nano., JACS, ACS Nano, and Nano Letters, with work that bridges machine learning and the chemical sciences.

Theme 3 : Advanced Characterisation and Simulation Techniques

Reconfigurable 2D Materials for Low-Energy Electronics

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Abstract: Reducing the switching energy of the field-effect transistor remains the central obstacle to lowerpower electronics. That energy scales as ½CV², and the subthreshold slope of a conventional MOSFET is bounded at 60 mV/decade by Boltzmann statistics, which sets a floor on the operating voltage. Materials whose bandgap, or the topology of whose band structure, changes with an applied electric field offer a route past this floor: the field reconfigures the channel itself, enabling steep-slope switching at lower voltage and energy. Bilayer graphene opens a gap under a transverse field but reaches only ~250 meV, and most candidates exhibit a small gap, a weak response to the field, or both. These can be compared through a dimensionless figure of merit, the field-induced change in bandgap divided by the screened electrostatic potential drop across the material. For bilayer graphene this figure of merit falls below 0.1.

Using high-throughput density functional theory, we have screened a broad space of van der Waals heterostructures and identified a large class that overcomes this trade-off, combining bandgaps above 1 eV with a strong bandgap response to electric field. Figures of merit in this class exceed 0.7, roughly an order of magnitude beyond bilayer graphene. I will present the design rules that emerge from the screen, the structural and electronic features that govern the figure of merit, and our progress on integrating these channels into realistic device geometries through atomistic transport modelling. Together these establish a materials basis for transistors that switch below the Boltzmann limit.



Nikhil Medhekar is a Professor in the Department of Materials Science and Engineering at Monash University and an Adjunct Professor (Research) in the School of Physics and Astronomy. He received his PhD in Engineering from Brown University in 2009 and joined Monash in 2010. His group predicts and designs materials from first principles, with a focus on atomically thin materials for low-energy electronics, materials for energy storage and conversion, and metallic alloys. He was a Chief Investigator in the ARC Centre of Excellence in Future LowEnergy Electronics Technologies (FLEET) and is a Chief Investigator in the ARC Research Hub for Advanced Manufacturing with 2D Materials (AM2D). His group's modelling of van der Waals heterostructures is the basis of an ARC Linkage Project with TQ Transistors to prototype a low-energy transistor. He received the Young Tall Poppy Science Award in 2014.

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Theme 3 : Advanced Characterisation and Simulation Techniques

Intertwined chirality and symmetry breaking in moiré domain-wall networks

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Abstract: Moiré network formation in graphene bilayers breaks stacking symmetry and generates topological domain walls (TDWs) that host one-dimensional boundary states. Here we show that these TDWs undergo an additional symmetry breaking at the level of network geometry, leading to the spontaneous emergence of chiral configurations through lattice relaxation. Using atomistic structural relaxation, we establish a strain–flexibility phase diagram with three equilibrium morphologies — straight, mono-chiral, and dual-chiral — arising from TDW energy minimization within the geometric constraints of the moiré network. Tight-binding calculations show that straight and chiral networks support distinct low-energy electronic regimes. Straight networks retain a pronounced topological crossing point (TCP)-centerd local peak pair, nearly balanced edge states on the two sides of a TDW, and uniformly gapped AB/BA domains with smooth low-energy interference patterns. Chiral networks suppress the TCP-centred peak pair, redistribute low-energy spectral weight toward the walls, drive curvature-selective edge asymmetry, and break the smooth domain interference pattern into step-like features. Chirality, therefore, selects between a TCP-centered regime with concentrated low-energy response and a wall-centered regime with directional boundary localization, opening distinct routes toward low-energy states concentrated at TCP regions or directional one-dimensional channels along the walls.



Dr Xue Yan is a Research Fellow in Computational Materials Design in the Department of Mechanical Engineering at the University of Melbourne. She received her PhD in Materials Science and Engineering from the University of Melbourne, following her engineering training at Tsinghua University and Northwestern Polytechnical University in China. Her research focuses on computational materials science, with particular expertise in functional two-dimensional materials and nanomaterials. She uses first-principles calculations and molecular simulations to understand and design materials for energy storage and conversion, industrial reactions, and advanced electronic devices. Dr Yan has published over 20 peer-reviewed articles in leading journals, including *Nature Nanotechnology, Nature Synthesis, Nature Communications, Science Advances*, and *Advanced Materials*.

Theme 3 : Advanced Characterisation and Simulation Techniques

The Soft X-ray Beamline at the Australian Synchrotron: Capabilities, research and future direction

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Abstract: As one of the first beamlines built for the Australian Synchrotron, the Soft X-ray spectroscopy (SXR) beamline has been delivering photons for nearly 20 years to a diverse user community spanning multiple scientific fields. Featuring a wide photon energy range (90 – 2500 eV) and full polarisation control of the x-rays from an APPLEII elliptically polarised undulator source, the SXR beamline offers experimental stations capable of performing soft X-ray Photoelectron Spectroscopy (XPS) and Near Edge X-ray Absorption Fine Structure (NEXAFS/XANES). The facilities are supported by a wide range of sample preparation tools and offline characterisation methods. In this presentation, an overview of the beamline capabilities and key experimental systems will be given. Recent research from the user community will be highlighted to illustrate the breadth of application of SXR techniques, and some plans for major capability upgrades will be detailed. Finally, advice for beamtime proposals will be presented to assist new users in developing competitive applications.



Dr Anton Tadich received his PhD from La Trobe University (Victoria, Australia) in 2008, working in the photoemission instrumentation group led by Professors John Riley and Robert Leckey, both of whom pioneered the technique of Angle Resolved Photoelectron Spectroscopy (ARPES) in Australia. Following his PhD, Dr Tadich obtained a position as a beamline scientist at the Soft X-ray Beamline, Australian Synchrotron. Alongside his beamline colleagues, Dr Tadich is responsible for the training and management of visiting scientists at the beamline, as well as the maintenance and development of beamline instrumentation and techniques. He has significant expertise in synchrotron-based photoelectron spectroscopy, vacuum instrumentation and surface science techniques, and is an expert in the application of these tools to investigate the chemical and electronic structure of low dimensional condensed matter systems such as surface-transfer doped diamond, 2D materials, transition metal dichalcogenides (TMDs) and topological insulators/semimetals.

Theme 3 : Advanced Characterisation and Simulation Techniques

Using Synchrotron X-ray Absorption Spectroscopy (XAS) to Study Any Material

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Abstract: Determining atomic bond lengths, number and type of neighbouring atoms and their coordination environment in a crystalline material is relatively simple using X-ray crystallography (XRD). However, many materials and devices such as batteries are not crystalline structures but mixtures or layers of many different non-crystalline components, making them unsuitable for XRD. To study such amorphous materials, X-ray absorption spectroscopy (XAS) can be used to provide the same information and more (e.g. oxidation state in Figure 1), albeit with more challenging data processing. In this presentation, the Soft, Medium and hard X-ray Absorption Spectroscopy Beamlines (SXR, MEX1/2, XAS) at the Australian Synchrotron will be presented with examples of samples from current research trends, i.e. in-situ electrochemistry and in operando battery cycling, to demonstrate how the techniques can be used to solve various research questions.

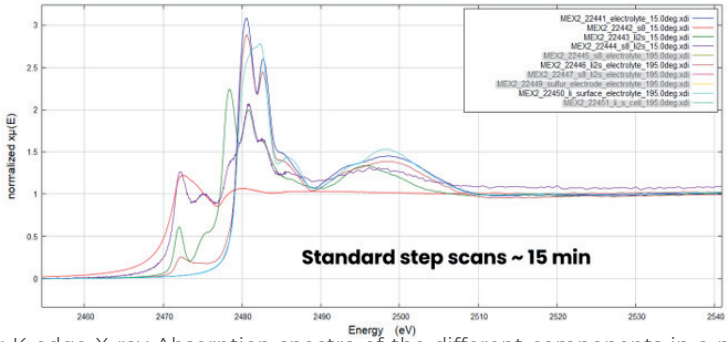

Figure 1 Sulfur K-edge X-ray Absorption spectra of the different components in a metal-sulfur coin cell battery. The different sulfur K-edge energy postions for the different components indicate different sulfur speciation and oxidation state.



Pria is a beamline scientist at the Australian Synchrotron, specialising in medium-energy X-ray absorption spectroscopy at the MEX-1 and MEX-2 Beamlines. Her research expertise lies primarily in materials spectroscopy, underpinned by a strong background in advanced optical spectroscopy and organometallic chemistry. Her doctoral research investigated exciton dynamics in transition-metal and lanthanoid-based materials, with a particular focus on understanding and improving energy-conversion processes relevant to photochemical and electrochemical applications. Following completion of her PhD, Pria undertook a postdoctoral fellowship in the Ultrafast and Microspectroscopy Laboratory (UML) at the University of Melbourne and the ARC Centre of Excellence in Exciton Science. Her postdoctoral research focused on the spectroscopic characterisation of upconverting and thermally activated delayed fluorescence (TADF) materials, with emphasis on elucidating excited-state processes and their application in light-energy conversion.

Theme 3 : Advanced Characterisation and Simulation Techniques

Unveiling electronic Inhomogeneity in moiré-engineered two-dimensional semiconductors

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Abstract: Moiré superlattices in twisted two-dimensional materials provide a powerful platform for engineering electronic properties through geometric control. However, the influence of atomicscale disorder on moiré electronic states remains insufficiently understood. In this work, we investigate disorder-induced symmetry breaking in the electronic structure of marginally twisted bilayer MoS_2 using low-temperature scanning tunnelling microscopy and spectroscopy.

We study a marginally twisted bilayer MoS_2 sample with a twist angle of approximately 1°, revealing a relaxed moiré superlattice with distinct MX and XM stacking regions. Spatially resolved spectroscopic measurements demonstrate systematic variations in the electronic band onsets between these regions, with energy shifts of approximately 15 meV observed in both the valence and conduction bands. These variations indicate that local disorder breaks the inversion symmetry of the moiré electronic landscape.

By combining experimental observations with theoretical modelling, we establish a connection between the spatial distribution of charged defects and the observed electronic inhomogeneity. Our calculations show that structural relaxation is essential for accurately describing the moiré electronic structure and understanding how disorder modifies the local band landscape. These results highlight the importance of relaxation and electrostatic effects in determining the properties of moiré materials, even in systems with relatively long-wavelength superlattices.

This work provides new insights into the interplay between structural relaxation, disorder, and electronic reconstruction in twisted two-dimensional semiconductors, with broader implications for the design and control of moiré quantum materials.



Atomic fabrication scientist at Silicon Quantum Computing (SQC) in Sydney, Australia. I received my PhD in Physics from Monash University at the group of Prof. Michael S. Fuhrer, where I specliazed on the fabrication and characterization of twisted two-dimensional semiconductors using low-temperature scanning tunnelling microscopy. I am currently applying my expertise in scanning probe microscopy and nanoscale physics to atomic-scale fabrication of quantum devices at SQC.

Theme 4

Emerging Materials for Diagnostics and Therapeutics

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Patient-Specific Carotid Artery-on-Chip "Physical Twins" Reveal Flow-Dependent Thrombosis and Personalised Antithrombotic Response

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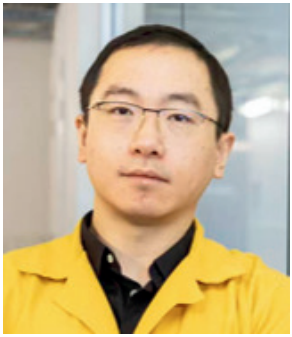
Abstract: Background: Patient-specific vascular geometry and haemodynamics strongly influence arterial thrombosis, yet conventional flow chambers and animal models cannot reproduce the anatomical and mechanobiological heterogeneity of individual carotid lesions. We developed a microfluidic "Physical Twin" platform to recreate patient-specific carotid thrombosis and evaluate geometry-dependent antithrombotic responses.

Methods: Carotid artery geometries from CT scans were reconstructed and fabricated as full-lumen microfluidics using high-resolution digital light processing. Channels were functionalised with neutralised human collagen type I, seeded with human carotid artery endothelial cells, and flow-conditioned to an arterial phenotype. Following localised laser injury, recalcified human whole blood was perfused under patient-specific flow conditions defined by computational fluid dynamics. Real-time confocal imaging quantified platelet accumulation, von Willebrand factor (VWF) deposition, thrombus growth and embolisation.

Results: Distinct patient geometries generated divergent thrombotic phenotypes. High-shear bifurcations (>3,000 s^{-1}) produced compact VWF A1-dependent thrombi, with VWF–GPIbα inhibition markedly suppressing both thrombus growth and embolisation. In contrast, disturbed/low-shear geometries produced mechanically fragile aggregates in which embolisation could become uncoupled from thrombus size and was more dependent on VWF–integrin-mediated stability. VWF accumulation correlated strongly with embolisation frequency, while antithrombotic efficacy varied substantially between flow phenotypes.

Conclusion: Patient-specific carotid Physical Twins integrate clinically relevant anatomy, endothelial biology and thrombosis within a controllable organ-on-chip system. By linking vascular geometry to molecular mechanism and drug response, this platform moves microfluidics beyond disease modelling toward functional precision testing for stroke-risk stratification and personalised antithrombotic therapy.



Dr Zihao Wang is the Post-Doctoral Researccher in the School of Biomedical Engineering at the University of Sydney, where he also conducts research in microfabrication and biomedical device development. He received his PhD in Aerospace Engineering from the University of Sydney in 2023, developing satellite attitude-control technologies subsequently deployed in orbit. His current work integrates high-resolution 3D printing, thermoplastic microfabrication and automated manufacturing to create patient-specific vessel-on-chip platforms. His research aims to make complex microfluidic devices more accessible and scalable for vascular disease modelling and personalised medicine.

ICNASA 2026 Keynote & Oral Speakers

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Compositional Engineering of Bioactive Metal–Organic Nanoparticles for Immune Modulation

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Abstract: Advances in nanoparticle-mediated therapeutic delivery are poised to revolutionize disease treatment and prevention. Interactions between nanoparticles and the immune system are critical determinants to shape their therapeutic applications, efficacy, and safety. Therefore, understanding and modulating nanoparticle–immune system interactions are essential for tailoring nanoparticlebased delivery strategies to specific applications and optimizing treatment outcomes. We recently developed a bioactive Metal–organic Nanoparticle (b-MPN NP) platform composed of polyethylene glycol, bioactive payload, metal ions, and phenolic ligands that have shown great potential for selective organ deposition and the delivery of a broad spectrum of therapeutic agents. The diverse choice of building blocks of b-MPN NPs provides a flexible design space for tunning their interactions with biological systems (e.g., tissues and cells) through compositional engineering.[1–5] In this talk, I will present our recent studies investigating immune responses elicited by these nanoparticles following their accumulation in lymphoid organs in mice, the influence of b-MPN NP composition on immunogenicity and reactogenicity in vivo, and composition-mediated nanoparticle association with immune cells following incubation with human blood. These studies are envisioned to advance our understanding of how composition of bioactive metal–organic materials influences their immune activity, underpinning the rational design of platforms for immunotherapy and immune modulation using these materials.



Dr Jingqu Chen is a Senior Research Fellow in the Department of Chemical Engineering at The University of Melbourne. Dr Chen received her PhD from The University of Melbourne in December 2021 under the supervision of Prof. Frank Caruso. Following her PhD completion, she held a Research Fellow position in the same group, where she pioneered the development of bioactive metal–organic nanoparticles capable of integrating the functionality of small molecules, nucleic acids, and proteins. Her current research focuses on understanding how these nanoparticles interact with biological systems, including biomolecules, cells, and tissues. Dr Chen's research is highly interdisciplinary, spanning materials science, nano-bio interfaces, and nanobiotechnology. Through this research, she aims to develop enabling material platforms for disease treatment, prevention, and diagnosis.

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[#] denotes co-first authorship

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Surface Coatings for the Prevention of Thrombosis and Bacterial Infections

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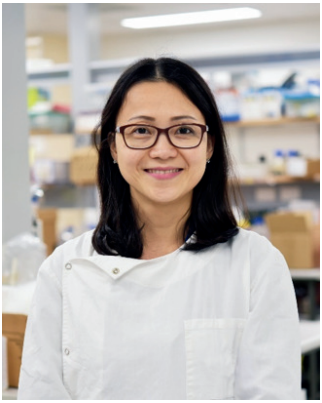
Abstract: We have developed surface coating materials to address two critical limitations of blood-contacting medical devices, surface-induced thrombosis and bacterial infection, by developing a series of multifunctional surface modification strategies. Through the integration of passive antifouling and active therapeutic mechanisms, the research establishes innovative material platforms capable of enhancing haemocompatibility, preventing biofilm formation, and promoting vascular regeneration. The first approach, based on amino acid-derived biomimetics, employs poly(aspartic acid) and its sulfated analogue to replicate the anticoagulant behaviour of natural glycosaminoglycans. The second platform utilises photothermal silver-coated iron oxide nanostars incorporated within poly(ethylene glycol) matrices to provide both passive and active protection. The third and most advanced strategy integrates catalytic copper(II)–salphen complexes into hydrogel and nanogel systems. Collectively, these studies advance the field of surface modification for cardiovascular and implantable devices by introducing adaptable, multifunctional coatings that not only resist thrombosis and bacterial colonisation but also actively promote vascular healing and integration.



Hang Ta is a Professor at School of Environment and Science and Queensland Quantum and Advanced Technologies Research Institute, Griffith University. She is an ARC Future Fellow and a former Heart Foundation Future Leader Fellow. She currently leads a team of 10 PhD students and postdoctoral researchers developing innovative materials for the diagnosis and treatment of life-threatening diseases. She got a PhD in biomaterials for drug delivery from University of Melbourne and then worked at Baker Heart and Diabetes Institute and University of Queensland before moving to Griffith University in 2020.

Prof Ta has been awarded a number of prizes, grants and prestigious fellowships. She has secured over $10 million ($7 million as lead investigator) in competitive grant funding from national funding agencies for both discovery and infrastructure projects. She is Immediate Past President of the Australian Society for Molecular and Imaging, Associate Editor/Editor or on Editorial Boards and is a peer reviewer for several journals, is a chair/co-chair of international and national conferences. She is a member of ARC College of Expert, serves on the committees of various scientific societies and also serves on different national grant review panels (e.g. ARC, NHMRC, MRFF, Heart Foundation).

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Glucose-Responsive Nano Sugar with Kidney Tropism Enable Multi-Day Therapy in Diabetic Mice

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Background: Type 1 diabetes (T1D) occurs when the immune system destroys the insulinproducing beta cells, leaving the body with little or no insulin. People with T1D require lifelong insulin replacement. However, conventional insulin injections cannot automatically adapt to changing blood glucose levels, while automated insulin delivery systems combining an insulin pump and continuous glucose monitor can be expensive and inaccessible. We developed biocompatible, glucose-responsive insulin nanoparticles to provide longer-lasting and safer blood glucose control. **Methods and Results:** The nanoparticles preserved insulin activity and released more insulin as glucose levels increased. We examined therapeutic efficacy in two T1D mouse models: chemically induced diabetic mice and Akita mice, which develop diabetes because of an insulin-gene mutation. A single subcutaneous injection provided blood glucose control for up to 72 hours, substantially longer than insulin alone. Treated T1D mice responded appropriately to a glucose challenge, demonstrating glucose-responsive activity in the body. No major treatmentrelated toxicity was observed. The findings also suggested that sustained blood glucose control may help reduce diabetes-related kidney injury. **Significance:** This glucose-responsive insulin nanoparticle system may offer a safer and more convenient alternative to frequent insulin injections. By releasing insulin when the body needs it, the system could reduce high and low blood glucose, lessen the injection burden and potentially protect against long-term diabetic complications.



Dr Rong Xu is an emerging leader in nanomedicine and translational biotechnology. He holds a prestigious international Breakthrough T1D Fellowship (2025–2028) at Monash University, where he leads the Nanomedicine for Metabolic Diseases laboratory. After receiving his PhD in biochemistry and extracellular vesicle research from La Trobe University in 2017, Dr Xu established an internationally recognised research program focused on glucose-responsive insulin delivery and engineered exosome therapeutics. Dr Xu has published 46 peer-reviewed articles in leading journals, including the Journal of Clinical Investigation, Advanced Materials, and Nature Reviews Clinical Oncology. His research has attracted more than 12,000 citations, with an hindex of 28. He has secured over AUD 2.3 million in competitive research funding, including fellowships and grants from Breakthrough T1D in the United States, United Kingdom, and Australia; Diabetes Australia; and major philanthropic foundations. His multidisciplinary work integrates advanced nanomaterials, bioengineering, and translational science to address critical unmet needs in type 1 diabetes and its cardiovascular complications.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

LBiochips for Mitochondrial Function Sensing and Therapeutic Regulation

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Abstract: Emerging materials are transforming the way diseases are detected, monitored and treated by enabling more sensitive diagnostics, targeted delivery and precise therapeutic intervention. In this presentation, I will introduce our recent work integrating advanced biomaterials with biochip technologies to sense and regulate mitochondrial function in disease. We have developed organ-on-a-chip platforms that recreate vascular and neurovascular microenvironments for quantitative evaluation of mitochondrial dysfunction and therapeutic responses, together with fluorescence imaging[1] and artificial intelligence for high-throughput assessment of mitochondrial morphology and function[2]. Beyond diagnostics and functional sensing, we have explored emerging material-based strategies for mitochondrial therapeutics, including a light-responsive material platform for isolating high-quality mitochondria for transplantation[3] and hybrid macrophage–mitochondria extracellular vesicles for targeted regulation of mitochondrial reactive oxygen species in diabetic wounds[4]. These approaches illustrate how functional materials can bridge disease modelling, biomarker sensing, organelle engineering and therapeutic delivery. By integrating responsive materials, biochips and mitochondrial biology, our work provides a versatile framework for developing next-generation diagnostic and therapeutic technologies with improved precision and translational potential.

Dr Bo Peng is a tenured Associate Professor at Northwestern Polytechnical University, China, where he serves as Deputy Director of the Department of Bioelectronics, College of Flexible Electronics, and Deputy Director of the Xi'an Key Laboratory of Biomedical Materials. He received his Bachelor's degree from Huazhong University of Science and Technology, an MRes from University College London, and his PhD from the National University of Singapore under the supervision of chemical biologist Professor Shao Q. Yao. He subsequently undertook postdoctoral training at CSIRO and Monash University with Professor Nicolas H. Voelcker. His research focuses on organ-on-a-chip technologies for disease modelling and mechanistic studies, together with bioelectronic and biomaterial approaches for disease diagnosis and therapy, with particular interests in mitochondrial sensing and regulation. Over the past five years, he has published more than 40 papers, including 31 as first or corresponding author, in journals including Nature Communications, Angewandte Chemie International Edition, Advanced Materials, ACS Nano and Research. He currently serves as a Young Council Member of the Mitochondrial Biology Branch of the Biophysical Society of China and a Young Editorial Board Member of the Journal of Pharmaceutical Analysis.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Carrier-free Nanoparticle Platforms for Therapeutic Applications

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Abstract: Nanomaterials are being developed as carriers to control the pharmacokinetics, biodistribution, and cellular interactions of therapeutic cargo, while protecting them from degradation and premature clearance.[1] However, synthetic nanocarriers can display immunogenicity stemming from their material components and can suffer from laborious and difficult-to-control manufacturing processes.[2–4] A way to improve the safety and efficacy of drugs is to minimize the use of materials by engineering nano-sized drugs (nanodrugs or NDs) largely composed of the active ingredients. In this presentation, "carrier-free" platforms for the formulation of small molecule drugs and therapeutic proteins into nanodrugs are presented. For small molecules, high-frequency (200–500 kHz) ultrasoundis used to formulate hydrophilic and hydrophobic drugs into "carrier-free" NDs.[5,6] This method was used to synthesise NDs from approved and promising anti-cancer drugs and their combinations.[7]NDs harnessed the advantages of nanosized formulations and showed sustained release of active drug, cell internalisation, and solid tumour deposition, slowing the progression of tumour growth better than the original "free" drug.

For protein therapeutics, we employed a simple template-mediated approach to fabricate "pure" antibody nanoparticles with controlled physicochemical properties.[8,9] We exploit the porosity of decomposable mesoporous silica particles to form therapeutic antibody nanoparticle assemblies of Herceptin. The AbNPs exhibited well-defined size and morphology, retained the receptor binding specificity of the free antibody, and increased antibody internalization and accumulation in 2D and 3D cultures and in vivo. These formulation methods can be adapted to various small molecule drugs and proteins with potential to impact diverse cancers and diseases.



Dr. Christina Cortez-Jugo is a Senior Research Fellow at The University of Melbourne. She has a PhD in Engineering from The University of Melbourne (Caruso Nanoengineering Group), with postdoctoral training at MIT (Langer Lab) on nanoparticle platforms for gene delivery and at Monash University (ARC Super Science Fellowship) on microfluidic nebulization devices for pulmonary delivery. She collaborates widely with clinicians and life scientists on targeted drug delivery approaches toward infectious and neurodegenerative diseases, cancer, and women's health. She specialises in nanoparticle engineering, including the development of novel nanomaterial platforms for the delivery of diverse therapeutic cargos to specific sites supported by funding from the ARC, NHMRC, mRNA Victoria, Friedreich's Ataxia Research Alliance, and Cumming Global Centre for Pandemic Therapeutics.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Engineering adaptive liquid-metal biointerfaces through Predict–Design–Restore for coordinated host defence and regeneration

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Abstract: Conventional antimicrobial coatings are static: passive biocidal activity fades with time, compromises host compatibility and ignores the dynamic interplay between infection, immunity and tissue repair. Predict–Design–Restore is a framework for adaptive biomaterials in which biointerfaces are engineered not merely to resist colonisation but to anticipate pathological perturbation, modulate interfacial responses and restore tissue homeostasis under biological stress. The concept is embodied in gallium-based liquid-metal adaptive biointerfaces, which exploit redox-driven nanoscale restructuring, conformal fluidic surface behaviour, dynamic oxide-mediated reactivity and controlled ion-mediated signalling[1]. Iron-mimetic gallium activity and galvanically mediated silver nano-amalgamation disrupt microbial metabolism and biofilm persistence while modulating immune responses and promoting regeneration[2,3]. Within the framework, pathological shifts associated with infection and inflammatory dysregulation are predicted through responsive interfacial behaviours; multifunctional liquid-metal systems are designed to coordinate antimicrobial defence with immune-regenerative signalling, with plasma engineering placing and programming them: plasma-sprayed hydroxyapatite–gallium composites on implant alloys[4], plasma-polymer-primed silver–gallium nanodroplets, and plasma-processed bioactive coatings and biopolymers that resolve inflammation[5,6]; and tissue homeostasis is restored through adaptive transitions from infection control to pro-healing modulation at the same interface (Fig. 1). Rather than passive coatings, these systems act as responsive bioactive boundaries that continuously rebalance host–microbe–immune interactions. Adaptive liquid-metal biointerfaces thereby integrate antimicrobial action, immune modulation and regenerative control as coordinated interfacial functions, and Predict–Design–Restore provides a translational roadmap for intelligent surfaces and devices that sustain biological function across implants, wound interfaces and infection-prone systems.

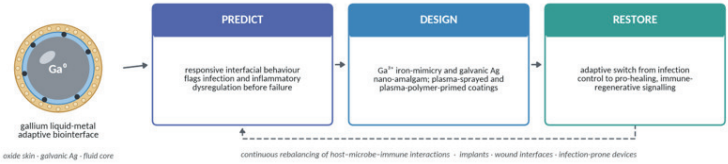
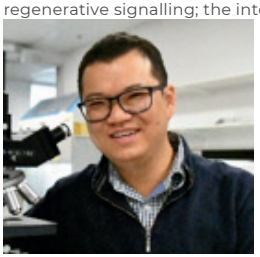


Figure 1. Predict–Design–Restore at a gallium liquid-metal adaptive biointerface: responsive behaviour flags pathological shifts; Ga3+ iron-mimicry, galvanic Ag nano-amalgamation and plasma-engineered placement coordinate defence with immune-regenerative signalling; the interface then switches to pro-healing modulation.



Vi Khanh Truong is Associate Professor in Biomedical Nanotechnology, ARC Future Fellow and Fulbright Fellow at Flinders University, Deputy Director of the Biomedical Nanoengineering Laboratory and Head of Biointerface & Translational Medicine. After a PhD at Swinburne University of Technology (2012) and fellowships at RMIT University and North Carolina State University (Fulbright, 2019), he established a gallium liquid-metal biointerface programme spanning plasma nanoengineering, antimicrobial nanocoatings and translational biomaterials. He is a 2026 Eureka Prize finalist.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Lipid Self-Assembly: From Nanostructure to Therapeutic Function

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Abstract: Lipid nanoparticles (LNPs) have emerged as versatile carriers for drugs, nucleic acids, and mRNA therapeutics. Among them, lyotropic liquid crystalline nanoparticles exhibit complex internal mesophase structures, including inverse hexagonal and bicontinuous cubic phases, that critically influence cargo encapsulation, release kinetics, cellular interactions, and in vivo biodistribution. However, achieving precise control over lipid self-assembly remains a major challenge, particularly in multicomponent formulations. This presentation will highlight strategies to understand and control lipid self-assembly using synchrotron small-angle X-ray scattering (SAXS) to elucidate structure–property relationships. By tailoring internal nanostructures, we have developed lipid nanoparticles with tunable biological performance and targeted delivery characteristics. The presentation will also describe the design of pH-responsive "smart" LNPs containing novel ionisable lipids that undergo structural transitions in acidic environments, enabling enhanced drug release at tumour and infection sites. Applications of these responsive nanocarriers for delivering anticancer and antimicrobial agents, as well as RNA therapeutics for chronic kidney disease, will be discussed, demonstrating how controlling lipid self-assembly enables next-generation nanomedicines.



Dr. Nhiem Tran is Deputy Head of International, Engagement, and Outreach and a tenured Senior Lecturer in the Department of Applied Chemistry and Environmental Science at RMIT University, Australia. He obtained his PhD in Physics from Brown University, USA, in 2012 and has been awarded several prestigious fellowships, including the CSIRO John Stocker Postdoctoral Fellowship and the RMIT Vice-Chancellor's Research Fellowship. Dr. Tran has established an internationally recognised research program in nanomedicine, biomaterials, and lipid nanoparticle engineering. His research has advanced the understanding of how lipid self-assembly and nanostructure govern drug and RNA delivery, cellular interactions, and biological performance, underpinning the development of smart, stimuli-responsive nanocarriers and infection-resistant biomaterials. He has published more than 80 peer-reviewed articles and received the 2025 RMIT STEM College Deputy Vice Chancellor Impact Research and Innovation Award. Beyond research, Dr. Tran is committed to advancing the scientific community through leadership and service. He serves on the Board of Directors of the Australasian Colloid and Interface Society (ACIS) and is an Editorial Board Member of Discover Nano, contributing to the promotion of research excellence and collaboration in nanoscience and biomaterials.

ICNASA 2026 Keynote & Oral Speakers

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Plasma Bio-engineering: From bioactive interfaces to advanced biofabrication

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Abstract: Engineering materials to direct biological interactions is central to advancing implantable devices, regenerative medicine and emerging biomedical technologies. Plasma bio-engineering offers unique opportunities to tailor material chemistry, interfacial interactions and biological functionality across diverse materials and geometries. This keynote will highlight our research into developing plasma-based technologies for engineering bioactive surfaces, functional nanoparticles and advanced soft materials.

Our work combines plasma polymerisation, ion implantation and atmospheric-pressure plasma technologies to create bio-instructive interfaces across metals, ceramics, polymers and hydrogels. These approaches enable the covalent immobilisation of proteins, peptides, nanoparticles and hydrogel networks, providing control over cellular responses, antimicrobial activity and tissue integration. We demonstrate their applications across orthopaedic and dental implants, cardiovascular devices, wound dressings and regenerative medicine. Extending beyond conventional surface modification, our recent research explores plasma-polymerised nanoparticles as modular platforms for therapeutic delivery and plasma-assisted biofabrication for engineering complex three-dimensional constructs. Particular emphasis is placed on integrating atmospheric-pressure plasma jets with 3D bioprinting, enabling localised control of material properties and biological functionality during fabrication. We also explore plasma-generated radicals as a means of engineering hydrogel networks and robust hydrogel–solid interfaces.

These advances illustrate how plasma bio-engineering can bridge surface science, materials engineering and biofabrication, opening new opportunities for developing the next generation of functional biomaterials and biomedical technologies.



Associate Professor Behnam Akhavan holds a joint appointment in Physics and Biomedical Engineering at the University of Sydney and is an Alexander von Humboldt Research Fellow. He directs the Plasma Bio-Engineering Laboratory, developing plasma-enabled technologies for biointerface engineering, advanced biomaterials and biofabrication. Previously, he held research appointments at the Max Planck and Fraunhofer Institutes in Germany and at the University of Sydney. He subsequently took up an academic appointment at the University of Newcastle, affiliated with the Hunter Medical Research Institute (HMRI), where he founded the laboratory. He has authored over 120 publications, attracted more than 4,000 citations and secured over AUD 9 million in competitive research funding. His contributions have been recognised through the ARC Discovery Early Career Researcher Award (DECRA) and his selection as one of Australia's Most Innovative Engineers by Engineers Australia.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Engineering Nanozyme Selectivity through Materials Design and Mechanistic Control

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Abstract: Nanozymes have emerged as a promising class of artificial enzymes, offering superior stability and structural tunability compared with natural enzymes. However, achieving enzyme-like catalytic selectivity remains a fundamental challenge. Our research addresses this challenge by uncovering the mechanistic origins of nanozyme catalysis and leveraging this understanding to rationally engineer nanomaterials with precisely controlled active sites, local coordination environments, and substrate interactions.

In this presentation, I will highlight our recent advances in nanozyme engineering using reticular chemistry and nanostructured materials to precisely regulate the local coordination environment, substrate recognition, and reaction pathways. By tailoring the active-site architecture and secondary coordination sphere, we have developed nanozymes with enhanced catalytic selectivity that more closely emulate the behaviour of natural enzymes while retaining the robustness of inorganic catalysts. These selective nanozymes enable highly efficient biocatalytic transformations for disease diagnosis and therapy, environmental pollutant degradation, and sustainable energy conversion.

Professor Kang Liang FRACI FRSC leads the NanoMicroBio Systems Group in the School of Chemical Engineering at the University of New South Wales (UNSW). He received his B.E. and PhD from the University of Melbourne in 2010 and 2014, respectively. His research focuses on the interface engineering of nanostructured materials and nanobiohybrid systems for applications in biomedicine and environmental technologies.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Quantitative Evaluation of Surface-Modified Upconversion Nanoparticles for Targeted Cancer Imaging and Fluorescence-Guided Surgery

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Abstract: Cancer remains a leading cause of mortality worldwide, with surgical resection serving as a primary treatment for many solid tumours. Fluorescence-guided surgery offers opportunities to improve tumour identification and margin assessment through real-time imaging. Upconversion nanoparticles (UCNPs), which convert near-infrared excitation into visible luminescence, are promising fluorescent nanoprobes. However, systematic investigations correlating their physicochemical properties, cellular interactions and imaging performance remain limited.

This study establishes a quantitative evaluation framework for UCNP-based cancer imaging, focusing on the effects of surface modifications on optical properties, cellular uptake, intracellular localisation and biocompatibility. Three UCNP formulations, core-shell, core-shell@PAA and core-shell@silica, were systematically characterised for their physicochemical properties, optical performance, colloidal stability and cytocompatibility. Their biological interactions were investigated using two-dimensional culture models comprising five cell types. Cellular uptake was quantified using inductively coupled plasma mass spectrometry (ICP-MS), while transmission electron microscopy (TEM) and single-nanoparticle confocal fluorescence microscopy were employed to correlate intracellular localisation with fluorescence imaging performance. Furthermore, epidermal growth factor receptor (EGFR)-mediated targeting was investigated to evaluate selective cancer cell labelling.

This study provides an integrated analytical framework linking UCNP surface chemistry, quantitative cellular uptake, intracellular distribution and fluorescence imaging performance. The findings offer insights into optimising UCNP-based fluorescent nanoprobes for targeted cancer imaging and support their potential translation into fluorescence-guided surgical applications.



Dr Helen (Xiaoxue) Xu is a Senior Lecturer in the School of Electrical, Mechanical and Biomedical Engineering, at the University of Technology Sydney (UTS). She has been awarded three prestigious postdoctoral research fellowships from Macquarie University, UTS and the University of Queensland, and joined UTS as a Lecturer in 2022. Dr Xu's research focuses on the design and development of innovative biomaterials for biomedical implants and devices. Her research encompasses fluorescent upconversion nanoparticles for precision theranostics inlcuding cancer cell imaging and labeling, drug delivery, and multimodal biomeidcal imaging contrast agent.

Dr Xu further developed biodegradable metallic materials, including copper-based alloys and micro/nanostructured copper oxides for intrauterine devices, zinc-based alloys for cardiovascular stents and orthopaedic implants. Dr Xu has published 105 peer-reviewed research articles, attracting over 6,000 citations, with an H-index of 41. She has secured more than AU$2 million in research funding, demonstrating her strong research track record and contributions to biomaterials science and biomedical engineering.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

From shared receptors to nanomedicine: targeting pathogenic macrophages across chronic lung diseases

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Abstract: Pathogenic myeloid cells drive chronic inflammation, permanent tissue damage and treatment resistance across chronic lung diseases such as asthma and COPD. This population is heterogeneous, comprising monocytes, macrophages, neutrophils and eosinophils, and precisely targeting these cells concurrently, without the broad immunosuppression seen with systemic corticosteroids, has remained a clinical challenge. Through patient characterisation coupled with transcriptomic profiling, we identified a shared pathway driving these diseases: signalling by the three β common cytokines, GM-CSF, IL-3 and IL-5, through their shared receptor subunit, the β common chain receptor CD131 (βc). This makes CD131 an attractive target for concurrently blocking multiple inflammatory pathways and effector cell types for broader therapeutic benefit. Using aetiologically relevant murine surrogates of these diseases, we confirmed that this shared βc/CD131 mechanism operates across both human disease and mouse models. Using a fully human monoclonal antibody that has recently completed a first-in-human phase 1 clinical trial, we showed that CD131 blockade prevents recruitment and accumulation of all pathogenic cell types, suppressing hyperinflammation and lung injury in ARDS models[1], reducing cigarette smoke-induced inflammation and emphysema[2], and limiting airway inflammation and fibrosis in asthma[3] and asthma-COPD overlap, demonstrating the potential of targeting shared myeloid signalling across distinct disease settings. Single-cell RNA-sequencing further revealed an under-recognised role for monocyte-derived macrophages as master regulators of these inflammatory processes[4].

With the emergence of lipid nanoparticles as a versatile platform for therapeutic delivery, our recent efforts have turned to targeting these pathogenic macrophages directly, work that carries both promise and translational challenges.



Dr Hao Wang is a Vice-Chancellor's Research Fellow at the Centre for Respiratory Science and Health, RMIT University. After completing his PhD in metabolic diseases in 2015, he undertook postdoctoral training with Professor Steven Bozinovski, developing expertise in respiratory immunology and myeloid cell biology. He subsequently progressed to co-leading translational research projects in partnership with CSL, establishing CD131 and CSF3R as complementary myeloid therapeutic targets across experimental ARDS, COPD and asthma. These projects integrate patient profiling with preclinical disease models to support antibody therapeutic development. His work has generated four patents and a substantial first- and senior-author publication record. His current research builds on receptor signalling and single-cell macrophage biology to advance lipid nanoparticle-based therapeutic delivery.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Nanotechnology-Enabled Advanced Omics: Unlocking Molecular Insights for Biomedical Research

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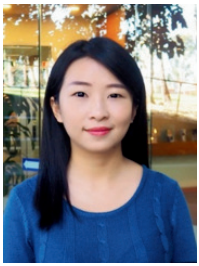
Abstract: Biomolecules, including proteins, peptides, and metabolites, play pivotal roles in various biological processes, and their profiles serve as indicators of cellular and organismal status, offering promise for disease diagnosis and therapy. However, the dynamic and intricate nature of diverse biomolecules, coupled with the minimal sample volumes involved, presents considerable challenges in achieving sensitive detection. Recently, we have pioneered several new platform technologies[1-5] for deep proteomics and metabolomics. Our innovative approach has demonstrated superior detection performance compared to previous studies and existing commercial products.



Dr Lei is an ARC Discovery Early Career Researcher Award (DECRA) fellow at the University of Sydney. She completed her PhD at the Australian Institute for Bioengineering and Nanotechnology (AIBN) at The University of Queensland (UQ). Shortly after her PhD, she received the Queensland Government Advance Queensland Research Fellowship to support her research on nanotechnology-enhanced bio-detection with an industry translational focus. She was then awarded the UQ Amplify Fellowship in 2021 and secured the prestigious ARC DECRA in 2024. Dr Lei has published articles in prestigious journals including ACS Nano, Adv. Mater., Natl. Sci. Rev, Small, Biosens Bioelectron, and Angew. Chem. Her research interests include nanotechnology-based bioanalysis, mass spectrometry, omics, and protein corona.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Understanding Antimicrobial Peptides as Next-Generation Antibiotics

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Abstract: Antimicrobial peptides (AMPs), known as host defence peptides, are potentially potent alternatives to conventional antibiotics, given their broad spectrum of activity. They mainly interact with cell membranes through surface electrostatic potentials and the formation of secondary structures, resulting in permeability and destruction of target microorganism membranes. To further improve the antibacterial activity, we have applied different chemical modifications on several AMPs to assist peptide insertion into the membrane lipid bilayer, inducing curvature and resulting in membrane pore formation, destabilisation, depolarisation, and leakage. Our findings highlight the advantages of modern chemical biology methods in developing novel AMPs with more potent antibacterial activity.

On the other hand, Proline-rich antimicrobial peptides (PrAMPs) constitute a unique class of antimicrobial peptides characterised by high proline/arginine content and predominantly non-lytic mechanisms of action. Unlike many other membrane-disrupting peptides, PrAMPs often enter bacterial cells through dedicated uptake pathways and primarily act on intracellular targets, most notably the 70S ribosome. However, bacterial resistance to PrAMPs can emerge through reduced peptide uptake and changes in membrane composition. To gain a deeper understanding of their membrane uptake and mechanisms of action, we applied chemical biology techniques to enhance our understanding of antibacterial mechanisms and advance the clinical application of PrAMPs in antimicrobial therapy.



Dr Wenyi Li is a Senior Lecturer and NHMRC Investigator EL1 Fellow at the Department of Biochemistry and Chemistry, La Trobe Institute for Molecular Science, La Trobe University in Melbourne, Australia. Trained as a peptide chemist in chemical biology, he obtained his PhD from the University of Melbourne. After two postdoctoral trainings at the Leibniz-Forschungsinstitut für Molekulare Pharmakologie (FMP), Germany and the University of Melbourne, he established his independent research group at LIMS in 2023. His research program focuses on developing antimicrobial peptides to combat bacterial and fungal infections.

Dr Li has received prestigious recognition, including the Rennie Memorial Medal from the Royal Australian Chemical Institute (RACI, 2024), the Young Investigator Award from Pharmaceuticals (2025), and the Young Peptide Scientist Award from the Chinese Peptide Society (2023). He currently serves as the President-Elect of the RACI Victoria branch. His work aims to advance novel peptide-based therapeutics against drug-resistant pathogens, addressing the critical global challenge of antimicrobial resistance.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Engineering Nano-Bio Interfaces: From Biomedical Nanotechnology to Plant Nanobiotechnology

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Abstract: The nano-bio interface governs how nanomaterials interact with biological systems and ultimately determines their biological activity, safety, and functionality. Understanding and controlling these interactions is therefore essential for the rational design of nanomaterials for biomedical and agricultural applications. However, the structural complexity and dynamic nature of biological interfaces make it challenging to connect interfacial processes with biological outcomes. Our research uses biological membranes as a common framework to investigate nano-bio interactions across increasing levels of complexity. At the nano-lipid membrane interface, we identified distinct interaction and assembly mechanisms and established strategies for controllable organization of nanomaterials on lipid bilayers. At the nano-cell membrane interface, we extended these principles to regulate nanomaterial-cell interactions and guide the design of biocompatible delivery systems. More recently, we expanded this framework to plant cells, where the cell wall introduces an additional hierarchical barrier and reaction interface. These studies reveal how nanomaterial properties, interfacial transformations, and plant physiological processes collectively govern nano-plant interactions. Together, these findings demonstrate how mechanistic understanding of nano-bio interfaces can enable rational interface engineering across biological systems, bridging fundamental nanoscience with biomedical and plant nanobiotechnology.



Dr. Feng Wang is Professor and Head of the Department of Pharmaceutical Science and Engineering at Hefei University of Technology. He received his Ph.D. from the University of Science and Technology of China in 2012 and conducted postdoctoral research at the University of Waterloo with Prof. Juewen Liu. His research focuses on nano-bio interfaces, analytical chemistry, functional nucleic acids, and plant nanobiotechnology. He has published more than 80 peer-reviewed papers in journals including J. Am. Chem. Soc., Angew. Chem. Int. Ed., Advanced Materials, Nano Letters, and ACS Nano, with over 5,000 citations. He is a recipient of the Anhui Hundred Talents Program and the Anhui Distinguished Young Scholar Fund.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Engineering Small Extracellular Vesicles for Tissue Regeneration

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Abstract: Stem cell-derived small extracellular vesicles (sEVs) have great therapeutic potential for tissue regeneration, but their translation is limited by low production yield, safety concerns, and poor bioavailability in target tissues.

We have developed complementary strategies to engineer sEV production, function, safety, and delivery. Biomaterials can regulate cellular paracrine activity and thereby modulate sEV production and bioactivity. We demonstrated that ionic products from 45S5 Bioglass® (BG) significantly increased mesenchymal stem cell-derived sEV (MSC-sEV) production while altering their microRNA cargo to enhance pro-angiogenic activity, providing a strategy to simultaneously improve sEV yield and therapeutic function.

We also developed a cargo-remodelling approach to improve sEV biosafety. Glioblastoma-derived sEVs possess intrinsic homotypic targeting but contain endogenous cargos that may promote tumour progression. Saponin-mediated cargo depletion removed these potentially harmful cargos while preserving vesicle integrity, surface proteins, and tumour-targeting properties. The engineered sEVs lost their protumoural activity and, after doxorubicin loading, achieved effective drug delivery and tumour suppression in subcutaneous and orthotopic glioblastoma models.

To further improve tissue-specific delivery, embryonic stem cell-derived sEVs were surfacemodified with the targeting peptide c(RGDyK), enhancing their accumulation at glioma sites, and subsequently loaded with paclitaxel to improve therapeutic efficacy.

Together, these studies demonstrate biomaterial-mediated regulation, cargo remodelling, and surface modification as complementary strategies to overcome key limitations in sEV production, functionality, safety, and targeted delivery, advancing the development of engineered sEVs for regenerative medicine and other biomedical applications.



Dr. Haiyan Li currently a Senior Lecturer in the School of Engineering at RMIT University. Over the past 20 years, she has built a diverse research career across both industry (Unilever) and academia, having held positions at Monash University, the French National Institute of Health and Medical Research (INSERM), Shanghai Jiao Tong University, and RMIT University. She received her PhD in Materials Engineering from the Chinese Academy of Sciences in 2005. Dr. Li is a well-established researcher in the field of biomaterials and tissue engineering. She has authored over 130 peer-reviewed journal articles and 4 book chapters, with her work cited more than 11,000 times and an h-index of 57 (Google Scholar). Her current research focuses on the development of microgels to advance granular microporous hydrogel scaffolds and engineering sEVs for tissue engineering.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Decoding protein solution behaviours using synchrotron small-angle X-ray scattering and machine learning

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Abstract: Ionic liquids are designable chemical environments that tune protein stability, assembly and phase behaviour, but how specific ion interactions propagate into macroscopic outcomes remains difficult to predict. This presentation combines synchrotron small-angle X-ray scattering, crystallography and machine learning to decode ion-driven protein behaviour across length scales.

At the molecular scale, scattering modelling and near-atomic-resolution crystal structures show that nitrate-based ionic liquids bind within the protein hydration layer, near arginine, lysine, serine, asparagine and tryptophan residues, without major unfolding[1]. At the colloidal scale, high-throughput, in situ heating and time-resolved small-angle X-ray scattering mapped lysozyme phase behaviour in ethylammonium nitrate. Automated analysis converted each profile into a pseudo radius of gyration, a crystallinity index and oligomer populations, revealing oligomeric intermediates that precede crystallisation within a narrow composition window. Non-linear machine-learning models captured this window better than linear models[2], and a species-resolved benchmark showed that ion and additive effects in deposited crystal structures are strongly protein-specific.

Finally, the same structure-based logic was transferred to ionic liquid formulations for oral insulin delivery. Solution scattering resolved pH-dependent insulin association states and distinct formulation nanostructures[3], while grazing-incidence small-angle X-ray scattering on supported lipid bilayers revealed rapid, concentration-dependent membrane restructuring[4]. Together, scattering provides quantitative structural descriptors, and machine learning converts them into predictive ion-design rules for crystallisation and peptide delivery.



Dr Qi (Hank) Han is a Research Fellow in the School of Science at RMIT University, Melbourne. He received his PhD in Materials Engineering from Deakin University. His research combines ionic liquids, protein science, synchrotron X-ray scattering and machine learning to understand how ion chemistry regulates protein crystallisation, aggregation, interfacial behaviour and self-assembly, and to design biomolecular formulations and peptide-delivery systems. He has authored more than 80 publications, deposited seven protein structures in the Protein Data Bank, and led 16 synchrotron beamtime awards. He received the 2025 Australian Synchrotron Early Career Researcher Award.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Molecular Bioelectronics for Precision Medicine: From Single-Molecule Sensing to Intelligent Diagnostics

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Abstract: Rapid and accurate molecular diagnostics require technologies that can detect low-abundance biomarkers in complex biological samples while remaining fast, robust and accessible. Organic electrochemical transistors (OECTs) offer a distinctive solution by coupling molecular recognition with intrinsic electronic signal amplification under aqueous and low-voltage conditions. In this talk, I will present our development of molecular bioelectronics for precision medicine, spanning protein, nucleic-acid and extracellular-vesicle biomarkers. I will first discuss nanobody-functionalized OECTs for rapid single-molecule protein detection and subsequent biointerface engineering strategies that improve receptor orientation, stability and sensor longevity. I will then describe our recent approaches to amplification-free RNA sensing, including small-molecule- and morpholino-functionalized OECTs that combine programmable molecular recognition with rapid electronic transduction. These platforms enable highly sensitive RNA detection within minutes and demonstrate compatibility with clinical samples. I will next highlight our independent work on blood-based diagnostics for neurodegenerative diseases, including multiplexed profiling of extracellular-vesicle biomarkers for Alzheimer's disease, rapid composite-biomarker analysis for Parkinson's disease, and electronic profiling of neuronal extracellular vesicles for early prediction of Parkinson's disease. Together, these studies illustrate a progression from detecting individual molecules to decoding complex disease-associated molecular signatures. I will conclude by outlining a future research vision in which programmable molecular interfaces, multiplexed liquid biopsy, microfluidics and bioelectronic signal processing converge to create intelligent diagnostic systems capable of translating dynamic biological information into clinically actionable decisions.

Dr Keying Guo is an Associate Professor in Biotechnology and Food Engineering at the Guangdong Technion–Israel Institute of Technology (GTIIT), where he leads an independent research program in organic bioelectronics, biosensing and precision diagnostics. He received his PhD in Drug Delivery Sciences from Monash University and subsequently conducted postdoctoral research at Monash University and King Abdullah University of Science and Technology (KAUST). His research focuses on organic electrochemical transistors, molecular biointerfaces, amplification-free nucleic-acid sensing, extracellular-vesicle diagnostics and point-of-care technologies. He has published more than 70 peer-reviewed papers, including work in Nature Biomedical Engineering, Science Advances, Advanced Materials, Advanced Science, Advanced Functional Materials and Biosensors and Bioelectronics. His recent research develops bioelectronic approaches for ultrasensitive molecular profiling and blood-based diagnosis of neurodegenerative diseases, including Alzheimer's and Parkinson's disease. Dr Guo currently holds an Adjunct Associate Professorship at Monash University and a Distinguished Professorship at Shanghai University. His research has been supported by national, provincial, institutional and translational funding, and has contributed to patented bioelectronic sensing technologies.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Programming Biomaterial Systems Across Scales for Regenerative Therapeutics and Biointegrated Sensing

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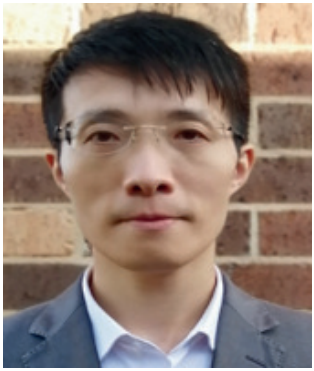
Abstract: Living systems achieve function through coordinated organization, regulation and information exchange across molecular, cellular and tissue scales. Translating this systems-level coordination into engineered materials is central to next-generation diagnostics and therapeutics. Our research focuses on programming how biomaterials assemble and organize across scales to shape their interactions with biological systems.

We connect the organization of matter with the organization of living processes. Discoveries at one scale are translated into function at the next, creating a continuous path from material formation to biological instruction, regenerative action and information generation. This program has progressed from fundamental control of soft-matter assembly to spatially organized tissue repair, preclinical translation and sensing-enabled therapeutic interfaces.

The resulting materials can guide tissue organization, coordinate complex healing processes and report their physical interaction with the body. This work provides a foundation for future diagnostic–therapeutic technologies capable of integrating regenerative action, biointegrated sensing and adaptive response.



Dr Linpeng Fan is the Founder and Group Leader of the BioSymphony Research Group at The University of Melbourne, where he is an ARC DECRA Fellow in Biomedical Engineering. His research investigates how structure–function coupling across material and biological scales governs coordinated cellular and tissue behavior and translates these principles into biomimetic tissue and organ models, regenerative technologies, and biointegrated therapeutic devices to advance intelligent biomedical systems. His contributions span bidirectional ice templating, synergistic co-aligned nanofiber–macrochannel architectures, programmable self-assembly of hierarchical fibrous networks, and wound-edge-activated targeted regeneration strategies.

The targeted regenerative technology platform pioneered in his group has progressed from fundamental discovery to preclinical validation, establishing a translational pathway toward next-generation clinical solutions. Building on these advances, his group is engineering responsive biointerfaces that integrate therapeutic regulation, personalized fabrication, and multimodal sensing to enable intelligent, adaptive biomedical systems. His work has been published in leading journals, including Nature Communications, ACS Nano, and Nano Letters.

ICNASA 2026 Keynote & Oral Speakers

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Architected and Translatable Biomaterials for Regenerative Medicine and Medical Implants

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Abstract: The clinical translation of biomaterials requires balancing mechanical performance, biocompatibility, scalability, and predictable in vivo behaviour. Two complementary biomaterial platforms will be presented that address these challenges through structural and architectural design rather than complex chemistries, with applications in regenerative medicine and dynamically loaded implants. The first platform comprises resorbable implants and injectable hydrogels engineered to support host-driven tissue regeneration while degrading into benign by-products. Preclinical studies in small and large animal models demonstrated favourable biocompatibility, cell infiltration, and neovascularization, resulting in enhanced soft and hard tissue regeneration.

The injectable hydrogel platform showed strong translational potential, enabling minimally invasive delivery, site stabilization, and sustained release of diverse bioactive agents, with safety and efficacy further confirmed in an early-stage clinical study.

The second platform addresses durability limitations of elastomeric medical devices under repetitive loading. Architected reinforcement strategies, including multilayered and spatially programmed internal designs, significantly improved toughness and fatigue resistance without sacrificing elasticity. These scalable approaches enable stress redistribution and crack suppression in complex device geometries.

Together, these platforms establish a unifying design paradigm in which architectural control enables predictable biological performance, enhanced mechanical durability, and clinical translatability for next-generation regenerative therapies and resilient biomedical implants.



Fariba Dehghani is a Professor in the School of Chemical and Biomolecular Engineering at the University of Sydney and Director of the Bioengineering Research. She is a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) and a Fellow of the Royal Society of New South Wales, recognising her contributions to engineering, science, innovation, and technology translation. Her multidisciplinary research spans bioengineering, biomaterials, regenerative medicine, drug delivery, biosensors, polymer processing, and sustainable bioprocessing. Her work has led to

innovative technologies including advanced biomaterials, biosensors, and sustainable bioprocessing platforms.Professor Dehghani has a strong track record in translating research into practical and commercial outcomes, contributing to several patents that has been sublicensed to industry and spin-off companies. She is also recognised for her leadership in fostering multidisciplinary collaborations across engineering, medicine, science, and industry.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Engineering Biocatalytic Nanomaterials for Precision Therapy and Biosensing

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Abstract: Precision therapy and minimally invasive diagnosis are central to modern biomedical engineering. However, current methods are hindered by high costs, drug resistance, poor prognosis, and severe side effects and lack of portable, highly selective, low-cost point of care-testing devices. My group developed a biocatalytic nanoplatform to address these challenges. However, the core research questions of catalytic nanomaterials for cancer therapy and diseases sensing are in vivo enzyme instability, low multi-enzyme cascade efficiency, and a lack of tumor microenvironment-responsive and multifunctional catalysts. This talk presents five years of team-led research engineering enzyme-immobilized metal-organic frameworks/covalent-organic frameworks biocatalysts and single-atom nanozyme, focusing on Australia's unmet clinical needs (i.e., cancer therapy and diseases sensing). Key findings include universal enzyme immobilization strategies that retain ~80% activity under harsh, in vivo-like conditions; spatially ordered multi-enzyme cascades with a 7.3-fold activity boost; and first-in-class single-atom nanozyme (exhibiting four enzyme-like activities) that achieve ~90% tumor cell kill. It also features translatable biocatalytic biosensing platforms for low-cost, portable point-of-care testing (a limit of detection of 0.34 μM for xanthine), cancer cells diagnostic device, and smartphone-compatible sensor.



Dr Jieying Liang is a Lecturer and NHMRC Emerging Leadership Fellow (EL1) at the University of New South Wales. Her research focuses on biocatalytic nanomaterials for precision therapy and biosensing. She leads an interdisciplinary team (Chemical Engineering/biomedical engineering) with over $2.5 M in competitive funding (NHMRC EL1, ARC Discovery Project, and international grants).

Over the past five years, her work has yielded 15 top-tier publications (impact factor > 10, including JACS, Adv Mater, Angew Chem, more than 2000 citation), three universal design principles for biocatalytic nanomaterials, and four first-in-class biomedical engineering platforms. Her core mission is to translate nanomaterial engineering into real-world biomedical engineering solutions that address unmet clinical needs.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Sulfoxide Polymers for Diagnostic and Therapeutic Applications

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Abstract: Sulfoxide polymers offer a unique combination of strong hydration, good biocompatibility, and highly tunable chemical structures, making them promising materials for biomedical applications. In this presentation, I will discuss our recent work using sulfoxide polymers in two areas: fluorine-19 magnetic resonance imaging (^{19}F MRI) and the development of low-immunogenicity delivery systems for biomacromolecules.

For imaging applications, we have explored how sulfoxide-containing polymers can be used to improve the performance of ^{19}F MRI probes. By controlling polymer structure and the local environment around fluorinated groups, we aim to improve the MRI signal and develop more effective imaging materials.

We have also investigated sulfoxide polymers for the delivery of biomacromolecules, including proteins and nucleic acids. Their highly hydrated nature and favourable interactions with biological systems make them attractive alternatives to conventional polymer materials used in delivery systems. Our studies show that sulfoxide polymers can be incorporated into nanoscale delivery platforms while maintaining good biocompatibility and favourable biological performance.

Together, these studies demonstrate the potential of sulfoxide polymers as a versatile materials platform for both diagnostic imaging and therapeutic delivery.



Dr Changkui Fu is currently a Senior Research Fellow at the Australian Institute for Bioengineering and Nanotechnology (AIBN) of The University of Queensland. He obtained his Bachelor and PhD degree in Chemistry from Tsinghua University in 2010 and 2015, respectively. Upon PhD graduation he moved to the University of New South Wales to work with Prof Cyrille Boyer on developing advanced photopolymerisation technologies. In 2016, he relocated to the AIBN of UQ to work with Prof Andrew Whittaker on developing polymeric MRI contrast agents. Since 2018 he started independent research on several fellowships (e.g. UQ Development Fellowship, NHMRC Investigator Grants and ARC Future Fellowship), focusing on developing innovative polymer solutions to address challenges in the biomedical field. He is currently leading several research programs, including 1) building innovative synthetic methodologies for advanced polymer synthesis; 2) developing biocompatible polymers with tailored structure and function for drug delivery and imaging applications; and 3) developing advanced antifouling surfaces with new polymer brush technology. He has published >90 papers in a variety of leading journals such as Angewandte Chemie, Journal of the American Chemical Society, ACS Nano, Progress in Polymer Science, Macromolecules, ACS Macro Letters, Polymer Chemistry, and Biomacromolecules, receiving ~7000 citations and an h-index of 47. He is the inaugural recipient of RACI Polymer Science Lectureship Award presented by RACI Polymer Division.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

From mRNA Vaccines to Cancer Immunotherapy: Translating Clinical Insights into mRNA Therapeutics

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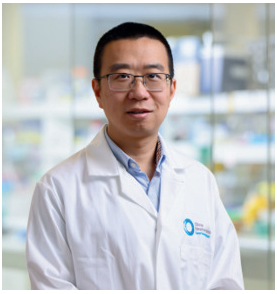
Abstract: Characterising how mRNA vaccine components behave in human blood offers a practical window into the in vivo kinetics of mRNA–lipid nanoparticles (LNPs). We have previously shown that both vaccine mRNA and vaccine-specific ionisable lipids can be quantified in serial blood samples for weeks after vaccination.

We examined immune responses to PEG following SARS-CoV-2 mRNA–LNP vaccination in a clinical study, identifying substantial boosts in anti-PEG antibodies in mRNA-1273 recipients and, to a lesser extent, BNT162b2 recipients.[1] These antibodies may alter the biodistribution of subsequently administered PEG-containing nanomedicines. Our recent studies have further explored links between PEG-specific antibodies and mRNA vaccine circulation in human blood[2] and demonstrated how anti-PEG antibodies can influence patient-specific nanoparticle targeting in blood in the context of cancer.[3]

In this talk, I will highlight insights from these studies and introduce an emerging analytical framework that integrates blood-based measurements of mRNA-associated signals, LNP components, and transcript quality to support more predictive evaluation of mRNA–LNP drug delivery in humans. This framework is intended to guide the rational optimisation of next-generation mRNA vaccines and systemic mRNA therapeutics towards improved stability, more consistent performance across individuals, and safer nanomedicine design.[4,5]



Dr Ju is an NHMRC Emerging Leadership Investigator and Head of the Nanomedicine and Gene Therapeutics Laboratory at the Olivia Newton-John Cancer Research Institute (ONJCRI), La Trobe University. He completed his PhD at the University of Melbourne in 2017 under Professor Frank Caruso, studying stealth nanoparticles and bio–nano interactions, before continuing as a Research Fellow. He later joined RMIT University as a Vice-Chancellor's Postdoctoral Fellow and ARC DECRA Fellow, pioneering human studies of PEG immunogenicity and mRNA–lipid nanoparticle (LNP) kinetics. In 2025, he established his laboratory at ONJCRI to advance mRNA–LNP science and cancer immunotherapy.

Dr Ju has published 78 referred articles, including 20 first and/or corresponding author articles in top journals such as Nature Nanotechnology, Nature Reviews Immunology, Advanced Materials, ACS Nano (×6), Chemical Society Reviews, Accounts of Chemical Research, Advanced Drug Delivery Reviews. The impact of his research has been recognised by the prestigious awards, including: 2025 Young Tall Poppy Science Award, 2022 Australasian Colloid and Interface Society (ACIS) ECR lectureship, 2021 Victoria Fellowship. Beyond research, De Ju serves as an Editor for the Journal of Materials Science (Springer Nature) and as a Committee Member of the Royal Australian Chemical Institute (RACI) Victorian Branch and Australian Chapter of The Controlled Release Society (Drug Delivery Australia).

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

3D Printing of Nanoparticle-Integrated Hydrogels

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Abstract: Light-based 3D printing offers precise control over hydrogel architectures, yet integrating mechanical robustness, tailored microstructures, and biological functionality remains challenging.[1, 2] This presentation highlights our group's recent advances in addressing these challenges through nanoparticle integration and nanodroplet templating.[3] Polymer-coated liquid metal nanoparticles are incorporated into photocurable hydrogels to regulate light propagation and polymerization kinetics, improving printing fidelity.[3] Their interactions with the hydrogel network enhance mechanical properties while imparting photothermal responsiveness and antibacterial activity. Complementing this approach, an emulsion-based strategy uses solvent nanodroplets as sacrificial templates for printing interconnected porous hydrogels.[4]

Together, these studies demonstrate how nanoscale resin design can control both the architecture and functionality of 3D-printed hydrogels. These complementary strategies provide a versatile foundation for engineering mechanically robust, multifunctional hydrogel platforms for tissue engineering and other biomedical applications.



Associate Professor Ruirui Qiao is a Group Leader and ARC Future Fellow (2026–2030) at the Australian Institute for Bioengineering and Nanotechnology, The University of Queensland. She received her BSc (2005) and MSc (2007) from Peking University and her PhD (2014) from the Chinese Academy of Sciences. Her research focuses on functional polymer/inorganic nanohybrids and biomaterials for biomedical applications, including nanoparticle-enabled hydrogels, 3D/4D printing, and soft robotics. She has published over 130 peer-reviewed articles and serves as an Associate Editor for Science Advances and the Journal of Nanobiotechnology.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Developing Regenerative Therapies for Bone and Joint Diseases

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Abstract: Bone and joint diseases are leading contributors to the chronic disease burden worldwide. In this talk, we will cover some of our recent research on regenerative therapies for bone and joint diseases, particularly those involving interface tissues such as osteochondral and tendon-bone junctions, where clinical treatments relieve pain rather than stop disease progression. Our team is investigating several approaches for developing new regenerative therapies: (1) improving the viability and paracrine activity of mesenchymal stromal cells (MSCs), through microcarrier culture and preconditioning methods; (2) designing multiphasic scaffolds for promoting tissue regeneration and modulating stem cell activity; (3) developing nanotechnological tools that improve drug delivery and tissue repair. Examples of applying these approaches in various musculoskeletal conditions will be discussed, such as in injuries and degenerative diseases involving bone, cartilage, tendon, and neural tissues.



Jiao Jiao Li FRSN FRSB FIEAust is an Associate Professor in Biomedical Engineering at University of Technology Sydney (UTS), and a Rebecca L Cooper Medical Research Foundation Al & Val Rosenstrauss Fellow. Her research in regenerative medicine develops combinational approaches including stem cells, extracellular vesicles, bioactive materials, and nanomaterials to treat chronic diseases, particularly bone and joint disorders. Recent recognitions of her research include 2026 Professional Engineer of the Year (Sydney), 2024 Eureka Prize for Emerging Leader in Science, 2023 Metcalf Prize for Stem Cell Research, 2022 Premier's Prize for NSW Early Career Researcher of the Year, and 2022 Young Tall Poppy Scientist of the Year. Professionally, she serves on the Australian Research Council (ARC) Advisory Committee, Board of Australian Institute of Policy & Science (AIPS), and Biomedical College Board of Engineers Australia. Her editorial roles include Associate Editor of Cartilage, International Editorial Board of Journal of Orthopaedic Translation, Editorial Board of Biomedical Materials, and Editorial Advisory Board of ACS Biomaterials Science & Engineering.

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Brain Targeted Drug Delivery and Therapy

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Abstract: Brain and central nervous system diseases impose one of the heaviest and fastest-growing health burdens worldwide, yet drug development for these conditions remains markedly less successful than for other therapeutic areas, with low phase I-to-approval rates, high post-market withdrawal, and persistently disappointing efficacy. Three interlocking obstacles underlie this gap: therapeutics cannot reliably cross the blood–brain barrier, cannot locate intracranial lesions with sufficient precision, and cannot eliminate the pathogenic proteins that drive disease.

This presentation describes three original strategies developed to address each obstacle in turn. First, pulsed-light modulation of blood–brain barrier active transcytosis enables safe, efficient brain entry without disrupting tight junctions; mechanistic work identified a ROS–ATP–GTP–Rab transcytosis pathway and achieved up to 36.5-fold enhancement in small-molecule and 10.6-fold in protein drug delivery, with proof of concept in Alzheimer's disease and glioma models.[1] Second, genetically engineered hybrid-membrane biomimetic carriers combine cell- and organelle-derived membranes to achieve homologous lesion recognition followed by mitochondrial targeting, delivering subcellular-level precision and substantially improved therapeutic efficacy in glioma.[2-3] Third, two complementary platforms address pathogenic protein clearance: a brain-targeted single-CRISPR capsule (31 nm, 100% loading) that acts at the DNA level, and the nanoparticle targeting chimera (NPTAC), a new targeted protein degradation paradigm that replaces the conventional ternary degrader architecture with a single-step synthesis, 22-hour circulation, and nanomolar-range efficacy via an endocytosis–autophagolysosome mechanism.

Together, these advances offer an integrated framework for precision drug delivery to the brain, with supporting patents licensed and translational development underway.

Professor Shi is an emerging global leader in biomaterials-based brain-targeted drug delivery, ranked No.1 among early career researchers (under 40) for both publications and citations in the field according to Web of Science and Google Scholar, with pioneering work in target gene discovery and nanomedicine for brain diseases such as brain tumour. After completing his PhD at the University of Adelaide in 2014, he was awarded a Macquarie University Research Fellowship and established an independent Advanced Brain Drug Delivery Group in early 2015. Supported by competitive fellowships and grants (NHMRC Peter Doherty, NHMRC-ARC Dementia Research Development, Australian Endeavour Leadership, NHMRC Leadership, and CIA grants from ARC, NHMRC and the Mason Foundation), the group grew to include research fellows, postdocs and eight PhD students. In October 2019 he became executive director of an international joint centre for biomedical innovation with more than 35 researchers, and in October 2024 moved to UTS as Chair Professor in Nanomedicine.

His research addresses a central challenge in treating brain disease: delivering therapeutics across the blood–brain barrier. He has developed several patented delivery platforms (e.g. Bio-NPs, Glu-NPs) underpinning more than 130 publications — 86 as first or corresponding author, 68 with impact factor >10, 16 with impact factor >30, and 19 invited reviews and book chapters — in journals including Nature Nanotechnology, Nature Biomedical Engineering, Science Translational Medicine, Advanced Materials, Science Advances, Nature Communications, JACS and Angewandte Chemie. His work has been recognised by the Biomaterials Young Investigator Award (2023) and a Rising Star Award in Nanobiotechnology (2022). He maintains a global collaborative network across the US, Europe, Japan, Singapore, Korea and China, alongside industry partnerships (Minomic International, Lleaf) yielding commercial products (Blood-Brain Barrier on Chip), five granted US patents and translational research grants.

Since 2014 he has attracted over $16M AUD in competitive funding, including more than $10M as sole CI or CIA, with five consecutive fellowships from NHMRC, ARC, the Australian Government and Macquarie University. He has supervised 12 postdocs and 16 PhD students (10 completions), many of whom have secured fellowships, tenure-track positions and awards, and has delivered 22 invited and 20 keynote talks.

His leadership extends to founding a joint university research centre, leading the International Nano-Brain Society, chairing international conferences, and co-founding Exploration (Wiley) as executive editor-in-chief. He serves as grant assessor and panel member for NHMRC Investigator and IDEAS schemes, ARC Discovery, Dementia Australia, the Neurological Foundation and the Sanfilippo Children's Foundation, and sits on the editorial boards of numerous journals.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Synthesis and room/subzero temperature pressure-driven sintering of metastable calcium phosphates

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Abstract: Calcium phosphate (CaP) biomaterials are widely used as bone substitutes due to their chemical similarity to the mineral phase of bone. Among the most biologically attractive but processing-sensitive CaP phases are amorphous calcium phosphate (ACP), low-crystalline nano-hydroxyapatite (nHAp), and octacalcium phosphate (OCP; $Ca_8(HPO_4)_2(PO_4)_4{\cdot}5H_2O$). Their metastable nature prevents densification by conventional high-temperature sintering, as thermal treatment induces phase transformations, particularly in OCP, which is unstable even at relatively low temperatures. Recent work by Rubenis et al. further demonstrated that pressure-driven sintering can be extended to sub-zero temperatures, enabling consolidation of ACP and the fabrication of porous scaffolds using ice-based templates while preserving metastable phase characteristics. ACP, nHAp, and OCP were synthesized and densified at room or sub-zero temperatures using pressure-driven sintering under uniaxial pressures up to 1500 MPa. In addition, OCP-based composites reinforced with carboxymethyl cellulose (CMC) were fabricated. Comprehensive characterization of powders and consolidated materials was performed using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FT-IR), Raman spectroscopy, Brunauer-Emmett-Teller (BET) surface area analysis, and scanning electron microscopy (SEM). All investigated CaP phases were successfully consolidated, reaching 92-98% of theoretical density while retaining their original phase composition. Only minor pressure-induced structural changes were observed in nHAp and OCP. These results demonstrate that room and sub-zero temperature pressure-driven sintering provides a versatile route for producing dense, phase-pure metastable CaP ceramics and mechanically robust bioresorbable composites for load-bearing bone regeneration applications. The authors acknowledge financial support from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 857287 (BBCE - Baltic Biomaterials Centre of Excellence).



Janis Locs is a Professor and Leading Researcher at the Institute of Biomaterials and Bioengineering, Riga Technical University, Latvia and Coordinator of the Baltic Biomaterials Centre of Excellence. His research focuses on calcium phosphate biomaterials, bioceramics, bone cements, biomaterial composites, and advanced sintering technologies for bone regeneration and implant applications. He has led numerous national and international research projects and has extensive experience in the development of bioresorbable and drug-delivering biomaterials for orthopaedic and maxillofacial applications.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Dynamic Nanostructures in Lipid Nanoparticles: From Interfaces to mRNA Microneedle Delivery

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Abstract: Lipid nanoparticles (LNPs) have transformed mRNA delivery, but their use in alternative dosage forms requires these soft, dynamic assemblies to tolerate environments far removed from bulk aqueous solution. Dissolving microneedle patches offer an attractive route for minimally invasive mRNA delivery, but fabrication exposes LNPs to dehydration, confinement and high local concentrations of formulation components.
Here, we investigate how mRNA-loaded LNPs respond structurally during incorporation into dissolving polymer microneedles. Small-angle X-ray scattering reveals that drying can induce substantial changes in LNP organisation, including the emergence of non-lamellar, inverse-hexagonal-like structure. The extent of this restructuring depends strongly on formulation conditions, while appropriately formulated systems can recover nanoparticle organisation following rehydration and retain mRNA encapsulation and biological activity.
These findings highlight LNPs as dynamic materials whose structure can adapt to changes in their local environment rather than simply being preserved or destroyed during formulation. Along the way, I will describe several complementary and emerging approaches used to interrogate LNP structure and behaviour, including grazing-incidence X-ray scattering and surface-sensitive techniques that provide insights not accessible from conventional bulk measurements.



Brendan Dyett is currently a Research Fellow at RMIT supported by an Australian Research Council Discovery Early Career Award. His research interests involve applying microscopy and scattering based techniques to investigate nano/microscale dynamics at interfaces. He received his PhD in Chemistry from the University of Melbourne, Australia, investigating the surface and mechanical properties of non-wetting thin films. He subsequently undertook a postdoctoral position in the Soft Matter and Interface research group led by Xuehua Zhang, investigating the dynamics and assembly of surface nanobubbles and nanodroplets. Following this, he carried out postdoctoral work under Charlotte Conn and Calum Drummond within the Molecular Assembly Laboratory at RMIT University, examining the mode of interaction of lipid nanoparticles with cellular membranes. Currently, he continues to work towards developing mechanistic understanding of lipid nanoparticle-cell interactions and strategies to overcome biological barriers.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Lanthanide Luminescent Materials for sensing and therapeutic applications

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Abstract: Lanthanide-doped nanoparticles (UCNPs) are capable of converting low-energy near-infrared (NIR) light into visible emissions. Their distinctive properties, including broadly tunable emission colours and low cytotoxicity, make them highly attractive for a wide range of applications, such as bioimaging, single-molecule tracking, and super-resolution microscopy. Typically, sensitizer ions (Yb3+) and activator ions (Er3+, Tm3+, or Ho3+) are co-doped into an optically inert host lattice, such as $NaYF_4$.

In this presentation, I will discuss our recent work aimed at broadening the excitation range and expanding the applications of lanthanide-doped nanoparticles. I will first introduce an emission-sensitisation strategy that overcomes surface quenching by bypassing energy relaxation from long-lived lanthanide excited states through the incorporation of an acceptor dye. Finally, I will present our recent work on the sensing and therapeutic applications of lanthanide nanoparticles.

Dr Guochen Bao is an Emerging Leadership 1 Fellow of the Australia National Health and Medical Research Council (NHMRC EL1), a Chancellor's Research Fellow (CRF) at University of Technology Sydney (UTS), with expertise in organic synthesis, analytical chemistry, spectroscopy, hybrid nanomaterials, nanophotonics characterisations, and biomedical engineering. Currently, Dr Bao leads the research focusing on developing hybrid materials, with desired functions, and optical and nanophotonic properties, and integrating these new functionalities into molecular/nano-probes and functional devices for ultrasensitive bioassay, biomedical imaging, and precise therapy.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Indigenous knowledge and new materials: lessons from genomics for nano- and atomaterials science

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Abstract: Nano- and atomaterials promise to deliver a range of benefits in energy, health, manufacturing and environmental sustainability. Yet the history of other emerging technologies shows that scientific promise does not guarantee public trust or a fair distribution of benefits. Genetic research is a salutary example. Indigenous peoples stand to benefit from genomics, but genetic research in Indigenous communities has often been controversial, with concerns raised about consent, ownership, commercialisation and a lack of benefit to the communities involved. This keynote considers what materials scientists might learn from these experiences. I draw on my work as an anthropologist of science and Founding Deputy Director of the National Centre for Indigenous Genomics[1] to outline how Indigenous governance and sustained engagement have reshaped genomic research in Australia. I then turn to materials science. Researchers at the University of Queensland have worked with Indjalandji-Dhidhanu Traditional Owners for nearly two decades to develop nanocellulose from spinifex grass, leading to a spin-out company majority owned by Indigenous Australians.[2] Similar questions apply to the critical minerals on which catalysis and energy storage depend. Who owns knowledge about the plants, minerals and environments from which new materials are derived? How should benefits be shared? What does meaningful Indigenous governance look like? I argue that these questions are best addressed early, before research agendas and commercial pathways become fixed. Early and sustained engagement can build the relationships needed for Indigenous communities and materials scientists to realise the potential of these technologies.



Emma Kowal is Distinguished Professor of Anthropology, Founder and Co-Convenor of the Science and Society Network at Deakin University, Founding Deputy Director of the National Centre for Indigenous Genomics at ANU, Past President of the Society for Social Studies of Science (4S), and member of the NHMRC Australian Health Ethics Committee. She is a cultural and medical anthropologist who previously worked as a medical doctor and public health researcher in Indigenous health. Her books include Trapped in the Gap: Doing Good in Indigenous Australia, the collection Cryopolitics: Frozen Life in a Melting World, and Haunting Biology: Science and Indigeneity in Australia.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Fusogenic Lipid Cubosomes as Nanocarriers for Next-Generation Nanomedicine

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Abstract: The further development of lipid nanocarriers remains central to advancing next-generation nanomedicine and gene delivery. Although clinically approved lipid nanoparticles have achieved remarkable clinical impact, their reliance on endocytosis often leads to endosomal degradation and low cytosolic delivery efficiency. Lyotropic liquid crystalline lipid nanoparticles with internal inverse cubic phases, namely cubosomes, present an attractive alternative owing to their intrinsic fusogenicity with biological membranes. Their lipid bilayer architecture promotes fusion with plasma or endosomal membranes, providing a pathway for efficient cytosolic release of therapeutic cargo. Here, we highlight our advances on cubosomes, including the mechanistic understanding of their membrane fusion behavior, microfluidic-based formation with precise size control, phase- and size-dependent nano-bio interactions, and proof-of-concept therapeutic applications. We have deciphered that the fusion behavior of lipid dye-labeled cubosomes with supported lipid bilayers, mammalian cell membranes, and Gram-negative bacteria follows a universal scaling law of lipid dye fluorescence intensity over time, . Moreover, cubosome sizes were precisely controlled from 130 to over 300 nm using a commercial microfluidic platform, following a quantitative scaling law with total flow rate (Q), . Systematic in vitro evaluation of how mesophase and particle size of LNPs modulate biological performance revealed that lipid nanocarriers with cubic phase and smaller size displayed stronger cell association, compared to their corresponding counterparts. As proof-of-concept, we have highlighted the therapeutic potential of cubosomes for the delivery of diverse cargos, such as antibiotics, anti-cancer drugs, thrombolytic agents, and nucleic acids, expanding the clinical impact to broader nanomedicine frontiers.

Dr. Yu is currently a Vice-Chancellor's Postdoctoral Research Fellow in the School of Science at RMIT University and a Lead Chief Investigator of an mRNA Victoria Research Acceleration Fund project. His research focuses on self-assembled nanomaterials, particularly lipid nanoparticles, for nanomedicine. His current interests include structure–function relationships of lipid nanocarriers, membrane fusion, intracellular delivery, and bioresponsive nanomaterials for precision therapeutics and gene delivery.

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ICNASA 2026 Keynote & Oral Speakers

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Engineering Dynamic Tumor–Vascular Interfaces: Microfluidic Platforms for Cancer Metastasis and Mechanobiology

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Abstract: Cancer metastasis is a complex, multistep process regulated by interactions among tumor cells, the extracellular matrix (ECM), and the vascular endothelium. However, conventional experimental models often lack the physiological relevance and spatiotemporal control required to investigate these dynamic interactions, particularly during cancer cell intravasation. Here, we present INVADE (Intravasation-On-µDevice), a biomimetic microfluidic platform engineered to reconstruct three-dimensional tumor–vascular interfaces under controlled microenvironmental conditions. By integrating geometrically confined tumor niches, ECM environments, and perfusable endothelialized microchannels, INVADE enables real-time visualization and quantitative analysis of cancer cell invasion and intravasation. Using breast cancer models, we identified distinct invasion strategies, including collective invasion by MCF-7 cells and interactive invasion involving functionally distinct MDA-MB-231 subpopulations. We further revealed dynamic epithelial–mesenchymal phenotypic transitions and bidirectional tumor–endothelial interactions, highlighting the regulatory role of the vascular microenvironment during intravasation. Extending beyond these findings, we have developed microfluidic approaches to investigate how ECM properties, geometric confinement, and dynamic mechanical cues influence cancer cell behavior. By integrating biomaterials engineering with controlled mechanical stimulation, these approaches provide opportunities to examine the physical regulation of cancer invasion within engineered microenvironments. Together, this work demonstrates the potential of microfluidic engineering to advance cancer mechanobiology and establish physiologically relevant platforms for disease modeling and future therapeutic evaluation.

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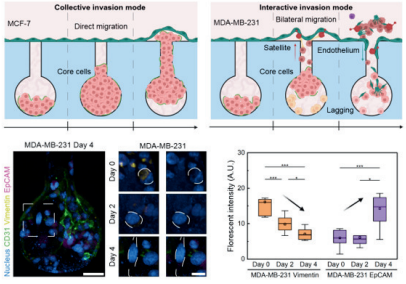



Dr Fengtao Jiang is a Research Officer at the Heart Research Institute, Australia. He received his PhD in Biomedical Engineering from the University of Sydney. His research focuses on microfluidics, cancer mechanobiology, and tumor–vascular interactions.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Novel Responsive Lipid Nanoparticles for Multidrug-Resistant Organism Therapeutics

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Abstract: Multidrug-resistant organisms (MDROs) are a major global health challenge because treatment options are increasingly limited. This study developed and evaluated novel lipid nanoparticles (LNPs) with tuneable surface charge and inverse lyotropic liquid crystalline mesophases as potential antimicrobial platforms. Monoolein (MO) was used as the principal structure-forming lipid, with DOTAP, ALC-0315 and SM-102 incorporated as cationic or ionisable lipids. LNP physicochemical properties, including particle size, dispersibility, zeta potential, pH-responsive behaviour and internal mesophase structure, were characterised. Antimicrobial activity was subsequently assessed in vitro against Escherichia coli, methicillin-resistant Staphylococcus aureus (MRSA), and sensitive, amphotericin B-resistant and fluconazole-resistant Cryptococcus neoformans strains. LNP properties were dependent on lipid composition and pH, while oleic acid (OA) altered particle size, surface charge and structural transitions and enhanced interactions with microorganisms. SM-102 and DOTAP LNPs showed the strongest inhibition of E. coli, whereas MO, ALC-0315 and SM-102 inhibited MRSA, with MO showing particularly strong activity consistent with its fusogenic behaviour. Against C. neoformans, antimicrobial activity varied with LNP composition, physicochemical properties, fungal strain and growth conditions. The fusogenic cubic phase, particularly that formed by MO, and positive surface charge emerged as important attributes for fungal disruption. Overall, fusogenic LNPs combining cubic mesophases with controlled positive surface charge demonstrate potential as versatile antimicrobial platforms for addressing MDRO-associated infections.

Abdulah Bawazeer is an Executive Director at Diana Medical Research and Development Center, with leadership experience spanning healthcare transformation, research and development, biotechnology, medical innovation and strategic program development. His interests include antimicrobial resistance, nanomedicine, biotechnology, research commercialization and translating scientific research into scalable healthcare technologies and products. He also focuses on developing strategic partnerships and supporting the connection of commercial and research relationships with the Ministry of Industry and Mineral Resources, as well as universities, research institutions, industry and investment stakeholders.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Decentralized cancer liquid biopsy profiling within a clinical biosensor validation framework

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Abstract: Clinical liquid biopsy (eg. blood or urine) specimens as a minimally invasive source of crucial molecular information continue to grow in importance for efficacious targeted cancer treatment. Yet, current molecular profiling technologies are still confined to centralized laboratory testing which escalates testing costs, result turnaround time and patient anxiety. Crucially, there is also a scarcity of purposeful clinical validation studies to rigorously evaluate emerging liquid biopsy technologies from research settings to facilitate clinical translation. Here, we report liquid biopsy biosensor advancements in achieving rapid, accurate, and decentralized molecular profiling of a clinically accredited prostate cancer (PCa) urinary circulating RNA biomarker panel. This biosensor approach, termed 'Accelerated non-inVasive bioAnalyte Testing And Reporting' (AVATAR), integrates accelerated isothermal assay chemistry and wireless mobile operation capabilities onto a portable electrochemical readout platform. Using independent training (n = 124) and validation (n = 114) PCa clinical urinary specimen cohorts, we showed AVATAR achieved superior PCa risk stratification to current clinical PCa testing with area-under-curve values of 0.88 (95% confidence interval: 0.84–0.92) and 0.86 (95% confidence interval: 0.83–0.89) respectively within 55 min of assay time. To accelerate AVATAR for using PCa liquid biopsies as a surrogate for invasive tissue sampling, we designed a tailored multi-year PCa follow-up study with individual patient liquid biopsy specimens showing strong molecular biomarker correlation with comprehensive transcriptomic sequencing of matched tissue specimens (n = 39). By creating this bespoke biosensor technology clinical translation framework, we demonstrated AVATAR for decentralized PCa liquid biopsy molecular profiling to augment clinical precision cancer management planning.



Dr Kevin M. Koo is currently a NHMRC Emerging Leadership Fellow and Prostate Cancer Foundation of Australia (PCFA) Future Leader Fellow. Kevin was awarded his PhD in Cancer Nanobiotechnology (Dean's Award for Outstanding Thesis & Springer Thesis Prize) from the Australian Institute for Bioengineering & Nanotechnology (AIBN), UQ. Kevin is a molecular nanotechnologist specializing in translational research across the prostate cancer disease continuum.

He presently leads a multidisciplinary research group to develop clinical biomarker assays and nanobiosensor technologies for precision oncology applications. He was a recipient of a Metrohm Australia-New Zealand Young Chemist Award (2018) and QLD Young Tall Poppy Science Award (2023).

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Structure-Guided Engineering of Ionisable Lipid Nanoparticles for Targeted mRNA Delivery

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Abstract: mRNA-lipid nanoparticle (LNP) technology offers major opportunities for preventing and treating diverse diseases, yet the structural mechanisms that govern intracellular RNA delivery remain incompletely understood. Here, we establish a mechanistic framework linking pH-responsive mesophase evolution within LNPs to mRNA delivery efficiency. Using time-resolved small-angle X-ray scattering (SAXS), we first investigated clinically relevant ionisable lipids used in mainstream COVID-19 mRNA vaccine formulations, including ALC-0315 and SM-102. Under endosomal acidification conditions, these LNPs underwent dynamic structural transitions into inverse lyotropic liquid crystalline mesophases, including bicontinuous cubic and inverse hexagonal phases. Partial phase diagrams constructed as a function of ionisable lipid composition and pH revealed distinct structural transition pathways between formulations, which correlated strongly with cellular association and mRNA transfection performance in macrophage cells.

Guided by these structural insights, we rationally engineered LNPs by incorporating monoolein (MO) as a structural helper lipid to replace DSPC in Moderna-like LNP formulations. MO incorporation promoted pH-dependent mesophase transitions and enhanced inverse hexagonal phase formation, a structural feature associated with membrane fusion, mRNA release and intracellular delivery. Compared with clinically relevant COVID-19 vaccine LNPs, MO-based LNPs achieved superior mRNA transfection efficiency across multiple cell types, including lung macrophages, epithelial cells and cancer cells. Optimised pH-responsive LNPs achieved > 70% EGFP mRNA transfection efficiency in macrophages. In vivo studies further confirmed enhanced mRNA expression of MO-based LNPs following intranasal pulmonary delivery and spleenenriched mRNA expression following intravenous administration.

Together, these findings identify internal nanostructure and pH-responsive mesophase dynamics as key design parameters for next-generation RNA delivery systems.



Dr Xiong (Eric) is a Postdoctoral Research Fellow at RMIT University, specialising in the development of drug delivery systems for clinically relevant disease models. His current research focuses on lipid nanoparticle (LNP)-based and LNP-integrated platforms for cancer immunotherapy and enzyme-catalysed combination therapy. By combining nanomedicine design, biomaterial integration and preclinical evaluation, his work aims to develop multifunctional delivery systems with improved therapeutic efficacy and translational potential.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Microfluidic laser-emission aqueous droplets for biomedical applications

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Abstract: Laser emission provides unique optical fingerprints for ultrasensitive biochemical analysis by amplifying light–matter interactions within microresonators[1-4]. However, conventional aqueous droplet lasers rapidly evaporate and are unstable in air, limiting their bioanalytical applications[5]. This study introduces laser-emitting aqueous droplet technology[6], water droplets in fluorocarbon oils that function as both biological microreactors and optical whispering-gallery-mode (WGM) lasers. We aimed to develop stable, high-throughput microlaser droplets capable of real-time bioactivity monitoring at single-cell and multicellular levels. Laser-emission droplets were fabricated via microfluidic droplet generation using fluorocarbon oils (e.g., FC-84, RI=1.26) with 2% surfactant for stabilization. Organic dyes such as FITC or Rhodamine B served as gain media. The lasing behavior was characterized under pulsed optical pumping, and the bioreactivity was evaluated through enzyme assays (trypsin-BSA hydrolysis), cellular metabolism analysis (NHDF and A549 cells), and single-yeast enzyme secretion using Fluorescein Di-β-D-Glucopyranoside substrates. The droplets exhibited stable laser emission with thresholds around 16.5 μJ mm^{-2} and lifetimes extended by over 1,000-fold compared to water droplets in air. The lasing spectrum was highly sensitive to refractive index (RI) variations, achieving a sensitivity of 373 $nm{\cdot}RIU^{-1}$, nearly 200-fold higher than conventional WGM sensors. This also enabled label-free detection of enzymatic activity, pH-dependent cellular metabolism, and single-cell heterogeneity. The lasing threshold-gated screening allowed differentiation of yeast cells with minimal fluorescence differences (~4.5%). This study establishes laser-emission aqueous droplet as a robust platform for high-throughput and long-term laser-based bioactivity analysis.



Dr Guocheng Fang is a Cancer Institute NSW Fellow at University of Technology Sydney (UTS). He previously held a Presidential Postdoctoral Fellowship at Nanyang Technological University, Singapore, and received his PhD from UTS in 2021. His research integrates microfluidics, biophotonics, and artificial intelligence to create intelligent organoid-on-chip platforms for disease modelling and drug screening. His work spans biomedical engineering, optical sensing, and AI-enabled phenotyping. He has authored over 50 peer-reviewed publications in leading journals, including Nature Communications, PNAS and Advanced Materials. He also serves as Young editor of Journals, including Micro-Nano letters, Materials Letters.

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Theme 4: Emerging Materials for Diagnostics and Therapeutics

Decoding Cancer Mechanobiology to Improve Nanotherapeutic Delivery

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Abstract: The tumour microenvironment is a critical determinant of cancer progression and therapeutic response, yet its physical properties remain poorly integrated into the development and evaluation of anticancer therapies.[1,2] In particular, the role of extracellular matrix mechanics and cellular mechanotransduction in therapeutic vulnerability and nanomedicine efficacy remains insufficiently understood.[1] We have demonstrated that nanoparticle internalization by cancer cells can be optimised by modulating cancer cell mechanobiology resulting in enhanced therapeutic efficacy.[3,4] These findings highlight the need to better understand the complex interplay between cancer cells and the surrounding tumour stroma, and how this interaction influences cellular behaviour and therapeutic response. To address this complexity, we moved toward the study of patient-derived tissues and the establishment of advanced cancer models that reproduce key features of the tumour microenvironment.[5,6] Accordingly, we generated three-dimensional pancreatic and breast cancer models, including patient-derived organoids, to study tumour–stroma interactions and evaluate nanoparticle-based therapies. Using these models, we investigated different classes of nanotherapeutics, including lipid nanoparticles, mesoporous nanoparticles and nanodrugs, to characterise their interactions with cancer cells and the surrounding tumour microenvironment and to validate their therapeutic efficacy, including in combination with standard chemotherapy. Integrating tumour mechanics, mechanotransduction and nanomedicine with advanced cancer models will enable the investigation of how the physical and molecular properties of cancer shape therapeutic delivery and response, providing a physiologically relevant platform for the development of next-generation cancer nanotherapies.

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Dr Marco Cassani is a Principal Investigator at the International Clinical Research Center (ICRC) of Brno, Czech Republic, and Honorary Fellow at the University of Melbourne. He obtained his PhD in Nanochemistry from the Italian Institute of Technology in 2018. He subsequently held a postdoctoral position at FNUSA-ICRC and was awarded an AIRC-MSCA-COFUND Fellowship and an MSCA Global Fellowship. As a group leader, he has been awarded the AZV ČR Junior Star grant and the GAČR Czech–Korean international grant. His research integrates mechanobiology, nanomedicine, patient-derived organoids and cancer therapeutics, with a focus on understanding and exploiting the physical and molecular determinants of therapeutic response.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

Nanoparticle-Engineered CD8⁺ T-Cell-Derived Microrobots for Breast Cancer Immunotherapy

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Abstract: Adoptive T-cell immunotherapy achieves remarkable clinical outcomes against hematological malignancies, yet its therapeutic efficacy against solid tumors is severely restricted by multiple tumor-microenvironment-associated obstacles, including dense extracellular matrix barriers, insufficient T-cell tumor infiltration, T-cell exhaustion, and lipid-metabolism-mediated therapeutic resistance. In this work, we developed three types of functional nanoparticle-modified T-cell microrobots to overcome these bottlenecks.
First, matrix-degrading T-cell-derived microrobots (T cell@HCH-R) were constructed by covalently anchoring collagenase- and hyaluronidase-loaded nanocapsules onto T-cell surfaces. These microrobots efficiently degrade tumor collagen and hyaluronic acid, significantly improving tumor spheroid penetration, intratumoral accumulation of CD8⁺ T cells, and in-vivo antitumor potency without impairing T-cell proliferation or biosafety.
Second, catalase-conjugated live T-cell smart microrobots (T cell@CAT) decompose intratumoral hydrogen peroxide to generate oxygen, driving enhanced active migration and deep tumor-tissue penetration while retaining native T-cell bioactivity.
Third, magnetic therapeutic engineered FCD-T cells were fabricated via bioorthogonal conjugation of Fe_3O_4-Cy5.5 nanocomposites onto CD8⁺ T cells. Under external magnetic guidance, FCD-T cells realize directional accumulation within tumor lesions, and support dual-modal magnetic-resonance and fluorescence in-vivo imaging for real-time tracing of T-cell distribution, which mitigates low tumor-targeting efficiency and addresses the difficulty of immune-cell visualization.

Dr. Zhaogang Teng is a Professor and doctoral supervisor at the Institute of Advanced Materials (IAM), Nanjing University of Posts and Telecommunications. He received his Ph.D. in Physical Chemistry from Jilin University (2009), followed by postdoctoral research at Fudan University and Jinling Hospital, where he later served as Director of the Molecular Imaging Laboratory. His research focuses on the design of functional biomaterials for precision diagnosis and therapy of malignant tumors, including mesoporous molecular imaging probes and stimulus-responsive nanomedicines. He has published 180 SCI papers in journals such as J. Am. Chem. Soc., Adv. Mater., and Angew. Chem. Int. Ed., and has received honors including the First Prize of the Jiangsu Science and Technology Award.

Theme 4: Emerging Materials for Diagnostics and Therapeutics

From Sensing to Therapy: Carbon Dot–Hydrogel Platforms for Complex Wound Healing

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Abstract: Complex wound healing remains challenging because bacterial infection, excessive inflammation, oxidative stress, and impaired angiogenesis often coexist and delay tissue repair. Here, we present two complementary carbon dot (C-dot)–hydrogel platforms that harness the multifunctional properties of C-dots[1] to advance wound management from sensing to therapy. In the first system, C-dots were incorporated into an ionically crosslinked sodium alginate hydrogel to integrate wound monitoring with responsive therapeutic delivery. The C-dots provide visible, pH-responsive fluorescence for monitoring changes in the wound microenvironment while simultaneously functioning as superoxide dismutase (SOD)-like nanozymes to scavenge reactive oxygen species (ROS). The hydrogel further enables responsive C-dot release. In vitro studies demonstrated excellent cytocompatibility, enhanced fibroblast proliferation, and protection against ROS-induced cellular damage. In the second system, C-dots were incorporated into a poly(vinyl alcohol) hydrogel to address multiple pathological factors in complex wounds. The C-dots exhibited high SOD-like activity (13,577 U mg^{-1}) and efficient photothermal conversion (η = 38.51%), enabling ROS scavenging, anti-inflammatory activity, photothermal antibacterial treatment, and promotion of angiogenesis. The hydrogel achieved >99% antibacterial efficacy against Escherichia coli and Staphylococcus aureus and accelerated repair in an LPS-induced inflammatory wound model. Together, these platforms demonstrate the potential of C-dot hydrogels for integrated wound sensing and multimodal therapy[2].

Dr. Lei Bao is an interdisciplinary materials scientist and engineer and a Senior Lecturer in Chemical and Environmental Engineering at RMIT University. Lei leads an interdisciplinary research team developing advanced materials and nanoplatforms for applications spanning sustainable technologies, environmental sensing, disease diagnosis, and treatment. Lei is also committed to fostering an inclusive research environment where students and early-career researchers can develop and thrive in STEM. She has received several competitive fellowships and prestigious awards, including the NHMRC Investigator Grant (2026), the ARC Discovery Early Career Researcher Award (2019), the 2026 Victorian Young Tall Poppy Science Award (2026), the RMIT Research Excellence Award for Early Career Researchers (2019), and the Australian Colloid and Interface Society Female ECR Award (2017).

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Theme 5

Sustainable Energy Storage and Applications

Theme 5: Sustainable Energy Storage and Applications

Wiring Proton Gradients for Energy Conversion via Light-Responsive Molecular Switches

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Abstract: Harnessing light energy for sustainable energy conversion is a key challenge in developing next-generation energy technologies. In this work, we introduce a molecular-switch approach based on merocyanine photoacids to create and control proton gradients in aqueous environments. By tuning the solvation environment in water–methanol mixtures, these switches produce substantial, reversible changes in acidity, generating proton concentration gradients of up to 4 pH units under 500 nm irradiation. This controlled, light-triggered proton transfer can be coupled to an electrochemical readout, delivering stable open-circuit voltages up to 240 mV.

More broadly, this platform establishes a route to photo-responsive proton-gradient control without committing to a specific device concept. The ability to modulate proton activity with molecular-level precision provides a useful analogue to biological energy transduction and offers a versatile basis for integrating photoacids into functional architectures. These findings highlight opportunities for developing responsive materials and interfaces that translate light inputs into programmable chemical and electrical outputs, with relevance to artificial molecular systems and related energy-conversion strategies.



Dr. Dong Jun Kim is a Senior Lecturer at the School of Chemistry, UNSW Sydney, where he leads a research group at the intersection of supramolecular chemistry and materials science. He earned his B.S. and Ph.D. in Materials Science and Engineering from Yonsei University (2010) and KAIST (2015), respectively, before pursuing postdoctoral research at Northwestern University under the mentorship of Sir Fraser Stoddart. Since establishing his independent group at UNSW in 2018, Dr. Kim has been awarded the ARC DECRA Fellowship (2021–2023) and has focused his research on developing artificial molecular machines and supramolecular materials for advanced energy storage applications.

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Theme 5: Sustainable Energy Storage and Applications

Battery Electrolytes: From Molecules to Devices

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Abstract: Reliable battery technologies require non-flammable electrolytes that transport ions efficiently while forming stable, ion-conductive and electron-insulating interphases. Electrolyte design still relies largely on trial and error, which limits the discovery of the most promising formulations. In addition, standard physicochemical properties are often insufficient to explain why some formulations fail while others succeed. This talk will show how computational chemistry, combined with experiment, can inform the design of new battery electrolyte materials. I will present examples of hidden properties of electrolytes in the bulk phase and at the electrified interface that are not apparent at first glance, yet play a determining role in device performance.[1,2] The same approach can guide the design of optimal cycling conditions that extend battery lifespan, such as initial interphase formation protocols.[3,4]



Dr Dmitrii Rakov is a Research Fellow at Adelaide University and an Adjunct Fellow at AIBN, The University of Queensland. He received his PhD from Deakin University under Prof. Maria Forsyth in December 2022. His research experience spans institutions such as Ural Federal University, Harbin Institute of Technology, NASA Ames Research Center, The University of Queensland, CSIRO, and Adelaide University. His research combines molecular simulation with electrochemistry to design electrolytes and formation-cycling protocols for sodium, ,lithium and aluminium batteries, in collaboration with Australian industry. He has secured grants from Australia's Economic Accelerator (Co-CI), ANSTO (beamtime, Co-CI) and the National Computational Infrastructure (CI), as well as an Impossible Without You (IWY) CSIRO Fellowship and awards from the Royal Australian Chemical Institute (Young Electrochemist 2022) and The Electrochemical Society (3 × Travel Grants, Best Presentation Award). His publication record includes first-, co-first- and corresponding-authored papers in Nature Materials (IF = 44.1), Energy & Environmental Science (IF = 34.5, ×2), ACS Nano (IF = 16.2), Angewandte Chemie (IF = 16.6, ×2, one Hot Paper), Nano Letters (IF = 10.8) and others.

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Theme 5: Sustainable Energy Storage and Applications

Overcoming redox barriers in black phosphorus negative electrodes through lattice P–N engineering for fast-charging Li-ion batteries

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Abstract: Electrochemical energy storage devices commonly face a trade-off between specific energy and power capability. Black phosphorus offers a high theoretical capacity of 2596 mA h g-1, but its practical application is limited by slow reaction kinetics during multiphase phosphorus redox processes. These sluggish transformations, involving bond rearrangement and soluble intermediates, hinder fast charging and compromise cycling stability. Here we show that introducing phosphorus-nitrogen bonds into a black phosphorus/carbon composite regulates the reaction pathway and accelerates charge transport. The engineered bonding environment modifies the electronic structure of black phosphorus and lowers lithium-ion diffusion barriers, enabling faster lithiation and delithiation. Meanwhile, nitrogen sites in the carbon matrix confine lithium-phosphorus intermediates, reducing their migration and improving structural stability. This combined effect enhances both rate capability and reversibility. When coupled with lithium iron phosphate in a pouch cell, the composite negative electrode delivers a specific energy of 282 Wh kg-1 and retains 80% of its capacity after 10 minutes of charging at high specific current. The device also maintains stable operation over thousands of cycles, demonstrating improved durability under fast charging conditions.



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Theme 5: Sustainable Energy Storage and Applications

Advanced aqueous Zn battery design with conversion-based cathodes

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Abstract:
Aqueous zinc-ion batteries (ZIBs) are attracting growing attention as safe, low-cost, and environmentally sustainable energy storage systems. Nevertheless, their development has been constrained by conventional intercalation-type cathodes, which rely on Zn2+/H+ co-intercalation. The inevitable participation of H^+ causes electrolyte pH fluctuations and by-product formation, compromising reproducibility and long-term stability. To address these challenges, I pioneered a conversion-type cathode mechanism that avoids H^+ involvement, significantly improving electrochemical stability while broadening the cathode landscape. This concept has been successfully extended to halogen-based systems such as I_2, further demonstrating its versatility. In parallel, I introduced dry electrode fabrication into aqueous batteries for the first time, achieving record areal loadings of over 100 mg cm^{-2}, which is 4–5 times the industrial benchmark of commercial lithium-ion batteries. This breakthrough not only overcomes the limitations of conventional slurry-based processing but also demonstrates the compatibility of aqueous batteries with scalable, high-energy-density electrode manufacturing. Collectively, these advances, from mechanistic innovation to electrode engineering, have accelerated the transition of ZIBs from fundamental laboratory research to practical application, laying a strong foundation for the development of safe, sustainable, and commercially competitive energy storage technologies.



Dr. Junnan Hao is a Senior Lecturer and ARC DECRA Fellow at Adelaide University. His research focuses on energy storage and conversion, particularly aqueous batteries and flexible energy storage devices. He has published more than 100 peer-reviewed papers, including over 30 ESI Highly Cited Papers (top 1% globally). His publications have received over 16,000 citations, with an h-index of 61. Dr. Hao has received numerous recognitions and awards, including Clarivate Highly Cited Researcher, ScholarGPS Highly Ranked Scholar, inclusion in the Stanford University World's Top 2% Scientists List, the Journal of Materials Chemistry A Emerging Investigator Award, the Chemical Communications Emerging Investigator Award, the Energy Renaissance Award, and the AINSE Early Career Researcher Excellence Award from the Australian Institute of Nuclear Science and Engineering.

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Theme 5: Sustainable Energy Storage and Applications

Phonon Engineering for High-Performance Thermoelectric Materials

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Abstract:
Thermoelectric technology offers sustainable solutions for power generation, waste-heat recovery, and refrigeration. Improving the thermoelectric figure of merit (zT) is essential for enabling its widespread commercial application. Unlike electrical conductivity and the Seebeck coefficient, which are coupled through electron transport, lattice thermal conductivity (k_l) is governed by phonon transport. Therefore, reducing κ_l provides an effective pathway to enhance zT. Our research has developed mechanisms to strengthen phonon scattering and suppress k_l. First, we established a strategy for tuning phonon dispersion to enhance intrinsic phonon–phonon scattering in Sb-alloyed GeTe.[1-2] Second, conventional point defects and grain boundaries scatter high- and low-frequency phonons, respectively, leaving mid-frequency phonons less affected. To address this limitation, we introduced high-density dislocations into Bi_2Te_3 through mechanical plastic deformation and generated stacking faults in $AgSbTe_2$ by controlling the synthesis process.[3-4] Third, high-density planar vacancies and superlattice precipitates were created in GeTe-based materials to further broaden the phonon-scattering spectrum.[5] Advanced electron microscopy and density functional theory calculations were employed to reveal the relationships between structural imperfections, phonon transport, and reduced k_l. These approaches resulted in enhanced zT across multiple thermoelectric material systems. The established phonon-engineering strategies provide applicable routes for tailoring thermal transport and improving thermoelectric performance.



Prof. Min Hong is a Professor and ARC Future Fellow at the University of Southern Queensland, Australia. His research focuses on thermoelectric technology, including semiconductor thermoelectric materials, organic/inorganic flexible thermoelectrics, physical/chemical principles of transport properties, and thermoelectric devices for refrigeration and power generation. As the leading author, he has secured publications in Joule, Energy & Environmental Science, Nature Communications, Advanced Materials, Advanced Energy Materials, Journal of the American Chemical Society, etc. He has also obtained fundings ARC and iLAuNCH Trailblazer, Department of Education, Australia.

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Theme 5: Sustainable Energy Storage and Applications

Observing Phase Transitions in Confined Volumes

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Abstract: Electrochemical reactions often involve dynamic phase and compositional transformations at interfaces, yet the fundamental mechanisms governing these processes remain challenging to resolve because they occur over highly localized length and time scales. Scanning electrochemical cell microscopy (SECCM) provides a unique platform for investigating such phenomena by confining electrochemical measurements within a microscopic droplet at the end of a pipette, creating a well-defined reaction volume with exceptional spatial and temporal control. Particular focus is placed on electrochemically driven phase transitions in confined environments, exemplified by hydrogen bubble formation during the hydrogen evolution reaction and metal dissolution/deposition in the intermetallic system. The confined droplet geometry enables direct investigation of the liquid-to-gas transition, revealing how local supersaturation, interfacial chemistry, mass transport, and three-phase boundary dynamics govern bubble nucleation and growth. In parallel, SECCM provides unprecedented insight into metal transport and redistribution processes, enabling site-specific investigation of dissolution, nucleation, alloying, and redeposition phenomena in the Ga-Pt system, where confinement strongly influences interfacial stability and phase evolution. Together, these studies demonstrate how electrochemistry in a pipette offers a powerful framework for visualising and quantifying phase transitions at electrochemical interfaces, providing fundamental insights relevant to electrocatalysis, energy conversion, and advanced materials processing.



Dr Minkyung Kang is a Senior Lecturer at the University of Sydney. She received her PhD in Chemistry from the University of Warwick in 2018, where she developed advanced electrochemical imaging techniques for single-nanoparticle analysis. Her research focuses on nanoscale electrochemistry, particularly the development of scanning electrochemical probe microscopy and single-entity approaches to understand structure–activity relationships in energy materials and sensors.

Theme 5: Sustainable Energy Storage and Applications

Ultra-Thin Hybrid Ion Exchange Interlayer for High Performance Aqueous Zn Metal Batteries

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Abstract: The application of aqueous zinc metal batteries (AZMBs) is limited by the poor cycling stability and undesired dendritic growth of Zn anodes. Herein, a Zn anode with an ultra-thin sulfonated poly(ether ether ketone) (SPEEK) and fluorinated carbon dots (FCDs) hybrid interlayer is developed to enhance AZMBs performance. The SPEEK/FCD interlayer possesses excellent stability and is found to play multiple functions, including effectively regulating electrolyte solvation structure by ion-exchange groups, promoting ion transport through the ion-exchange channels of the hybrid SPEEK/FCD interlayer, inducing the in-situ formation of a stable ZnF2-rich solid electrolyte interphase (SEI), and accommodating volume fluctuations during Zn plating/stripping cycles. As a result, at 1 mA cm−2and 1 mAh cm−2, Zn||Zn symmetric cells with the optimized SPEEK/FCD Zn electrode exhibit an ultralong lifespan of over 5500 h, much better than that of the bare Zn electrode (119 h). In addition, at 1 A g−1after 1000 cycles, the Zn||V2O5 full cell with the optimized electrode retains 89.8% of its initial capacity, compared to 40.3% for the bare Zn electrode. These superior performances indicate the optimized Zn electrode is promising for next-generation AZMBs. Also, the simple and scalable method offers a valuable reference for improving the performance of other aqueous batteries and beyond.



Tong Yang is a postdoctoral researcher and Senior Research Assistant at the School of Chemistry and Physics, Queensland University of Technology (QUT), Australia. He is a member of Professor Hongxia Wang's research group and currently conducts his research under the supervision of Dr. Jiaye Ye. He received his PhD from QUT, with research focused on advanced materials and interfacial engineering for rechargeable metal batteries. His current research interests include zinc and sodium metal batteries, functional polymer interfaces, electrolyte regulation, and advanced separator design. His research aims to develop functional materials and interface engineering strategies to improve the stability and electrochemical performance of next-generation energy storage systems.

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Theme 5: Sustainable Energy Storage and Applications

Engineering Sulfur Reaction Pathways for High-Energy Metal Sulfur Batteries

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Abstract

Metal–sulfur batteries offer high theoretical energy densities but remain limited by polysulfide shuttle, sluggish conversion kinetics, and challenges under practical sulfur-loading and lean-electrolyte conditions. Here, we explore sulfur chemistry from electrolyte-mediated conversion in Li–S batteries to cathode-confined quasi-solid-state conversion in room-temperature Na–S batteries. In ether-based Li–S systems, low-tortuosity conductive carbon architectures regulate polysulfide transport while maintaining rapid solution-mediated conversion, enabling high sulfur loading. In carbonate-based Na–S systems, suppressing bulk polysulfide dissolution shifts the reaction toward localized quasi-solid-state conversion, where sluggish sulfur redox becomes a major kinetic bottleneck. Catalytic regulation, particularly through engineered undercoordinated Mo sites, promotes electron transfer and accelerates reversible conversion of short-chain sulfur species. These studies demonstrate that controlling sulfur reaction pathways through integrated electrode architecture, electrolyte chemistry, and catalytic-site engineering provides a general strategy toward practical high-energy metal–sulfur batteries.



Dr Nana Wang is an ARC Future Fellow at the University of Technology Sydney. Her research focuses on advanced energy-storage materials and technologies, including solid-state batteries, lithium-metal batteries, sodium-ion batteries, and metal–sulfur batteries. Her current research aims to understand and regulate electrode–electrolyte interfaces and reaction pathways to develop safe, high-energy, and long-life rechargeable batteries.

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Theme 5: Sustainable Energy Storage and Applications

Design of Sub-Nanoscale Active Sites for Energy Conversion Applications

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Abstract: This presentation examines heterogeneous electrochemical processes at electrode interfaces, with a focus on advancing clean energy conversion, storage, and utilization. A central challenge in this field is the design of high-performance inorganic electrocatalysts that can sustain robust activity under operando conditions. Addressing this challenge requires a fundamental understanding of the structural, crystalline, and electronic properties of sub-nanoscale active sites as they evolve during real-time operation. To this end, we employ advanced in-situ characterization techniques—including X-ray Absorption Spectroscopy (XAS), X-ray Diffraction (XRD), and Raman spectroscopy—to probe the dynamic behavior of transition-metal-based catalysts (Mn, Fe, Co, Ni, Cu, Ru, Bi, Ag, Ir) in essential electrochemical reaction in water, carbon dioxide electrolyzers, rechargeable zinc air batteries, hydrogen fuel cells, and biomass molecule electrochemical hydrogenation. Our investigation reveals the evolution of precursors into sub-nanoscale active catalytic states and establishes direct correlations between structural/electronic modulation and catalytic performance. In particular, the observed activity enhancements are attributed to electronic interactions with supporting substrates and the unique chemical environments engendered by sub-nanoscale architectures. These insights provide a mechanistic foundation for rationally engineering durable, high-efficiency electrocatalysts for sustainable energy applications.



Porun Liu received his PhD in chemical science in 2011 from Griffith University. He subsequently worked as a Research Fellow in the Centre for Catalysis and Clean Energy. He was awarded a Griffith University Postdoctoral Research Fellowship in 2015, an Australian Research Council Discovery Early Career Researcher Award in 2017 and an Australian Research Council Future Fellowship in 2024. He is now a Professor in the School of Environment and Science, Griffith University, focusing on synthesis, in situ characterisataalysts in energy conversion, storage and carbon dioxide conversion.

Theme 5: Sustainable Energy Storage and Applications

Interfacial Engineering for Metal-Based Rechargeable Batteries

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Abstract
The surging global demand for sustainable energy and the depletion of fossil-fuel reserves underscore the urgent need for advanced energy storage systems. Metal-based rechargeable batteries offer compelling advantages in energy density, cost, and sustainability. However, the practical implementation of these systems is often hindered by instability in the metal plating/stripping process, leading to dendrite growth, parasitic reactions, corrosion, and loss of active material. These interfacial challenges are universal across monovalent and multivalent metal systems, and overcoming them is critical for enabling long-life, high-performance batteries.
This presentation will discuss recent progress in interfacial engineering and functional material design to control metal deposition behaviour. For sodium metal, we demonstrate that carbon nanofiber films with dynamically coordinated tin single atoms can not only enhance Na-ion adsorption at coordinated sites but also activate remote carbon atoms, yielding uniform sodium deposition, complete stripping, and stable cycling for 1200 h at 100 mA cm^{-2}. For zinc metal, we present a biomimetic antifreeze protein-based localized gel electrolyte that tailors Zn^{2+} solvation and promotes (002) Zn-faceted growth, suppressing dendrites, hydrogen evolution, and corrosion. This approach enables symmetric Zn cells to operate for 610 h at 10 mA cm^{-2} and delivers excellent stability in practical pouch cells. Additionally, this talk will provide a brief glimpse into our research endeavours, including collaborative efforts with industry partners, in the realm of Zn and Fe based redox flow battery technologies.



A/Prof Bin Luo is an ARC Mid-Career Industry Fellow & Group Leader in Australian Institute for Bioengineering and Nanotechnology (AIBN) & School of Chemical Engineering at the University of Queensland (UQ). He received his doctoral degree in Physical Chemistry from National Centre for Nanoscience and Technology of China, University of Chinese Academy of Sciences in July 2013. Dr Luo's research focuses on the design of new functional nanomaterials for energy storage applications.

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Theme 5: Sustainable Energy Storage and Applications

Molecular Insight into the Structure of Poly(Ionic Liquids) for Sodium Metal Battery Applications

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Polymer electrolytes hold great promise in developing next-generation high-energy density metal batteries. In addition to inhibiting dendrite formation, they are flexible, more stable and safer than liquid electrolytes. However, their practical applications is limited by generally low ionic conductivity at room temperature, typically two orders of magnitude lower than liquid electrolytes, and low metal ion transference numbers, often less than 0.5.

Cationic poly(ionic liquids) (PolyILs), with ionic liquid cations attached to polymer backbones, have attracted significant attention in recent years, due to their potential to simultaneously achieve high ionic conductivity and high metal-ion transference numbers. One such PolyIL, Polydiallyldimethylammonium bis(fluorosulfonyl)imide (PDADMA FSI), has demonstrated fast sodium ion diffusion at high salt concentrations, achieving an ionic conductivity of up to 10^{-3} S cm^{-1} and a Na transference number above 0.5 at 80°C [1]. These promising results inspire the further development of novel PolyILs with enhanced properties, which require the in-depth fundamental understanding that guides this design.

In the present work, we report our computational investigation of novel PolyILs based on phosphonium cations, which exhibit improved ionic conductivities compared to their ammonium-based counterparts. Specifically, here we present (1) the effect of longer side chains attached to the polycations on the morphology of PolyIL and its salt-concentrated system and the ion transport; and (2) the impact of different polycation architectures characterized by varying distances between the cationic centre and the polymer backbone. Our findings offer new insights into the relationship between PolyIL structure and sodium conduction, which is critical for their application in sodium metal batteries.

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Theme 5: Sustainable Energy Storage and Applications

Perovskite Oxide Electrocatalysts for Anion Exchange Membrane Water Electrolysis: From Materials Design to Device Performance

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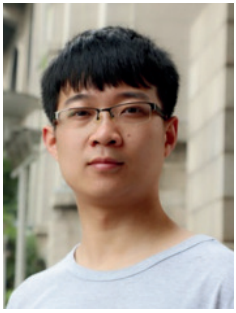
Green hydrogen produced by water electrolysis is expected to play an important role in the transition towards a low-carbon energy system. Among the available technologies, anion exchange membrane water electrolysis (AEMWE) has attracted growing interest because it combines the potential for high operating current densities with the use of lower-cost, non-noble-metal catalysts. However, the sluggish oxygen evolution reaction (OER) at the anode remains a major challenge limiting electrolyser efficiency and durability. Perovskite oxides, with the general formula ABO_3, where A is typically a rare-earth or alkaline-earth metal and B is a transition metal, are promising electrocatalysts owing to their compositional and structural flexibility.[1-4] Here, we demonstrate how tailoring the composition, structure and oxygen-related properties of perovskite oxides can advance both the fundamental understanding of OER electrocatalysis and the development of improved catalysts for AEMWE.[5-9] We highlight the versatility of perovskite oxides as a materials platform and demonstrate how fundamental catalyst understanding can be translated into improved electrolyser performance, offering opportunities for the development of efficient, durable and cost-effective water electrolysis technologies for sustainable hydrogen production.



Dr Xiaomin Xu is currently Senior Lecturer at the Curtin Centre for Advanced Energy Materials and Technologies (CAEMT), Western Australian School of Mines (WASM), Curtin University, Australia. He received his PhD degree in Chemical Engineering from WASM, Curtin University in 2021. His research interests focus on the development of functional materials for applications in electrochemical energy storage and conversion.

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Theme 5: Sustainable Energy Storage and Applications

Graphene Oxide–Silica Microcapsules Containing Phase Change Materials for Thermal Energy Storage

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Abstract:
Phase change materials (PCMs) utilize reversible phase transitions (e.g. solid–liquid) to store large quantities of heat. However, many organic PCMs suffer from low thermal conductivity and leakage problems during the solid-liquid phase transition that can be addressed using microencapsulation. In this work, we developed a scalable, surfactant-free Pickering emulsion templating method to microencapsulate paraffin wax within silica-graphene oxide shells. Graphene oxide serves dual functions as both emulsion stabilizer and interfacial catalyst for silica formation via sol-gel chemistry. We achieved 94% encapsulation efficiency and excellent thermal stability demonstrated over 500 melt-crystallization cycles. The obtained PCM is inherently flowable, demonstrating a 34% increase in heat transfer coefficient relative to water and directly mitigates paraffin's intrinsic thermal conductivity limitation.



Joyee Wong is a PhD candidate in the research group of Professor Rico Tabor at Monash University, Australia. She designs robust, scalable microcapsules from biopolymers and sustainable feedstocks, with the goal of making encapsulation technology cleaner and easier to manufacture. Her work centres on graphene oxide as a surfactant-free emulsifier. She studies how its surface chemistry and degree of reduction control its behaviour at oil–water interfaces, and uses that knowledge to tailor capsule performance. Her systems have applications in thermal energy storage, industrial heat management and controlled release. Combining materials characterisation with interfacial science, Joyee is focused on turning fundamental insight into practical, sustainable products

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Theme 5: Sustainable Energy Storage and Applications

Hard Carbon Anodes for High-Performance Sodium-Ion Batteries: From Processing to Electrochemical Performance

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Abstract:
Energy storage technologies are central to the transition towards a low-carbon energy system, driving the need for battery technologies that are scalable, cost-effective, safe and supported by secure supply chains. Sodium-ion batteries (SIBs) have emerged as a promising alternative to lithium-ion batteries (LIBs), offering the potential to reduce reliance on critical lithium resources while leveraging many of the established materials, manufacturing processes and technological advances developed for LIBs. A key distinction between the two technologies lies in the anode. Whereas commercial LIBs predominantly rely on highly ordered graphite, sodium storage is favoured in non-graphitizable carbons, commonly referred to as hard carbons. Hard carbons offer considerable opportunities for materials design because their structure and electrochemical properties can be tailored through precursor selection and thermal conversion. In particular, the use of low-cost and renewable feedstocks, including agricultural and biomass waste streams, provides an attractive pathway towards sustainable and potentially scalable hard carbon production. However, achieving consistently high electrochemical performance remains challenging, with low initial Coulombic efficiency, limited rate capability and complex sodium-storage mechanisms continuing to constrain their application.
In this talk we explore how the choice of precursors, conversion process used, temperature, atmosphere, time, rate, electrolyte and pre sodiation influence electrochemical performance drawing some conclusions on the role of the solid electrolyte interphase and the bulk material properties of the hard carbon on sodium storage mechanism and overall electrochemical performance



Associate Professor Nolene Byrne is a researcher at Deakin University Institute for Frontier Materials whose work focuses on developing advanced materials for next-generation energy storage systems. Her research investigates sustainable carbon anodes, ionic liquid electrolytes, and electrode–electrolyte interfaces for sodium-ion and lithium-ion batteries. She combines materials synthesis with advanced characterisation to understand battery degradation and improve performance, safety, and lifetime. Her research supports the development of high-performance, sustainable battery technologies for renewable energy storage and electrification.

Theme 5: Sustainable Energy Storage and Applications

Lignocellulose-Derived Hard Carbon for Sodium-Ion Battery Anodes

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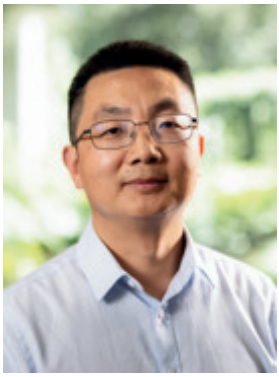
Abstract: Lignocellulosic biomass, such as sugarcane bagasse and eucalyptus wood, is recognised as a promising precursor to produce hard carbon (HC) for sodium-ion battery (SIB) anode applications because it is low-cost, abundant and renewable. However, the feedstock complexity and variability make the precise control of HC microstructure challenging. As a result, the resulting hard carbon anodes often have low reversible sodium-ion storage capacities of <300 mAh/g and low initial coulombic efficiencies (ICEs) of <85%. Lignocellulose is composed of cellulose, hemicellulose and lignin as three major components. In order to improve electrochemical performance of resulting HC materials, sophisticated and costly precursor modification and carbonisation approaches have been developed and reported. However, many of these reported approaches are neither scalable nor economically feasible.

Prof Zhanying Zhang and his group have been working on value-adding to lignocellulose since 2008. From 2023, his group has been focusing on developing cost-effective, scalable approaches for producing lignocellulose-derived HC anodes. His group has discovered that (1) removal of hemicellulose from alkaline lignin significantly improved the reversible Na-ion storage capacity and the ICE of resulting HC[1], (2) acid-catalysed ethanol pretreatment fractionated lignocellulose into superior cellulose and lignin precursors for HC synthesis[2], (3) melamine-based nitrogen-doping approach further improved the reversible storage capacity of ethanol lignin-based HC (unpublished), and (4) an innovative low-cost, scalable approach led to cellulose-based HC with electrochemical performance comparable to coconut shell-based coconut HC (unpublished). In this presentation, Prof Zhanying Zhang will summarise and discuss their recent achievements in lignocellulose-derived SIBs.



Professor Zhanying Zhang's group at QUT is dedicated to developing advanced biorefinery technologies to add value to agricultural, forestry, and food processing waste. Their work focuses on producing high-value functional materials, such as lignocellulose-based nanomaterials, biodegradable polymers and carbon materials, for applications in packaging/agricultural mulching, electrochemical energy storage and thermal energy management. Additionally, the group also develops high-value functional ingredients, such as oligosaccharide-based prebiotics and polysaccharide-based oleogels for food applications

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Theme 5: Sustainable Energy Storage and Applications

Interfacial Engineering and Mechanistic Characterisation for Next-Generation Sodium-Ion Batteries

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Abstract: Sodium-ion batteries (SIBs) have emerged as a promising technology for large-scale electrochemical energy storage owing to the natural abundance and low cost of sodium resources. However, their long-term cycling stability, rate capability, and energy density are strongly influenced by complex interfacial reactions and charge-storage mechanisms. This presentation will highlight our recent efforts in interfacial engineering and advanced characterisation to address these challenges and develop a fundamental understanding of sodium-ion battery chemistry.

For Prussian blue analogue (FePB) cathodes, we developed a sulphur-containing cathode–electrolyte interphase (S-CEI) through orbital hybridisation between Fe 3d orbitals in FePB and O sp^2 orbitals in 1-propene-1,3-sultone.[1] The resulting robust interphase was strongly anchored to the cathode surface and effectively suppressed the detrimental cubic-to-tetragonal phase transition during cycling. Consequently, the unit-cell volume shrinkage was substantially reduced, enabling a capacity decay of only 0.013% per cycle over 1,500 cycles at 1C, an exceptional rate capability of up to 90C, and stable operation over a wide temperature range from −20 to 60 °C.

Advanced characterisation techniques were further employed to elucidate sodium deposition and storage mechanisms. Using non-cryogenic transmission electron microscopy (TEM), we directly observed epitaxial interactions between the (002) planes of sodium crystallites and the (01–11) planes of zinc current collectors.[2] These interactions lower the nucleation energy barrier and promote uniform sodium deposition, providing a mechanistic basis for the development of high-energy-density sodium-based anode-free batteries. In parallel, high-resolution electron paramagnetic resonance (EPR) spectroscopy, complemented by in situ Raman spectroscopy and in situ synchrotron X-ray diffraction, was used to resolve the complex sodium-storage chemistry of hard carbon anodes.[3] These measurements provide new insights into the respective contributions of Na^+ intercalation, Na^+–solvent co-intercalation, defect-site storage, and quasi-metallic and metallic sodium formation.

Together, these studies demonstrate how rational interfacial engineering combined with multimodal advanced characterisation can reveal fundamental structure–interface–performance relationships and provide design principles for next-generation sodium-ion batteries.

Dr Qingbing Xia received his PhD from the University of Wollongong and has been a Research Fellow at The University of Queensland since 2020. His research focuses on advanced electrode and electrolyte materials for next-generation batteries, with particular emphasis on understanding electrochemical reaction mechanisms through in situ, operando, and advanced characterisation techniques. He has published more than 60 peer-reviewed papers in leading journals, including Advanced Materials, Angewandte Chemie International Edition, and Advanced Energy Materials. His research has attracted over 4,000 citations, with an h-index of 32. Dr Xia also serves as a reviewer for more than 30 international journals, including Nature Energy, Nature Communications, and Energy & Environmental Science, and as an external assessor for major research funding agencies, including the Australian Research Council (ARC), the National Natural Science Foundation of China (NSFC), and the European Research Council (ERC).

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Theme 5: Sustainable Energy Storage and Applications

Balancing Transport and Interfacial Stability in Solid-State Battery Cathodes

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Abstract:
All-solid-state batteries employing sulfide solid electrolytes offer attractive ionic conductivity and processability, but their performance remains limited by instability and coupled transport limitations within the composite cathode. Conductive carbon illustrates this challenge particularly well. It is required to establish electronic percolation and improve active-material utilization, yet it can also promote oxidative decomposition of sulfide electrolytes and accelerate cathode interfacial degradation. This presentation examines how the chemistry, distribution, and transport characteristics of conductive additives govern the performance of layered-oxide cathodes paired with Li_6PS_5Cl. We first show that controlled oxygen functionality on conductive carbon enables the in situ formation of a stabilizing carbon–electrolyte interphase, suppressing electrolyte decomposition while retaining effective electronic transport. For Ni-rich NMC cathodes, this stabilization prevents the progressive electrochemical isolation of active particles caused by resistive interphase formation. State-of-charge-resolved impedance and intermittent-titration measurements further reveal that interfacial degradation generates dynamic transport limitations that are not captured by conventional resistance measurements alone, particularly at low states of charge. Building on these findings, we show that cathode performance is maximized within an optimum ionic and electronic conductivity window. Insufficient electronic transport limits active-material utilization and promotes particle isolation, whereas excessive electronic conductivity accelerates sulfide-electrolyte decomposition. These results demonstrate that conductive carbon is neither inherently beneficial nor detrimental. Rather, durable solid-state cathodes require deliberate balancing of electronic percolation, ionic connectivity, and interfacial reactivity.

Dr Dipan Kundu is an Associate Professor at UNSW Sydney and leads the Laboratory for Battery Research and Innovation (LBRI). His research focuses on solid-state batteries, aqueous zinc-ion batteries, lithium and sodium-based systems, battery recycling, and the fundamental relationships between battery materials, interfaces, and transport processes. He received his PhD from ETH Zurich and has held a postdoctoral position at the University of Waterloo with Prof. Linda Nazar and an SNSF Ambizione Group Leader fellowship at ETH Zurich. Having worked closely with industry during his PhD and postdoc, he has had significant exposure to translational research. One of his discoveries led to a battery start-up (Salient Energy) in Canada, and in 2024 he co-founded 'ZenQuo', a UNSW spin-off aiming to develop an aqueous battery technology for stationary and backup-power applications.

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Theme 5: Sustainable Energy Storage and Applications

Catalyst materials for photothermal catalysis

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Abstract:
Photothermal catalysis provides an emerging strategy to bridge photocatalysis and thermocatalysis by designing catalyst materials that simultaneously harvest solar irradiation, generate localised thermal energy, and promote catalytic reactions[1]. This presentation focuses on the development of catalyst materials for photothermal catalysis, with particular emphasis on their application to solar-driven production of clean fuels and chemicals[2]. Fundamental interactions between light and catalytic materials, including electronic excitation involving atomic and molecular orbitals, energy-band transitions, non-radiative energy dissipation, and light-induced thermal effects, will be discussed in relation to catalytic performance.
The presentation will further explore materials strategies for integrating photochemical activation with light-induced thermocatalysis, thereby enabling complementary utilisation of photon and thermal energy. Particular attention will be given to the relationships among light absorption, electronic structure, thermal response, active-site chemistry, and reaction pathways, including their roles in demanding transformations such as methane reforming. By integrating catalyst design with reaction and reactor considerations, photothermal catalysis offers opportunities to exploit a broader fraction of the solar spectrum and to control energy delivery directly at catalytic interfaces[3]. Continued advances in photothermal catalyst materials may ultimately enable more efficient solar-to-chemical manufacturing, contributing to lower carbon emissions and reduced dependence on fossil-derived energy and feedstocks.



Professor Hongqi Sun is a University Professor of Chemistry and ARC Future Fellow at The University of Western Australia (UWA), where he serves as Director of the UWA Centre for Future Catalysis. His research focuses on advanced catalytic materials and processes for clean energy and sustainable chemical production, with particular interests in photothermal catalysis, solar-driven chemical transformations, critical minerals, and emerging space catalysis. His current research extends catalysis beyond terrestrial environments, including solar-driven chemical manufacturing under altered-gravity conditions.
Professor Sun has published more than 350 refereed journal articles and received over 50,000 citations. He was awarded the 2023 Western Australian Premier's Science Award for Mid-Career Scientist of the Year. He serves on the ARC College of Experts and the Board of the Minerals Research Institute of Western Australia (MRIWA), and is Editor-in-Chief of Cleaner Chemical Engineering.

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Theme 5: Sustainable Energy Storage and Applications

Energy-Efficient Plasma Nitrogen Fixation via Ozone-Enhanced Electrodeless Bubble Discharge

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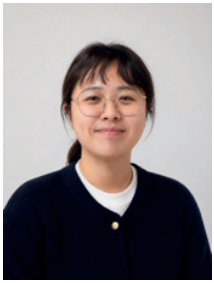
Electrically driven plasma nitrogen fixation offers a promising pathway for sustainable and distributed nitrogen conversion. However, plasma-activated water (PAW) systems are often limited by inefficient transfer of plasma-generated nitrogen oxides (NO_x) into the liquid phase, resulting in reactive nitrogen losses and high apparent energy costs.[1]
In this work, an electrodeless bubble discharge reactor was developed to integrate reactive oxygen and nitrogen species (RONS) generation, oxidation, transport, and absorption within a single plasma-liquid zone.[2] The bubble discharge configuration enhances gas-liquid mass transfer while avoiding electrode erosion. By introducing 0.1% O_3 into air, gas-phase NO_x chemistry was shifted toward highly soluble, high-valence nitrogen species, particularly N_2O_5, enabling more efficient uptake at the gas-liquid interface.
Under power-matched conditions, ozone enhancement dramatically improved liquid-phase nitrogen fixation, achieving at least 99.4% RONS capture efficiency, 99.1% liquid-phase RNS selectivity, and an RNS productivity of 6.36 mmol h^{-1}, with an overall energy cost of 9.9 MJ mol^{-1}, including ozone generation. Mechanistic analysis indicates that ozone promotes oxidation of NO and NO_2 toward N_2O_5, which is subsequently absorbed and hydrolysed to form nitrate-dominated liquid products. These results demonstrate an energy-efficient strategy for sustainable, electrically driven nitrogen fixation and distributed production of nitrogen-containing liquid products for agricultural applications.



Jingyi Luo is a PhD candidate and Associate Lecturer in the School of Chemical and Biomolecular Engineering at the University of Sydney, Australia. Her research focuses on low-temperature plasma technologies for sustainable chemical processes, particularly plasma-assisted nitrogen fixation and plasma-liquid interactions. Her current work explores energy-efficient plasma reactor design, reaction mechanisms, and the conversion of atmospheric nitrogen into valuable nitrogen-containing products for sustainable agricultural applications.

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Theme 5: Sustainable Energy Storage and Applications

Electrifying Chemical Manufacturing for a Net-Zero Future: Plasma Reactive Systems from Molecules to Applications

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Abstract: The transition to net-zero manufacturing requires chemical processes that can directly utilise renewable electricity while reducing dependence on fossil-derived heat, hydrogen and concentrated reagents. Plasma reactive systems offer a promising pathway by using energetic electrons, electric fields and interfacial reactions to activate stable molecules under mild bulk conditions.

This presentation will discuss our development of plasma-based and plasma–electrochemical systems spanning nitrogen fixation, carbon conversion, water treatment and resource recovery. Representative examples include the conversion of air and water into ammonia, nitrogen oxides and aqueous nitrogen products; the transformation of carbon dioxide, methane and biogas into value-added chemicals; and plasma-enhanced degradation and recovery processes. Particular attention will be given to how discharge characteristics govern reactive-species generation, plasma–liquid interactions, catalytic pathways and product selectivity.

The presentation will further examine the integration of plasma activation with electrocatalysis and downstream processing to direct complex reactive mixtures towards useful products. Key engineering challenges—including energy efficiency, reactor scale-up, material durability, process control and operation under intermittent renewable electricity—will also be discussed. By connecting molecular-level mechanisms with reactor engineering and application-driven validation, plasma reactive systems could provide flexible and modular platforms for decentralised fertiliser production, carbon utilisation, environmental remediation and critical-resource recovery, contributing to a more sustainable and resilient chemical industry.

Dr Tianqi Zhang is a Lecturer and ARC DECRA Fellow at the University of Sydney. His research focuses on plasma chemistry, plasma–electrochemical systems and electrified chemical manufacturing for sustainable nitrogen fixation, carbon conversion, environmental remediation and resource recovery. He has published more than 50 peer-reviewed articles, receiving over 3,100 citations with an h-index of 31, and was recognised as a Clarivate Highly Cited Researcher in 2024.

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Theme 5: Sustainable Energy Storage and Applications

Highly efficient electrocatalysts for energy conversion reactions

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The development of highly efficient catalysts to improve electrochemical performances is urgently needed due to the ever-increasing demand for energy conversion devices in the last few decades. Electrochemical water electrocatalysis and fuel cells are the two representatives for the next-generation energy conversion. However, the electrochemical performances are still not satisfying to be potentially used in industrial applications. Here we present our recent research on developing atomically dispersed electrocatalysts for energy conversion reactions.[1-5] We show that by carefully designing and tailoring the coordination environment, the efficiency of the applied catalysts could be maximized which would be highly beneficial for the electrochemical performances in their individual applications. For instance, in-situ exfoliated MXene coupled with Pt single atoms showed high hydrogen generation performance with a mass activity more than 40 times higher than the commercial Pt/C, while the epoxy-rich Fe single atoms boosted the oxygen reduction kinetics. All these provide theoretical and experimental guidance to develop highly efficient catalysts for energy conversion reactions in the future.



Dr. Yufei Zhao is a Lecturer at the Faculty of Science, University of Technology Sydney. She received her dual PhD degrees from the Beijing Institute of Technology in 2017 and the University of Technology Sydney, in 2018. After receiving her PhD, her research experience spans postdoctoral appointments at UTS and UNSW, followed by roles as Associate Professor at Shanghai University and Visiting Scientist at the University of Toronto. Her research focuses on the rational design of highly efficient catalysts and advanced electrochemical systems for sustainable energy conversion and storage.

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Theme 5: Sustainable Energy Storage and Applications

Carbon-anchored functionalized single atoms for anode-free sodium batteries

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Anode-free sodium metal batteries (AFSMBs) offer a compelling pathway toward high-energy-density storage but are hindered by dendrite growth and irreversible sodium inventory loss. Single-atom carbon hosts regulate Na deposition yet suffer from cycling-triggered aggregation of single-atom sites and sodium inventory consumption originating from high catalytic activity. Herein, on the basis of insights into the activity origin of single-atom sites, we present functionalization strategies of single-atom sites for enhanced activity, anti-agglomeration, and selective solid-electrolyte interphase construction. We demonstrate that the intrinsic activity of single-atom sites arises not only from their inherent reactivity but also from the activation of surrounding coordination environments and carbon frameworks. Higher nitrogen content within the first coordination shell boosts site activation capability, whereas metal-nitrogen coordination strength is modulated by elements in the second coordination shell. Introducing P heteroatoms into the second coordination shell strengthens metal-support interactions and endows single-atom sites with anti-agglomeration capability. To suppress uncontrolled surface reactions, axial ligands direct the selective formation of a sodium-fluoride-rich SEI film, which is critical for battery stability improvement. Consequently, dynamically coordinated Sn single-atom carbon hosts deliver 1500 cycles at 5 C in anode-free sodium coin cells. Fe single-atom hosts with further anti-agglomeration features achieve Ah-level anode-free pouch cells under a low electrolyte-to-capacity (E/C) ratio of 5 g Ah^{-1}, yielding a high energy density of 130 Wh kg^{-1} with 60 % capacity retention after 80 cycles at 0.85 C. This work establishes the correlation between the activity and functionality of single-atom sites and their coordination structures, providing a practical route for the rational design of single-atom hosts toward alkali-metal batteries.



Shengyong Gao is currently a PhD candidate at the Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland, under the supervision of Prof. Bin Luo. He obtained his B.E. from Beijing University of Chemical Technology in 2021 and was awarded an MSc in Analytical Chemistry from the Hong Kong University of Science and Technology in 2023. His research focuses on the rational design of single-atom electrode materials and interfacial chemistry for high-energy batteries toward practical sustainable energy-storage applications. He has authored over ten peer-reviewed articles in high-impact journals including Nat. Commun., Adv. Mater., and Angew. Chem. Int. Ed

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Theme 5: Sustainable Energy Storage and Applications

Electrocatalysis under Intermittent Conditions

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The rapid deployment of wind and solar power is reshaping the operating conditions of electrochemical energy conversion technologies. Future electrochemical systems will increasingly experience fluctuating power input, intermittent operation, and frequent start-up/shut-down cycles, creating new challenges for catalyst activity, structural stability, and reaction selectivity. Understanding how electrocatalytic materials and reaction interfaces respond to such dynamic conditions is therefore essential for the development of efficient and durable electrochemical technologies.

This presentation will focus on the dynamic regulation of electrocatalytic materials and reactions under renewable-energy-driven operating conditions. Particular attention will be given to the design and stabilization of low-precious-metal catalysts for proton exchange membrane (PEM) water electrolysis, together with catalyst engineering strategies for anion exchange membrane (AEM) water electrolysis under fluctuating power and repeated start-up/shut-down operation. The concept will then be extended to selective electrocatalysis and electrosynthesis, highlighting how dynamic electrical inputs influence reactive intermediates, reaction pathways, and product selectivity. By combining theoretical analysis, operando and ex situ characterization, and device-level evaluation, these studies provide insights into the structural and interfacial evolution of electrocatalytic systems under dynamic renewable-energy conditions and offer guidance for catalyst and device design.

Huanyu Jin is a Professor at the Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, where he also serves as Deputy Director of the Center for Low-Dimensional Energy Materials. Prior to join SIAT, he was a Research Fellow, PhD supervisor, and Future Making Fellow at the Adelaide University, Australia. His research focuses on energy electrocatalytic materials and devices, with particular interests in renewable-energy-compatible water electrolysis, electrocatalysis under complex operating conditions, and electrochemical extraction of resources from salt lakes and seawater. He has published more than 80 peer-reviewed papers, with over 16,500 citations and an H-index of 51. He has been recognized as a Clarivate Highly Cited Researcher and included among the world's top 2% scientists. His honors include the Stephen Wilkins Medal, the 2DM Emerging Young Scientist Award, and the Journal of Materials Chemistry A Emerging Investigator recognition. He currently serves on the Editorial Board of 2D Materials and as an Early Career Editorial Board member for journals including InfoMat, Journal of Energy Chemistry, and Carbon Energy.

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Theme 5: Sustainable Energy Storage and Applications

Developing High-Energy Electrode Materials for Metal–Air Batteries

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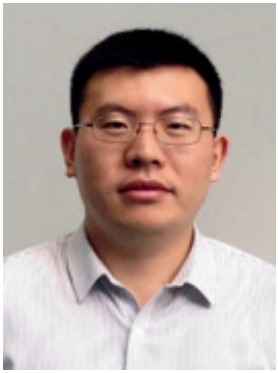
Abstract:
Owing to the superior high energy density, metal–air batteries (e.g. lithium–oxygen batteries and sodium–oxygen batteries) have been considered promising advanced battery systems to meet today's stringent requirements as the power source for electric vehicles (EVs) and renewable energy storage. However, the development of metal air batteries is still constrained by several serious challenges, including uncontrolled side reactions, low energy efficiency and poor cycling life. The electrochemical performances of lithium–oxygen batteries await dramatic improvement in the design of porous oxygen cathodes, efficient electrocatalysts and stable metal anodes. Herein, we present the research outcomes from our group on materials innovation for rechargeable metal air batteries. First, the family of metal air batteries will be introduced. Second, the design of porous carbon-based materials and redox mediators for high-performance air (oxygen) cathodes will be discussed. Third, facile and effective methods to enhance the electrochemical performance of lithium/sodium/Zn metal anodes will be presented, including electrolyte optimization, three-dimensional current collector design, and dual interface engineering on lithium/sodium metal anodes.



Dr Bing Sun is an associate professor in School of Mathematical and Physical Sciences at University of Technology Sydney (UTS). He completed his Ph.D. at UTS in 2012 and then started his postdoctoral research in the Centre for Clean Energy Technology at UTS. His research interests focus on the development of next-generation battery materials and technology for high-energy-density batteries. He is the recipient of Australian Research Council (ARC) Discovery Early Career Researcher Award (2018) and ARC Future Fellowship (2022). Dr Sun has published more than 140 peer-reviewed articles, including Nat. Energy., Chem. Rev., Joule, Chem. Soc. Rev., Nat. Commun., Sci. Adv., Adv. Mater., JACS, Angew Chem., etc. His research outputs have attracted 12,100 citations with an h-index of 65 (Web of Science).

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Theme 5: Sustainable Energy Storage and Applications

Solvent Coordination Engineering for Selective and Sustainable Battery Recycling

Yanqiu Lyu

Abstract: The rapid expansion of lithium-ion batteries has intensified the need for sustainable and resource-efficient recycling technologies. However, the selective separation of chemically similar metal species remains a major challenge, often leading to complex processing routes, high reagent consumption, and limited solvent recyclability.
In this talk, I will present our recent progress in addressing these challenges through solvent engineering and selective separation strategies. Our work focuses on deep eutectic solvents and related solvent systems to regulate metal coordination, solubility, and phase behaviour, while integrating solvent regeneration, process simplification, and scale-up. These efforts demonstrate that rational control of solvent environments can provide an effective pathway toward selective, closed-loop, and sustainable recovery of critical metals from spent lithium-ion batteries.



Dr Yanqiu Lyu is a Grant-Funded Researcher in the School of Chemical Engineering at Adelaide University, Australia. He received his PhD in Chemical Engineering from the University of Adelaide, with research focused on sustainable recycling technologies for spent lithium-ion batteries. His research interests span deep eutectic solvents, critical-metal separation, hydrometallurgy, electrolyte chemistry, and circular resource recovery. He has developed solvent-coordination-based strategies for the selective recovery of Li, Ni, Co, and Mn from spent battery cathodes, integrating molecular-level mechanistic understanding with solvent regeneration, process scale-up, and techno-economic evaluation. His research aims to bridge fundamental solvent and coordination chemistry with practical separation technologies for sustainable battery recycling and next-generation circular energy systems.

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Theme 5: Sustainable Energy Storage and Applications

Refining structures of functional molecules for energy storage and conversion

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Abstract: The development of highly efficient energy storage and conversion devices with excellent electrochemical performance is urgently needed due to the ever-increasing demand for clean energy in the last few decades. However, the electrochemical performance is far from satisfactory for industrial applications. Here, we present our recent research on the structure tuning of functional molecules designed for energy storage and conversion devices such as Li-O_2 batteries, Zn-ion batteries and CO_2 reactive capture.[1-5] We show that by carefully designing and tailoring the molecular structures, the efficiency of the functional molecules could be maximized which would be highly beneficial for the electrochemical performance in their individual applications. For instance, TEMPO-modified superoxide quencher could facilitate the conversion efficiency and prolong the cycle life of Li-O_2 battery,[1] while the redox-active polymeric network could efficiently activate CO_2 molecules and conversion.[4] All these provide theoretical and experimental guidance to develop highly efficient functional molecules for energy storage and conversion devices in the future.



Jinqiang Zhang obtained his PhD degree from the University of Technology Sydney in 2018. He worked as a Postdoctoral Research Associate in the Centre for Clean Energy Technology at the University of Technology Sydney from 2018 to 2021, and as a Postdoctoral Research Fellow at the University of Toronto from 2021 to 2023. He is currently Senior Lecturer, a Chancellor's Research Fellow, and ARC Future Fellow at the University of Technology Sydney. His work mainly focuses on the design and synthesis of functional organic molecules and single-atom catalysts in energy conversion and storage systems such as hydrogen evolution reactions, oxygen evolution reactions, oxygen reduction reactions, CO_2 reactive capture, lithium-ion batteries, lithium-sulfur batteries, and lithium-air batteries.

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Theme 5: Sustainable Energy Storage and Applications

Advanced Nanocomposite Materials for Zinc-ion batteries

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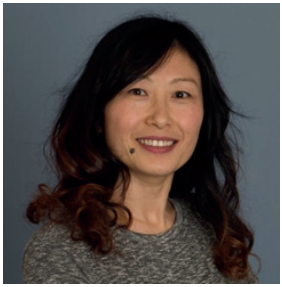
Abstract:
Aqueous zinc-ion batteries are promising candidates for safe, low-cost and sustainable energy storage because of their intrinsic safety, material abundance and environmental compatibility. However, their practical development is still limited by interfacial instability, non-uniform zinc deposition, parasitic side reactions, corrosion, electrolyte degradation and poor long-term cycling stability. Here, we present a materials-to-device strategy for improving aqueous zinc-ion energy storage through the design of advanced nanocomposite materials and regulated electrode/electrolyte interfaces. By tailoring material composition, surface chemistry, ion-transport pathways and interfacial architecture, nanocomposite electrodes and protective interfaces can be engineered to promote uniform ion flux, stabilise zinc deposition, suppress side reactions and enhance charge-transfer behaviour. This work demonstrates the importance of integrating nanocomposite materials design and interfacial regulation optimisation for next-generation energy storage systems, providing a foundation for safer, more durable and sustainable battery technologies.[1-6]



Professor Dan Liu is a materials scientist in the School of Science at RMIT University. Her research focuses on advanced functional nanomaterials, surface modification, electrochemistry, flexible energy systems, membranes and wearable devices. She has published more than 200 journal articles and has hold nationally competitive fellowship, including an ARC DECRA and ARC Future Fellowship. Her work spans functional nanomaterials and nanocomposites, energy harvesting, flexible and wearable supercapacitors, batteries, and sensing systems. She leads multidisciplinary research on the design of flexible/wearable energy storage and sensing devices for sustainable energy and emerging health-enabling technologies.

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Theme 5: Sustainable Energy Storage and Applications

Dual descriptor screening identifies a molecular mediator for low concentration ether electrolytes in lithium metal batteries

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Ether electrolytes are compatible with lithium metal but suffer from poor $LiPF_6$ solubility and limited oxidative stability. Improving salt dissolution often strengthens Li^+–solvent coordination, which impedes interfacial desolvation without necessarily enhancing oxidative stability. Here, we use dielectric constant and donor number as dual descriptors to screen 103 candidate molecules. We identify TFPC, which combines a high dielectric constant with low donor ability, as a molecular mediator that decouples salt dissociation from Li^+ coordination strength. Adding only 3% TFPC enables a low-concentration ether electrolyte containing 0.7 M $LiPF_6$. Spectroscopy, molecular dynamics simulations and density functional theory calculations indicate that TFPC promotes salt dissociation while reorganizing the Li^+ solvation environment. This reorganization weakens Li^+–solvent interactions and facilitates interfacial desolvation. The regulated solvation structure also suppresses parasitic reactions and promotes protective electrode interphases. The optimized electrolyte exhibits oxidative stability beyond 4.8 V versus Li/Li^+. Lithium metal batteries with Ni-rich cathodes retain 78% of their capacity after 200 cycles and show improved rate capability. These findings highlight the value of independently tuning dielectric polarization and Li^+ coordination strength when designing $LiPF_6$-based ether electrolytes for high-energy lithium metal batteries.



Huan Xu is a PhD student in the Department of Chemistry at the University of Hong Kong, under the supervision of Professor Zhengxiao Guo. Her research focuses on electrolyte design and mechanistic studies for high-energy-density batteries with improved safety, as well as the development and performance optimization of sodium-ion battery cathodes. She has published ten articles in SCI-indexed journals, including five as first author, and has contributed four patents.

Theme 5: Sustainable Energy Storage and Applications

Engineering Multifunctional Carbon Fibre Materials for Structural Energy Storage and Organic Electrochemical Systems

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The development of multifunctional materials combining mechanical performance with electrochemical energy storage presents exciting opportunities for next-generation composite systems. Within this field, carbon fibres are particularly attractive due to their excellent mechanical properties, electrical conductivity, and tailorable surface chemistry. Our research explores how these characteristics can be harnessed to develop multifunctional composites capable of providing both structural reinforcement and electrochemical energy storage.

The first part of this talk will focus on the development of structural lithium-ion batteries, where carbon fibres were utilised within both anode and cathode architectures, serving as mechanical and electrochemical components. Through the incorporation of active materials within an epoxy-based structural electrolyte system, we have demonstrated composites capable of energy storage fabricated using readily scalable and available manufacturing techniques. We also investigate the relationships between electrode architecture, active-material loading, ionic transport, and mechanical properties whilst highlighting key challenges and opportunities in balancing electrochemical and structural performance.

Building on these findings, our research also explores alternative electrode architectures through the introduction of redox-active organic functionality onto carbon fibres. Electrochemical grafting and polymerisation provide pathways to incorporate organic charge-storage materials directly onto conductive carbon substrates, potentially reducing reliance on conventional inorganic active materials. Investigations involving polyaniline (PANI), ortho-phenylenediamine (oPD), and anthraquinone (AQ) systems highlight opportunities to tailor interfacial chemistry and electrochemical behaviour towards lightweight, metal-free electrode architectures.

Together, these approaches demonstrate how composite engineering and electrochemical surface modification can advance the development of structural energy storage systems with increasingly integrated mechanical and electrochemical functionality.



Dr James D. Randall is a research fellow at the Institute for Frontier Materials, Deakin University, Australia, specialising in carbon fibre surface chemistry, multifunctional composites, and electrochemical energy storage systems. He completed his PhD at Deakin University in 2022 before undertaking postdoctoral research at Chalmers University of Technology, Sweden, on energy storage systems. Returning to Deakin in 2024, his research focuses on engineering carbon fibre interfaces to introduce new functionality through structural lithium-ion batteries and redox-active organic polymers.

He has authored 36 scientific publications and participated in numerous industry projects with partners including the Office of Naval Research (ONR), Rolls Royce, Solvay, and the Defense Science and Technology Group (DSTG). By combining electrochemical synthesis, carbon interface engineering, and advanced materials characterisation, he seeks to understand how molecular and electrode design influence charge-storage behaviour and composite multifunctional performance.

Theme 5: Sustainable Energy Storage and Applications

Interplay between reinforcement-induced microstructural heterogeneity and corrosion kinetics in TiB2 reinforced Mg-12.5Al-2Zn-1.5Ca nanocomposite

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Abstract: In the present study, the interplay between reinforcement-induced microstructural heterogeneity and corrosion kinetics in a TiB2-reinforced Mg–12.5Al–2Zn–1.5Ca nanocomposite was systematically investigated. The nanocomposite was fabricated using an ultrasonic stir-casting technique to ensure uniform dispersion of TiB2 nanoparticles within the Mg matrix. Microstructural characterization (XRD and FE-SEM) revealed the presence of Mg_2Ca and Al-rich intermetallics along with well-dispersed TiB_2 nanoparticles. This led to a refined and heterogeneous microstructure. The incorporation of TiB_2 nanoparticles acted as heterogeneous nucleation sites and restricted grain growth, leading to significant grain refinement and improved phase distribution. Mechanical analysis demonstrated enhanced microhardness and strength in the nanocomposite, driven by grain boundary strengthening, load transfer, and dispersion hardening mechanisms. Corrosion tests were performed in a 3.5 wt.% NaCl electrolyte, which showed an improved corrosion resistance compared to the base alloy. The observed corrosion behavior was strongly influenced by the heterogeneous microstructure of the nanocomposite. The presence of refined grains, reduced microgalvanic interactions, and the formation of a stable protective surface film collectively contribute to slowing and controlling the corrosion process. The results reveal a clear correlation between microstructural features and corrosion behavior, demonstrating how microstructural refinement influences overall performance. These findings highlight the potential of TiB_2-reinforced Mg-based nanocomposites for advanced structural and biomedical applications.

Theme 6

Catalysis for Energy and Sustainability

Theme 6: Catalysis for Energy and Sustainability

MHz acoustics for nanomaterials synthesis and enhanced electrocatalysis

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Abstract: High-frequency acoustics is emerging as a powerful new platform for nanomaterials manipulation, extending far beyond the capabilities of conventional ultrasound. Operating in the 10 MHz regime, well above the cavitation-dominated 20–40 kHz domain of traditional sonochemistry, these acoustic fields activate synthesis and manipulation pathways governed by fundamentally different mechanisms. In this cavitation-free regime, intense surface-localised electromechanical coupling drives interfacial polarization, molecular ordering, and selective bond disruption, despite the vast mismatch between acoustic and molecular length and time scales.

This talk will highlight how these unique conditions enable rapid crystallisation of highly oriented metal–organic frameworks (MOFs) and covalent organic frameworks (COFs), as well as the synthesis of strongly piezoelectric polymers such as PVDF and Nylon-11—achieved without the need for high electric poling fields. Beyond synthesis, high-frequency acoustics provides a direct pathway to enhance water electrolysis where intense interfacial acousto-electromechanical coupling frustrates the tetrahedral hydrogen-bond network, generating a high concentration of “free” water molecules that more readily access catalytic sites. Together with enhanced hydronium formation, accelerated mass transport, and efficient bubble removal, this yields a fourteen-fold increase in current density.

Extending these principles to the oxygen evolution reaction (OER), we demonstrate that coupling nanometre-amplitude vibrations to a ferromagnetic catalyst induces magnetic effect (coined as acoustomagneto-electrocatalytic (AME)), generating local magnetic fields that enhance catalyst magnetisation and enlarge magnetic domains without the need for permanent magnets. Collectively, these examples illustrate how MHz acoustics constitutes a versatile and universal stimulus for transforming matter across bulk, nanoscale, and electrochemical systems.



Amgad Rezk is an Associate Professor at RMIT University, Australia, where he co-leads the Micro/Nanophysics Research Laboratory (MNRL). He completed his PhD at RMIT University in 2014. He has received prestigious fellowships and awards, including the Vice-Chancellor’s Research Fellowship, the Winston Churchill Fellowship, and recognition as a finalist for the Victorian Young Achiever Award. His research focuses on high-frequency acoustics and their application to microfluidics, nanomaterials synthesis, and the manipulation of matter for catalysis and renewable energy technologies. His discoveries have been published in leading international journals including Nature Communications, Advanced Materials, Science Advances, Nano Letters, amongst others.

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Theme 6: Catalysis for Energy and Sustainability

Unlocking catalyst potentials in zero-gap membrane-electrode assemblies

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Practical electrochemical devices often operate through highly coupled reaction-transport processes whose internal electrochemical states cannot be resolved from the overall cell voltage alone. This blind spot is especially consequential for membrane-electrode assemblies, where standard two-electrode measurements conflate electrode and membrane behaviours, precluding operando separation of catalytic activity, catalyst utilisation, and degradation under working conditions. This talk will introduce a new operando electrochemical diagnosis framework combining a polyelectrolyte-stabilised silver/ silver-bromide reference electrode and a controlled ionic connection to probe the reactive regions of working devices. This framework is proven effective across acidic, neutral and basic environments for water and CO_2 electrolysis at current densities up to 500 mA cm^{-2}, and enables direct and independent electrochemical characterisation of catalyst layers under practical conditions. Using this framework, we uncover a hidden transport-driven collapse in catalyst utilisation that causes more than a threefold decrease in catalyst intrinsic activity, and detect catalyst-layer degradation well before any corresponding change becomes apparent in overall cell voltages. These results indicate a pathway towards restoring electrochemical observability and accelerating the development of practical electrochemical energy systems.



Dr. Mengran Li is a Senior Lecturer in Chemical Engineering at the University of Melbourne, an ARC DECRA Fellow, and the group leader of the Li Energy Lab. He received his PhD in Chemical Engineering from the University of Queensland in 2016, followed by postdoctoral appointments at the University of Queensland and Delft University of Technology. He joined the University of Melbourne in 2023 and was promoted to Senior Lecturer in 2025. Dr. Li's research focuses on electrochemical engineering for clean energy and industrial decarbonisation, with expertise in electrolysis and fuel cells. He has published more than 90 peer-reviewed papers, which have received over 10,000 citations, and currently leads nationally and internationally funded research projects. His research has been widely recognised internationally, and he is frequently invited to deliver keynote and invited lectures at major conferences.

Theme 6: Catalysis for Energy and Sustainability

Photothermal catalysis for solar fuels production

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Photothermal catalysis has been proposed as a promising alternative to conventional photocatalysis and thermocatalysis in the fields of energy preparation and environmental remediation, attributing to unprecedented light harvesting efficiency and superior throughputs under moderate reaction conditions [1]. It is basically a multiple energy complementary technology integrating solar energy mediated photochemical process and solar light induced thermocatalysis. Specifically, photo-excited energetic hot carriers via intraband or interband extinction (also called Landau damping) can directly initiate chemical reactions at much milder conditions. And hot carriers failing to participate redox reactions will be cooled into heat by thermalization (also named Ohmic damping) [2]. Photo-excited hot carriers can reduce the reaction barrier and improve reaction selectivity, while photo-generated internal heat can thermodynamically accelerate reaction rates and ginger up sluggish hot carriers. Therefore, photothermal catalysis has compensated the disadvantages of photocatalysis and thermocatalysis and significantly boosted the reaction rates to a level of industrialization by taking advantage of full-spectrum solar light, showing significant potentials on large-scale production of solar fuels [3]. Here, we present our ongoing research in harnessing the full spectrum solar energy using the photothermal catalytic strategy to drive CO_2 reduction with alkane or hydrogen. Using solar energy to catalytically reduce CO_2 and upgrade conventional fossil fuels has the potential to convert the waste of CO_2 into high value-added chemical fuels and feedstocks in a clean and sustainable manner, allowing the dual opportunity to store the intermittent renewable energy as well as closing the anthropogenic carbon cycle.



Dr. Jinqiang Zhang is a Lecturer of Chemistry and an ARC DECRA Fellow in the School of Molecular Sciences at The University of Western Australia. His research centers on solar-driven catalytic technologies for sustainable energy production. Till now, he has authored two book chapters and published over 140 peer-reviewed articles in leading journals, including Nat. Rev. Chem., Nat. Commun., Adv. Mater., Angew. Chem. Int. Ed., Mater. Today, ACS Nano, ACS Catal. His work has been cited almost 7,800 times, with an H-index of 51. Dr. Zhang leads projects funded by the Australian Research Council, including Discovery and DECRA Projects, and has received prestigious honors such as ACS Energy & Fuels Rising Star, and RSC JMCA Emerging Investigator.

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Theme 6: Catalysis for Energy and Sustainability

Advanced Membrane Engineering for Efficient CO_2 Electrolysis

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Electrochemical CO_2 reduction offers a pathway to multicarbon chemicals using renewable electricity, but CO_2 crossover and ion transport resistance limit carbon and energy efficiencies. We present two complementary membrane-engineering strategies for efficient acidic CO_2 electrolysis.

First, an electrolyte-filled porous separator enables zero-gap operation by regulating coupled proton and potassium ion transport.[1] Optimizing electrolyte composition and separator permeance suppresses (bi)carbonate electromigration while supporting multicarbon production. With a modified copper oxide catalyst, the system achieved 75% multicarbon Faradaic efficiency and 24% energy efficiency at 300 mA cm^{-2} and 3.5 V. CO_2 crossover was reduced to approximately 5% of the CO_2 converted into products.

Second, template casting produces microchannel-patterned bipolar assemblies while avoiding the compression of ion-conducting pathways associated with hot pressing. Optimizing channel geometry balances removal of regenerated CO_2 with ionic conduction, reducing membrane voltage loss by approximately 0.36 V at 200 mA cm^{-2}. With further optimization of catalysts, electrolyte and operating temperature, the electrolyzer achieved a full-cell voltage of 3.02 V, 58% ethylene Faradaic efficiency and 82% single-pass CO_2 efficiency at 200 mA cm^{-2}.

Together, these studies show how controlling coupled ion and fluid transport can suppress carbon loss and reduce voltage penalties, advancing membrane electrode assemblies for energy-efficient CO_2 conversion.



Dr. Min Liu is currently an ARC DECRA at the University of Queensland. He received his PhD in Polymer Science and Chemical Engineering from the University of Melbourne in 2020 under the supervision of Prof. Qiang Fu, Prof. Paul Webley, and Prof. Greg Qiao. He then joined the University of British Columbia as a postdoctoral fellow, where he worked with Prof. Zachary Hudson on self-assembling block copolymers and porous materials from 2022 to 2024. Subsequently, he moved to the University of Toronto to work with Prof. David Sinton and Prof. Edward Sargent (2024-2025), focusing on electrochemical CO and CO_2 reduction.

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Theme 6: Catalysis for Energy and Sustainability

Room Temperature Hydrogen Permeability of Metals and Thin-Film Ceramics

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Abstract: As a potential fuel of the future, the safe containment and distribution of hydrogen is of critical importance. With its small molecular size, hydrogen can permeate through many commonly used materials, including steel, eventually leading to embrittlement. This raises the need for hydrogen barrier coatings, for which ceramics are of great interest due to their intrinsically low hydrogen permeabilities. A thorough assessment of these materials should include measurements under pipeline operating conditions; that is, ambient temperature and moderate to high pressure. Given the anticipated impermeability of candidate materials, nanoscale films offer a unique opportunity to examine hydrogen-material interactions at room temperature. This work details the development of a permeation rig with sub-ppm detection capabilities and the use of atomic layer deposition to study the hydrogen permeability of alumina.



Joshua Butson is an early career researcher with a background in materials and electrochemistry. He completed his PhD at the Australian National University where he designed and tested high-performance solar water splitting devices, including a triple-junction device with a solar-to-hydrogen efficiency of over 20% under 1 sun. He then became a postoctoral researcher at the University of Melbourne working on molten carbonate electrolysis for CO_2 conversion, most notably leading a study on calcium carbonate as an earth-abundant alternative. Joshua is now a member of the earth-abundant alternative. Joshua is now a member of the Hydrogen Storage Research Group at Curtin University, currently developing robust measurement techniques for low-temperature hydrogen permeation.

Theme 6: Catalysis for Energy and Sustainability

Liquid Metal-Based Responsive Micro/Nanorobots: Development and Applications

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Liquid metals (LMs), combining high electrical and thermal conductivity with fluidity and deformability, represent an emerging class of functional metallic materials. The unique integration of metallic properties and liquid behaviors offers opportunities to overcome the limitations of conventional solid metals in applications requiring large deformation, adaptive interfaces, and self-healing capabilities. These features have stimulated growing interest in LMs for flexible and wearable devices, self-healing electronics, soft robotics, and biomedical micro/nanorobotic systems.

In this presentation, we will introduce our recent progress in the design and fabrication of LM-based micro/nanostructures, with particular emphasis on their integration with magnetic functional materials to enable remotely controlled deformation, motion, and actuation. Representative examples of magnetically, chemically, and thermally responsive devices and microrobots will be presented, together with a discussion of the underlying material design and interfacial engineering strategies. Finally, the opportunities for LMs to serve as adaptive and responsive material platforms for soft micro/nanorobotics will be discussed, with particular attention to their potential applications in biomedical manipulation and therapeutic technologies.

Long Ren is a Professor at the Institute for Quantum Science and Technology, Shanghai University. He received his Ph.D. from the University of Wollongong, Australia, in 2019 under the supervision of Academician Shixue Dou, and subsequently continued his research at the Institute for Superconducting and Electronic Materials, University of Wollongong. In 2021, he joined the International School of Materials Science and Engineering at Wuhan University of Technology. He joined Shanghai University in 2024. He has received several awards and honors including the Scientist Medal from the IAAM. His research focuses primarily on the fundamental properties of gallium-based liquid alloys and their applications in functional devices. He has published more than 80 papers in journals including Advanced Materials, Journal of the American Chemical Society, Materials Today, and Nature Energy, with over 40 papers as first or corresponding author. His current H-index is 47 according to Google Scholar.

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Theme 6: Catalysis for Energy and Sustainability

Tailoring high-performance and stable Ni catalysts for CO_2 reforming of CH_4

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Supported nickel (Ni) nanocatalysts are extensively utilized in numerous industrial fields, including energy, chemical, and environmental protection industries, due to their high activity, selectivity, relatively low cost, and abundant reserves in nature. However, the commercialization of Ni-based catalysts in various reactions, such as CO_2 dry reforming of methane (DRM) and hydrogenation reactions, suffers from their poor stability and quick deactivation. Here, we reveal each reaction pathway for DRM based on the Ni catalyst composition and geometry under working conditions, through one working platform combining in situ high resolution Cs corrected environmental transmission electron microscopy (ETEM) and electron energy-loss spectroscopy (EELS) coupled with mass spectroscopy (MS).[1] The formation of Ni_3C has been found to inhibit the decomposition of CO_2 and CH_4, and to promote the formation of onion-like carbon to encapsulate the Ni catalysts, leading to the deactivation of the Ni-based catalysts. Designing the suitable supports or promoters to keep the Ni surface structure under Ni-NiO cycle can drive the simultaneously amorphous carbon deposition-consumption cycle and minimize the coke formation. Based on this mechanism study, new types of high-performance Ni-based catalysts are developed with coke resistance through rapidly removing surface CO or oxidation of carbon species formed, which are promising for DRM applications.[2]



Professor Zichun Wang is a faculty member at Beijing University of Chemical Technology and the Director of the Industrial Catalysis and Low-Carbon Technology Laboratory. His research primarily focuses on the precise design and synthesis of advanced catalytic materials, the development of in-situ characterization techniques, and their applications in the resource utilization of biomass and solid wastes, as well as the conversion of greenhouse gases into valuable chemicals. He has been selected for prestigious programs including the Australian DECRA and the Overseas Talent Recruitment Program of the Ministry of Education of China. He has received awards such as the ARC DECRA Award from the Australian Research Council and the "National Award for Outstanding Self-Financed Chinese Students Abroad" from the Ministry of Education of China. He has also led multiple industrial technology transfer projects. In recent years, he has published over 70 SCI-indexed papers in internationally renowned academic journals and contributed to 2 book chapters in English. Among these, more than 40 papers have been published as first or corresponding author in prestigious journals such as Acc. Chem. Res., Nature Commun., Angew. Chem. Int. Ed, ACS. Catal., Mater. Today, Appl. Catal. B, Green Chem., and J. Catal..

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Theme 6: Catalysis for Energy and Sustainability

Engineering Active Sites and Heterointerfaces on MXene for Efficient Electrocatalytic Water Splitting

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Electrocatalytic water splitting offers a promising pathway for sustainable hydrogen production, yet its efficiency is limited by sluggish reaction kinetics and inefficient utilization of active species. Here, we demonstrate MXene as a versatile platform for engineering catalytic structures from atomically dispersed active sites to heterointerfaces for efficient water splitting.

High-density Pt and Ni dual single atoms are stabilized on Ti3C2TxMXene through a fluorine-free molten-salt-assisted strategy. The proximity of Pt and Ni enables cooperative catalysis, where Ni facilitates water activation while Pt provides favourable hydrogen adsorption and evolution kinetics. The resulting PtSAsNiSAs/MXene exhibits pH-universal hydrogen evolution activity, requiring overpotentials of only 23 and 59.4 mV to reach 100 mA cm-2in acidic and alkaline electrolytes, respectively, together with excellent long-term stability. In situ synchrotron FTIR spectroscopy and theoretical calculations further reveal the roles of interfacial water and Pt-Ni cooperation during hydrogen evolution.

Extending from atomic-site to interface engineering, a Co-TiS2/Ti3C2Txheterostructure is constructed to regulate the electronic structure and local coordination environment of catalytic sites through strong interfacial coupling, resulting in enhanced electrocatalytic activity and stability. Together, these studies establish MXene as a versatile platform for multiscale catalytic engineering and provide insights into the rational design of efficient and durable electrocatalysts for sustainable hydrogen production.



Jianan He is a final-year PhD candidate in Chemical Engineering at the University of Melbourne, Australia. Her research focuses on the design and development of advanced electrocatalytic materials for sustainable hydrogen production, with particular interests in MXene-supported single- and dual-atom catalysts and heterostructures. Her work integrates materials synthesis, electrochemical evaluation, synchrotron-based characterization, in situ/operando spectroscopy, and theoretical calculations to understand structure-performance relationships in electrocatalysis. She has published research on MXene-based electrocatalysts and is particularly interested in engineering atomic active sites and heterointerfaces for efficient water splitting.

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Theme 6: Catalysis for Energy and Sustainability

Designing Active Sites and Microenvironments for Durable Hydrogen Electrocatalysis

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Hydrogen fuel cells and electrolysers must run on impure feeds, dilute electrolytes and little precious metal. An electrode can then fail at the active site or in the thin electrolyte layer in front of it, where pH, ions and water differ from the bulk. We design both. At the site, a Ni–Mo–Nb metallic glass oxidises hydrogen with intrinsic activity comparable to a Pt disk and stays stable at 0.8 V vs RHE, where its crystalline counterpart oxidises.[1] In the ion layer, ionomer coatings on commercial Pt/C and IrO_x act as ion-selective gates: they keep Ca^{2+}, Mg^{2+} and Cl^- away and speed up H^+/OH^- transport, as operando Raman and pH probes show.[2] A diaphragm electrolyser fed with filtered natural seawater, without added alkali, ran for 1,500 h at 200 mA cm^{-2}. The catalyst can also shape this layer: fluorine segregating from a cobalt-based anode strips water from Na^+ and Cl^-, so they form contact ion pairs that keep Cl^- off the surface, enabling 2,450 h of electrolysis in seawater with 1 M NaOH at 0.5 A cm^{-2} (60 °C).[3] In the water layer, a crystalline hydrogen-bonded framework of melamine and isophthalic acid on Pt/C tunes adsorption on Pt and reshapes interfacial water. With only 0.03 mg_{Pt} cm^{-2} in 1 wt% KOH, an anion-exchange membrane electrolyser reached 8.0 A cm^{-2} at 2.0 V (80 °C) and ran for 2,000 h with periodic electrolyte renewal.[4] The space next to the catalyst is a design variable in its own right.



Fei-Yue Gao is an ARC DECRA Fellow in the School of Chemical Engineering, Adelaide University. He received his BEng from Harbin Institute of Technology (2017) and his PhD in Chemistry from the University of Science and Technology of China (2022), where he worked as a postdoctoral fellow before moving to Adelaide in 2023. He designs catalysts and electrode–electrolyte interfaces for durable hydrogen fuel cells and water electrolysers, including seawater electrolysis. His first- and co-first-author papers appear in Nature Catalysis, Nature Nanotechnology, Nature Communications and JACS, and his work has been cited over 6,400 times (h-index 36; Google Scholar, October 2026).

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Theme 6: Catalysis for Energy and Sustainability

Electrochemiluminescence Imaging for Analytical Application

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Electrochemiluminescence (ECL) is a controllable form of chemiluminescence where emission intensity is affected by a voltage imposed at an electrode surface. By the combination with optical microscopes, the recently developed ECL imaging techniques show tremendous application potential to evaluate electrocatalysis activity of nanomaterials. Recently, we developed a series of techniques for visual evaluation of single particle and cells based on a homemade ECL microscope. In terms of cell imaging, we developed a bio-coreactant-enhanced ECL microscopy realizes the ECL imaging of intracellular structure and dynamic transport. [1] The protein corona formation kinetics is monitored by a self-regulated ECL microscopy for comparing the protein corona formation kinetics in different complex systems and different nanomedicine carriers.[2] Because the ECL emission layer is influenced by the ECL reactions route, we recorded the ECL images of cells with the elevated temperature, thus providing a flexible approach to adjust the imaging scope within specific heights. To improve the spatial selectivity, we report a site-selective heat boosting electrochemiluminescence microscopy.[3] By generating a micron-scale heat point in situ at the electrode–solution interface, we achieved an enhancement of luminescence intensity up to 63 times, along with an advance of 0.2 V in applied voltage. Furthermore, we designed ECL patterning for renewable and enhanced bioimaging.[4] This approach overcomes the passivation processes, evidently improves the image quality of single biological entities including Shewanella bacteria and cells, and makes the subtle contour structures more distinct.

Professor Jun-Jie Zhu received his B.Sc. and Ph.D. degrees at Nanjing University. He was a postdoctoral researcher at Bar-Ilan University, Israel. His mainly research work in nano-bioanalytical chemistry, including the synthesis of biofunctional nanoparticles, biological and biomedical applications of nanoparticles, catalytic analysis, electrochemical and fluorescence biosensors. Research in Zhu group is multidisciplinary involving chemistry, nanotechnology, surfaces, sensors, and bioapplication. Zhu group is particularly interested in scientific questions and challenges at the interface involving chemistry, materials, and biology for which they have been trying to come up with innovative solutions and insights.

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Theme 6: Catalysis for Energy and Sustainability

Guiding the Chaos: Tuning Catalyst Acid-Redox Synergy for Product Selectivity

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Achieving a neutral or negative carbon footprint requires a fundamental shift away from low-oxygen fossil hydrocarbons toward highly oxygenated, unconventional renewable feedstocks. While traditional refining relies heavily on classic acid catalysis, processing these next-generation energy carriers demands an entirely new catalytic paradigm. Specifically, selective oxidation and reduction pathways present severe challenges regarding product selectivity and long-term catalyst stability, making redox catalysis a critical pillar of future energy technologies.

To address this challenge, we have developed a heterogeneously catalysed reaction technology that uniquely leverages the synergy between acid and redox functions. In this lecture, we report on recent progress in mapping the fundamental structure-function relationships of microporous and mesoporous catalysts. By combining advanced spectroscopic techniques with rigorous kinetic analysis, we isolate the specific surface properties driving complex reactions.

Using the heterogeneous catalytic conversion of bio-oils as a primary case study, we demonstrate how unlocking this molecular-level understanding of surface chemistry solves macroscopic problems such as increased product selectivity to high value intermediate chemical products. Ultimately, we show how bridging the gap between fundamental acidic and redox control directly enables the rational design and improvement of high-performance, industrially viable catalytic processes for a modern sustainable society.



Professor Michael Stockenhuber is a Full Professor of Chemical Engineering at the University of Newcastle, Australia, and currently serves as the President of the Australian Catalysis Society. He earned his PhD in Physical Chemistry from the Technical University of Vienna (TU Wien). An expert in process development and advanced in situ spectroscopic techniques—including XAS, XPS, IR, and MS—Professor Stockenhuber focuses his research on heterogeneous catalysis with a primary emphasis on structure-function relationships.

His current research addresses critical industrial and environmental challenges, including the catalytic combustion of ventilation air methane, the conversion of oxygenates, acid and base site characterisation, and the oxidation, reduction, and dehydrogenation of hydrocarbons. He contributes broadly to the global scientific community as a member of several prominent editorial boards and international scientific

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Electroacoustic Copper Restructuring for Highly Selective CO_2 Reduction to Methane

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Rising atmospheric CO_2 concentrations have intensified interest in converting CO_2 into value-added fuels such as methane (CH_4). Cu catalysts can steer the electrochemical CO_2 reduction reaction (CO_2RR) through facet-dependent pathways, but high CH_4 selectivity requires densely packed Cu (111)/(100) facet intersections and suppression of the competing hydrogen evolution reaction (HER)[1,2]. Such intersections are difficult to obtain with conventional Cu nanocubes, which remain predominantly (100)-terminated[3], and alternative morphologies typically rely on complex, non-scalable syntheses[1,2]. Here, we report that coupling surface reflected bulk waves (SRBWs), generated on a piezoelectric lithium niobate substrate, into an electrochemical cell directs the electro-dissolution and subsequent redeposition of a Cu film. In the absence of capping agents, this yields truncated Cu nanocubes with a mean lateral dimension of approximately 25 nm after 30 min of exposure. Electron backscatter diffraction (EBSD) revealed a higher (111)/(100) facet intersection density relative to the electrochemical control, while spectroscopic analyses showed SRBW-induced formation of Cu^{2+}/Cu^{+} co-existence at the surface. Under a transient potential-cycling protocol, the restructured films achieved a high CH_4 Faradaic efficiency of approximately 70%, with stable operation beyond 34 h. These findings establish acoustic-field-assisted restructuring as a scalable strategy for facet and intersection engineering in selective electrocatalyst design.



Dr. Caiden J. Parker is a upcoming researcher by conducting postdoctoral research in electrochemistry and is currently investigating CO_2 reduction to high valued products. During their PhD they investigated fundamental liquid metal chemistry involving dissolution and crystallisation of solid metals within liquid metal media with in-situ heating via TEM.

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Theme 6: Catalysis for Energy and Sustainability

Zwitterionic carbamate interfaces unlock efficient "liquid" CO_2 upgrading

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Abstract

Integrating carbon dioxide (CO_2) capture with direct electrochemical conversion could eliminate energy-intensive solvent regeneration, CO_2 purification and compression, but its practical implementation is constrained by poor mass transport and uncertain reactivity of captured carbon species. Here, we establish an integrated capture–conversion platform that directly electrolyses amine-captured CO_2 in liquid carbamate media. Systematic comparison of six structurally distinct amines identified piperazine (PZ) as an effective carrier that combines high CO_2 uptake with stable, concentrated zwitterionic carbamate species. Coupling PZ with an optimised nickel catalyst and an engineered gas–liquid–solid interface delivered CO Faradaic efficiencies of up to 60%. Molecular speciation, spectroscopy and theoretical analysis further provided the first quantitative verification that carbamate species contribute approximately 40% of the carbon converted to CO, resolving a central mechanistic uncertainty in reactive capture electrochemistry. In a 9 cm^2 zero-gap membrane-electrode-assembly electrolyser continuously supplied with simulated flue gas containing 20 vol% CO_2, the system maintained CO Faradaic efficiencies of 30–45% for more than 150 h, with single-pass CO_2-to-CO conversion efficiencies of approximately 20–42% and energy efficiencies of approximately 15–25% under ambient conditions. These results establish capture-agent selection and interfacial control as coupled design principles for durable, lower-energy electrochemical carbon utilisation and bridge molecular-level mechanistic understanding with device-scale operation.

Keywords: Reactive CO_2 capture; integrated capture–conversion; piperazine; carbamate electroreduction; zero-gap electrolyser

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Fewer Experiments, Better Predictions: Hybrid Kinetic-Machine Learning Models for Catalytic Conversion of Mixed Feedstocks

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Converting biomass, plastic waste and CO_2 into fuels and chemicals is central to moving away from fossil carbon, and solid catalysts determine how selectively and how fast these conversions proceed. Once a promising catalyst is found, however, optimising its operation remains slow. Temperature, residence time, feedstock ratio, pellet size and regeneration cycles must all be explored, and it is rarely clear how many experiments are enough. The problem becomes harder with real feedstocks, which are mixtures: what product spectrum should we expect from 30% plastic blended with 70% biomass, or 30% lignin with 70% sugars?

Predictive models could answer such questions, but each standard approach is insufficient. Kinetic models are grounded in reaction chemistry but are validated only within the conditions tested and become cumbersome across wide composition ranges. Artificial neural networks (ANNs) capture complex nonlinear behaviour but need far more data than catalytic experiments can practically supply.

In this talk, I present a hybrid approach that combines the strengths of both. A kinetic model, validated against a small set of experiments, generates large volumes of synthetic data to train an ANN. The ANN then identifies the experimental conditions that would be most informative, and only those experiments are carried out and used to refine the model. The outcome is a predictive tool that estimates the product stream as feedstock composition varies, built from a minimal number of experiments. I will illustrate the approach with biocrude hydrodeoxygenation reaction to sustainable aviation fuel (SAF), and discuss how it can shorten the path from catalyst discovery to scale-up.



Associate Professor Muxina Konarova is Director of Research and Innovation in the School of Chemical Engineering at The University of Queensland. Her research uses catalysis to turn waste carbon from plastics, biomass, methane and carbon dioxide into fuels, chemicals and durable materials. She received the 2025 Catalysis Development Excellence Award of the Asia-Pacific Association of Catalysis Societies, held two Advance Queensland Fellowships, and chaired the catalytic plastic recycling topic at the 18th International Congress on Catalysis. She leads the Queensland node of an ARC Research Hub on carbon waste, is an Associate Investigator in the ARC Centre of Excellence for Green Electrochemical Transformation of Carbon Dioxide, and partners with steel, refining and energy companies.

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From Active Sites to an Active-Site Ecosystem: Making Operando Truly Operando

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Active sites have long been central to understanding and designing electrocatalysts, while the importance of their surrounding microenvironments is increasingly recognised. Taking electrochemical CO_2 reduction (CO_2R) as a representative case, we propose the Active-Site Ecosystem as a coupled system comprising active sites, evolving microenvironments, and the exchanges and feedback between them. We distinguish Depot Sites that retain and stabilise reaction intermediates from Assembly Sites that facilitate their coupling into multicarbon products. Within this framework, we introduce Active-Site State Units and Microenvironmental Units as quantitative descriptors to advance function-guided, predictive catalyst design.

Understanding these dynamic interactions requires operando characterisation under practically relevant conditions. However, conventional operando measurements are often conducted at lower current densities or in electrochemical configurations that differ substantially from those used for catalytic performance evaluation, potentially probing interfaces that do not reflect actual catalytic behaviour. In this presentation, I will highlight our pioneering development of operando proton-transfer-reaction time-of-flight mass spectrometry (PTR-TOF-MS) for quantitative, time-resolved detection of reaction intermediates and products during CO_2R. I will also discuss recent advances in operando Raman spectroscopy for investigating catalyst surface restructuring and the evolution of local interfacial environments under realistic electrochemical conditions. Together with advanced data analysis strategies, these approaches provide new opportunities to resolve the dynamic interplay between active sites and their microenvironments, bridging mechanistic understanding and practical catalytic performance towards predictive catalyst design.



Dr. Hangjuan Ren is a Lecturer in the School of Chemistry at Monash University, appointed in January 2025. She completed her PhD in Materials Science and Engineering at the University of New South Wales (UNSW) Sydney. After earning her doctorate, Dr. Ren continued her research at UNSW Sydney as a Postdoctoral Research Associate. She then served as a Research Fellow at the Cambridge CARES Lab, contributing to a collaborative project between the University of Cambridge and the University of California, Berkeley. Dr. Ren further advanced her research career as a Research Associate at the Department of Chemistry, University of Oxford. Dr. Ren has also been a visiting scholar at the Helmholtz-Zentrum Berlin (HZB) and Free University of Berlin. Her research focuses on electrochemical CO2 reduction and water splitting, with a particular emphasis on operando and in situ characterisation to understand reaction mechanisms and guide catalyst design for sustainable energy conversion.

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Theme 6: Catalysis for Energy and Sustainability

Atomic-Level Regulation on Photocatalyst for Energy-Related Reaction

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The global energy crisis and environmental issues impel the aggressive search for a clean and renewable energy source to replace fossil fuels. Hence, conversion of renewable solar energy into clean fuels and valuable chemicals is of great significance. The core challenge of this advanced technology lies in the development of low-cost and environmentally benign photocatalysts with sufficiently high activity and stability. Hence, the rational design and synthesis of photocatalysts at the atomic level to achieve efficient and stable solar-to-chemicals conversion is highly promising. Furthermore, both advanced characterizations (e.g., aberration-corrected atomic-resolution transmission electron microscopy, synchrotron-based X-Ray absorption spectroscopy and various in-situ element/space/time-resolved characterizations) and density functional theory based theoretical computations are adopted to investigate the atomic-level structure/composition-performance relationship and mechanism in photocatalysts. Finally, a universal rule to develop high-performance photocatalysts for efficient solar-to-chemicals energy conversion is concluded.



Dr. Jingrun Ran is appointed as a senior lecturer in school of chemical engineering in Adelaide University. He was awarded with the ARC future fellowship in 2023 and ARC DECRA fellowship in 2020. His research is focused on the atomic-level regulation on photocatalysts for producing energy fuel and value-added chemical using renewable solar energy. He has been recognized as a Clarivate Highly Cited Researcher in 2020-2025, and recognized as the world's top 2% scientists (released by Stanford University) in 2020-2024. He has also been recognised as a Journal of Materials Chemistry A Emerging Investigator in 2021. He has published > 85 papers in well-renowned journal, including Nat. Commun. (2), Adv. Mater. (7), Angew. Chem. Int. Ed. (6), Energy Environ. Sci. (4), J. Am. Chem. Soc. (3), Adv. Energy Mater. (8), Chem. Soc. Rev (2). and Sci. Adv. (2) (over 23427 citations, h-index: 50 based on google scholar).

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Theme 6: Catalysis for Energy and Sustainability

Database-guided thermodynamic-kinetic regulation for PtNi-based intermetallic electrocatalysts

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Pt-Ni alloys exhibit outstanding oxygen reduction reaction (ORR) activity, yet achieving structural ordering to enhance stability remains a persistent challenge. Here, we propose a database-guided screening strategy to identify promoter elements (X) that facilitate ordering. By screening the critical disorder-to-order transition temperature (Tc), solid solubility (Csol), and diffusion pre-exponential factor (D0) of candidate elements from material databases, 6 sets of $L1_0$-Pt(NiX) nanoparticles were synthesized. The developed $L1_0$-PtNiFe catalysts demonstrated a high mass activity (MA) of 4.38 A mg^{-1}_{Pt}, retaining 82.1% after 50k cycles of accelerated durability testing (ADT) in half-cells, and retaining 79% of its initial MA of 1.1 A mg^{-1}_{Pt} after 30k cycles in membrane electrode assembly (MEA). Theoretical calculations reveal that X incorporation broadens the annealing temperature (Ta) window by forming Pt(NiX) with higher and lowering the kinetic threshold temperature (Tkin) via enhanced atom mobility. This work establishes a database-guided framework that enables phase transitions previously difficult to access by creating an effective annealing window through coordinated thermodynamic-kinetic regulation, thereby facilitating the formation of ordered PtNi-based intermetallic structures toward durable electrocatalysts.



Anran Song is a PhD candidate in Materials Science and Engineering at Shanghai Jiao Tong University. She was a visiting scholar in the Department of Chemical and Biomolecular Engineering at the University of Illinois Urbana-Champaign. Her research focuses on the design of metallic nanomaterials and electrocatalysts for fuel cells and water electrolysis. Her work has been published in Science Advances and the Journal of the American Chemical Society.

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Theme 6: Catalysis for Energy and Sustainability

Conformal Glazing of Covalent Organic Frameworks: Hydrogen Sieving When Dry, Proton Conduction When Wet

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Covalent organic frameworks (COFs) offer ~3 nm channels with chemically addressable walls, but they are intractable powders whose interior chemistry is fixed at synthesis. Coordination-polymer glasses are the complement: they process like a melt, yet vitrification buries their functional sites in a dense monolith, and the best proton-conducting phosphate glasses hydrolyse in ambient humidity.[1] We show that a low-viscosity coordination-polymer glass, admitted during the framework's own thermal activation, lines the COF channel instead of plugging it.[2] Nothing covalent holds the glaze: adhesion is many weak, exchanging contacts on the hydroxyl groups of the channel wall, and a framework of matched topology but lacking those hydroxyls is blocked by the same melt rather than glazed. The wall answers back, its own tautomeric equilibrium shifting where the glass engages it.

Glazing also sinters the powder into a free-standing membrane serving two energy functions in opposite hydration states. Dry, it sieves hydrogen, ranking among the most hydrogen-permeable membranes reported while retaining useful H_2/CO_2 selectivity. Fully hydrated, the same architecture conducts protons some fifty times better than the pristine framework, reaching values comparable to Nafion at 80 °C and holding them over days of continuous operation. Confinement allows this: the bare glass decomposes in liquid water whereas the glazed composite survives it, and the wall hydroxyls preserve the phosphate carriers that self-condensation would destroy.[3] Because the channels close on hydration, gas crossover is suppressed in the very state that carries protons. Full performance data will be presented.



Jingwei Hou is an Associate Professor in the School of Chemical Engineering at The University of Queensland and Director of the UQ Nanomaterials Centre. He received his PhD from UNSW in 2015 and held postdoctoral positions at the UNESCO Centre for Membrane Science and Technology and the University of Cambridge before joining UQ in 2019 as an ARC DECRA Fellow. He was subsequently awarded an ARC Future Fellowship (2021), an NHMRC Emerging Leadership 2 Fellowship and an ARC Mid-Career Industry Fellowship (2025). His group studies microporous glassy materials — MOF liquids, glasses and crystal–glass composites — and their use in separation, optoelectronics, biocatalysis and energy. He has published over 180 papers, including in Science, Nature Communications and JACS.

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Theme 6: Catalysis for Energy and Sustainability

Colloidal Synthesis of Photocatalytic Quantum Dots Heterostructure

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Colloidal synthesis using ligand mediated surface engineering is a powerful approach to manifest the physical and chemical properties of quantum dots. [1,2] We present a colloidal synthesis method to attract high-quality carbon quantum dots with surface ligand-induced dual emission through a colloidal synthesis strategy. [3,4] The colloidal synthesis improved the quality of carbon dots in its size control and uniformity. The colloidal carbon dots showed improved quantum yield and surface passivation-induced dual emission. The results revealed the surface function and interactions.

Benefitting from the good optical and colloidal stability, a new class of van der Waals heterojunction photocatalyst, which is synthesized by hot-injection method, whereby carbon dots (CDs) are grown in situ on ZnSe nanoplatelets (NPLs), i.e., metal chalcogenide quantum wells. [5] The resultant organic-inorganic hybrid nanoparticles, CD-NPLs, are able to perform methanol dehydrogenation with the occurrence of α-C-H splitting and C-C coupling. The novel CD-based organic-inorganic semiconductor heterojunction is poised to enable the discovery of a host of new nano-hybrid photocatalysts with full tunability in the band structure, charge transfer, and divergent surface chemistry for guiding photoredox pathways and accelerating reaction rates.



Dr. Dechao Chen is ARC DECRA Fellow at the Centre for Future Materials, School of Science, Engineering and Digital Technologies, University of Southern Queensland (UniSQ). Before he joined UniSQ in 2026, he was a research fellow at the Advanced Technologies Research Institute at Griffith University. He received his Ph.D. in Chemistry from Curtin University. His research focuses on the synthesis of environmentally friendly quantum dots and their applications in photocatalysis and optoelectronics.

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Theme 5: Sustainable Energy Storage and Applications

Molten salt synthesis of heterogeneous catalysts for solar energy conversion: old chemistry for advanced materials

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Abstract

The global transition to sustainable industrial synthesis requires a fundamental shift from fossil fuels to renewable energy. Direct solar-driven catalysis offers a compelling solution by harnessing sunlight to synthesise renewable fuels and chemicals. This approach effectively augments photovoltaics with a long-term chemical storage mechanism while simultaneously reducing both system costs and ecological footprints. Nevertheless, the realisation of this technology is currently hindered by a lack of high-performance catalysts. Herein, we report a suite of heterogeneous catalysts engineered via molten salt synthesis. The molten salt medium provides a unique high temperature liquid environment that facilitates precursor dissolution, ensures atomic-scale dispersion, and accelerates mass transfer. Furthermore, the inherent polarity of salt ions enables precise modulation of the material surface energy. By leveraging these advantages, we developed catalysts with tailored compositions and architectures that demonstrate superior activity, high selectivity, and exceptional operational durability. Given its inherent scalability, this molten salt approach represents a robust strategy for industrial-scale solar energy conversion



Biography

Dr Mu Xiao is an ARC DECRA Fellow in the School of Chemical Engineering at The University of Queensland (UQ). She earned her PhD in Materials Engineering from UQ in 2019 and was awarded a prestigious Humboldt Postdoctoral Fellowship at the Max Planck Institute of Colloids and Interfaces. Dr Xiao's research centres on the design and development of semiconducting nanomaterials for solar energy conversion and green hydrogen technology. An impactful contributor to her field, she has authored over 55 peer-reviewed publications with more than 5,500 citations (H-index of 31). Dr Xiao also serves on the editorial boards of eScience and Exploration.

Theme 6: Catalysis for Energy and Sustainability

Photoelectrochemical Nitrate Reduction to Ammonia Using a UiO-66/CuPc Composite Photocathode

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Ammonia (NH_3) is one of the most widely produced industrial chemical substances and it is primarily used as a feedstock for nitrogen fertilizers and as a carbon-free energy carrier. Nearly all industrial ammonia is currently produced through the conventional Haber-Bosch process, which is highly energy intensive and associated with substantial carbon emissions. Photoelectrochemical (PEC) nitrate reduction provides a sustainable alternative by directly harnessing solar energy to convert nitrate, a common water pollutant, into a valuable NH_3. In this work, UiO-66/ Copper (II) phthalocyanine (CuPc) composite photocathodes were developed by integrating the porous and highly stable UiO-66 metal organic framework (MOF) with visible-light responsive CuPc. UiO-66/CuPc photocathodes with different mass ratios were systematically evaluated. The 3:1 UiO-66: CuPc photocathode exhibits the highest PEC nitrate-to-NH_3 performance, achieving a competitive NH_3 yield rate of 0.57 μmol h^{-1} cm^{-2} with a Faradaic efficiency (FE) of 95% at a mild applied potential of -0.1 V vs RHE in a neutral pH condition. Compared with pristine UiO-66, the optimised composite offers 1.6 times higher NH_3 yield and 2.1 times higher FE. The enhanced PEC performance is associated with CuPc incorporation, which decreases the optical bandgap of UiO-66 from 3.96 to 2.86 eV, thereby extending its photo-response into the visible region and enhancing visible-light absorption. Meanwhile, CuPc incorporation also promoted more effective utilization of photoinduced charge at the photocathode, further contributing to the improved nitrate-to-NH_3 conversion. The proposed MOF-molecular assembly strategy provides valuable insights into photocathode design for selective nitrate conversion and sustainable solar-to-chemical applications.



Piumi Madhuwanthi Nishshanka is a Master by Research student in the School of Engineering at Macquaire University, Australia. Her reasearch focuses on the development of photoelectrochemical systems for sustainable ammonia production from nitrate, with particular emphasis on metal organic framework and molecular semiconductor based photocathodes. Her current work investigates UiO-66/CuPc composite photocathodes for selective nitrate to ammonia conversion, integrating material synthesis, characterization, and photoelectrochemical performance evaluation.

Theme 6: Catalysis for Energy and Sustainability

Reactive Liquid-Metal Interfaces: From Atomaterials to Catalysis and Environmental Remediation

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Gallium-based liquid metals offer an atomically smooth, continuously renewing surface whose composition is set by the metals dissolved beneath it. Solute atoms stay mobile, enrich at the interface according to their reactivity, and are replenished from the bulk as they are consumed. Choosing which atoms reach the interface is the principle that links our work on atomically thin materials, electrocatalysis and environmental remediation.

Selective interfacial oxidation first gave access to atomically thin oxides of the dissolved metal. Our recent work extends this to deliberate control of crystal phase, stoichiometry and defects in two-dimensional post-transition-metal compounds, using alloy composition, atmosphere and atomic migration as design parameters [1]. The same control places isolated catalytic atoms at the surface: nickel dispersed in liquid gallium reduces nitrate, a widespread water pollutant, to ammonia with a Faradaic efficiency above 99% at −0.18 V versus RHE [2].

Replacing nickel with a strongly reducing solute turns the interface into a reagent-delivery system. Lithium dissolved in gallium diffuses to the surface and reduces CO_2 to solid carbon near room temperature [3]. It also cleaves the C–F bonds of polytetrafluoroethylene (PTFE), a persistent polymeric PFAS, forming a carbon/LiF layer that works directly as a binder-free pseudocapacitive electrode, while the gallium is recovered for reuse [4].

Across these examples the liquid metal acts as a programmable solvent whose interface can be tuned atom by atom for materials synthesis, selective catalysis and the conversion of persistent waste under mild conditions.

Dr Ali Zavabeti is an ARC DECRA Fellow and Lecturer in Chemical and Environmental Engineering at RMIT University. His research focuses on liquid-metal interfaces, atomically thin and two-dimensional materials, functional nanointerfaces, optoelectronics, catalysis and sustainable energy technologies. He has authored more than 160 publications, with over 10,000 citations, including work in Science, Nature Materials and Nature Electronics. He is also Scientific Lead of the Centre of Excellence for Future Assistive Technologies, an international RMIT–Riga Technical University initiative. Prior to academia, he spent seven years with ABB Australia in process automation across the energy and process industries.

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Theme 6: Catalysis for Energy and Sustainability

Theoretical Investigation of Integrated CO2 Capture and Electrochemical Reduction:
Challenges and Opportunities

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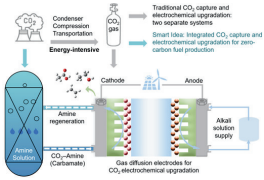
Efficient capture and utilization of CO_2 are crucial for mitigating climate change and achieving sustainable development. Traditional CO_2 capture methods rely heavily on energy-intensive thermal processes to separate pure CO_2 from amine-based solvents, which significantly reduces the overall energy efficiency and economic viability of CO_2 utilization technologies. Therefore, integrating CO_2 capture directly with electrochemical reduction emerges as a promising strategy to address these challenges.

In this presentation, we begin by reviewing the theoretical foundations of conventional CO_2 electrochemical reduction reactions (CO_2RR) through computational methods, particularly density functional theory (DFT). We then compare these traditional methods with computational approaches tailored for integrated CO_2 capture and reduction systems, specifically focusing on carbonate (CO_3^{2-}) and carbamate (amine-CO_2) reduction pathways. Key differences in the reaction mechanisms, thermodynamics, and kinetics among them are discussed in detail. We further present our latest theoretical results, on reducing carbonate/carbamate intermediates generated during CO_2 capture. Our computational insights into both carbamate and carbonate reduction pathways provide robust theoretical guidance for the rational design of efficient catalysts and the optimization of integrated CO_2 capture and electrochemical reduction processes, laying an essential foundation for developing economically viable, scalable, and environmentally sustainable CO_2 utilization technologies.



Dr Yu Mao is a Research Fellow in the School of Chemical Sciences at the University of Auckland. He received his Ph.D. in Physical Chemistry from Queen's University Belfast and his B.E. in Applied Chemistry from East China University of Science and Technology. His research focuses on theoretical chemistry and heterogeneous catalysis, in particular understanding and designing electrocatalysts for CO_2RR and related reactions using DFT and MD/AIMD, and on developing machine-learning constant-potential methods for electrochemical interfaces.

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Theme 6: Catalysis for Energy and Sustainability

Quantitative calculations of the photoluminescence quantum yield of organometallic emitters

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Organic light-emitting diodes (OLEDs) are widely viewed as the basis for next generation displays and lighting. However, to apply this technology widely and for it to reach its full potential, improvements in the emission efficiency and device lifetime are vital. So far, the development of blue, and especially deep blue, emitters in OLEDs has progressed rather slowly. Therefore, being able to predict the emission efficiency prior to the synthesis and measurement of properties is of crucial importance for the discovery of new highly efficient blue emitters.

Our work[1–2] has shown that it is possible to predict the emission efficiency through the calculation of the radiative rate and non-radiative rate using state-of-the-art computational strategies. Specifically, we find that the main non-radiative process of a series of iridium(III) complexes is the elongation or even breaking of a metal-ligand bond, and the non-radiative rate can be predicted from the energy barrier to this non-emissive state.

In this talk, I will present our advances[2] in quantitative calculations of the photoluminescent quantum yield of iridium(III) complexes using approaches based on transition state theory and their application[3] in the development of new highly efficient deep blue emitters for OLEDs.



Dr Zhou leads the Virtual Materials Group at Queensland University of Technology (QUT), specialising in the theoretical study and design of functional materials using quantum-mechanics-based computational methods. She earned her PhD from the University of Geneva, Switzerland, developing multiscale modelling methods. She has been a Senior Lecturer in physics at QUT since 2024. Previously, she conducted research at the University of Queensland through four fellowships: a Swiss National Science Foundation Early Postdoc Fellowship (2015), Australia-APEC Women in Research Fellowship (2016), UQ Development Fellowship (2017–2019), and Australian Research Council Discovery Early Career Researcher Award (ARC DECRA, 2019–2025), supporting her independent research career.

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Theme 6: Catalysis for Energy and Sustainability

Harnessing Solar Energy for Sustainable Catalysis: Photo-Driven Energy Production, Waste Valorisation and Environmental Remediation

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The development of solar-driven catalytic technologies offers a promising strategy for addressing interconnected challenges in sustainable energy,[1] resource recovery,[2] and environmental protection.[3] My research focuses on the rational design and application of photocatalytic and photothermal catalytic materials, including g-C_3N_4, TiO_2, layered double hydroxide (LDH)-derived metal oxide materials to harness solar energy for value-added energy production, biomass valorisation, plastic upcycling and pollutant removal. By tailoring the physicochemical properties, surface characteristics, and light-to-energy conversion capabilities of functional catalysts, my work explores how solar energy can be efficiently translated into chemical and thermal driving forces for sustainable transformations. In the field of biomass valorisation, photocatalytic processes are developed to convert biomass-derived platform molecules, such as benzyl alcohol and its derivatives, into higher-value chemicals under mild conditions. For plastic upcycling, photothermal catalysis is employed to promote the depolymerization of waste plastics, with a particular focus on polyethylene terephthalate (PET), demonstrating the potential of solar-generated heat for more efficient chemical recycling. In parallel, photothermal systems are investigated for solar-driven H_2 production over g-C_3N_4, highlighting the distinct potential of photothermal catalysis as an alternative to conventional photocatalytic approaches. The environmental application of g-C_3N_4 is further demonstrated through photothermal degradation of organic pollutant Rhodamine B (RhB), providing an alternative approach to solar-assisted wastewater treatment. Collectively, these studies establish a unified solar-driven catalytic framework that integrates renewable energy utilization with biomass upgrading, plastic waste upcycling, clean H_2 production, and environmental remediation, providing new opportunities for developing efficient and sustainable chemical processes.



Dr Haimei Xu is currently a Research Assistant at RMIT University, working with Prof. Tianyi Ma and Prof. Baohua Jia. Prior to this, she worked with Prof. Valentin Valtchev and Prof. Yuanshuai Liu at Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences, (QIBEBT, China) as a Postdoctoral Research Fellow from 2021-2024. She obtained her Ph.D. degree from Macquarie University (Australia) in 2021 under the supervision of Prof. Yijiao Jiang and Prof. Jun Huang (University of Sydney). Her research primarily focuses on the synthesis of advanced functional materials, heterogeneous catalysis for renewable biomass valorisation and plastic upcycling, in situ characterization, and elucidation of structure–activity relationships. To date, she has published 40+ journal articles covering the fields of energy, materials science, and mechanistic studies, in Chem. Soc. Rev., JACS Au, Adv. Funct. Mater., Appl. Catal. B: Environ., Small and Natl. Sci. Rev. Among these, 14 were published as first author, co-first author, or corresponding author.

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Theme 6: Catalysis for Energy and Sustainability

Molecular Design of MIL-53(Cu) for Selective Electrochemical CO_2 Reduction to C_2 Products

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Electrochemical CO_2 reduction provides a promising route for converting CO_2 into value-added chemicals using renewable electricity; however, the selective production of C_2 products remains challenging due to the stringent requirements for efficient C–C coupling. In this work, density functional theory (DFT) calculations were performed to investigate a series of ligand-engineered MIL-53(Cu) nanozymes as artificial enzyme catalysts for CO_2 reduction. By introducing electron-donating and electron-withdrawing functional groups into the organic ligands, the Cu–Cu distance and electronic structure of the catalytic sites can be systematically tuned, thereby regulating the adsorption of key reaction intermediates and the catalytic performance. Among the investigated catalysts, COOH-functionalized MIL-53(Cu) exhibits the optimal geometric and electronic configuration, delivering the highest predicted activity and selectivity toward ethanol production with a limiting potential of only 0.47 V. The computational predictions were further validated experimentally, where COOH-functionalized MIL-53(Cu) achieved a Faradaic efficiency of 55.5% for C_2 products at −1.19 V versus the reversible hydrogen electrode, significantly outperforming the benchmark Cu electrode. These findings demonstrate that ligand engineering is an effective strategy for optimizing Cu active sites and provide valuable insights into the rational design of artificial nanozymes for highly efficient and selective CO_2 electroreduction.



Dr. Xin Mao is DECRA Fellow and Lecturer in the School of Chemistry and Physics at Queensland University of Technology (QUT), Australia. He received his Ph.D. from the School of Chemistry and Physics at QUT in 2022 and subsequently continued his postdoctoral research in the group of Professor Aijun Du. In 2024, he joined the group of Professor Yan Jiao at the University of Adelaide as an ARC-funded Research Fellow. He later returned to QUT as a Lecturer. His research focuses on computational electrocatalysis, with particular interests in developing and applying molecular dynamics simulations and constant-potential methods to investigate electrocatalytic reactions involving small molecules.

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Theme 6: Catalysis for Energy and Sustainability

Promoting Ampere-Level Nitrate Reduction to Ammonia Through Designing Chiral Catalysts

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Electrochemical reduction of nitrate reduction to ammonia (NRA) offers a sustainable approach for NH3 production and NO3 removal[1]. Nevertheless, the current NRA catalysts still suffer from relatively low NH3 yield rate (<1.20 mmol h-1cm-2). We present chiral Cu-nanotips with tailored local environment, which is based on copper nanotip and chiral ligands grow along the tip to obtain radial nanoclusters with core-shell structure.The catalyst achieves an ultrahigh NH3yield rate of 4.36 mmol h-1cm-2at 1 A cm-2, a high Faradaic efficiency (FE) of 98.13% at 1400 mg-N L-1, outperforming most of the recently reported catalysts.At a NO3-concentration as low as 420 mg-N L-1, it still delivers a high FE of 92.39% and an NH3 selectivity of 99.19%, proving its feasibility for industrial applications.The chiral shell of the catalyst exhibits favorable water dissociation for *H generation and high energy barrier for H2formation, contributing to the efficient NRA at low NO3-concentration[2]. Cu nanotips has tip-enhanced enrichment effect to promote NO3-accumulation, leading to efficient NRA at low NO3-concentrations[3]. This work shows a promising chiral Cu-nanotips catalyst for efficient NRA, and the design strategy combing tailored local environment and tip-enhanced enrichment effect could be used to design other catalysts for wide ranges of applications.



Zhirong Lang is a PhD student in the Department of Chemistry at The University of Hong Kong. Her research focuses on design of chiral catalyst and electrocatalysis. Her research interests include electrochemistry, synthesis of organic material and chiral catalysts, electrocatalysis, and catalyst surface chemistry.

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Theme 7

Nano-/Atom-fabrication, Advanced Manufacturing and AI

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Functional Materials and Intelligent Electronics for a Connected and Sustainable Future

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Abstract: Recent advances in electronic materials and fabrication technologies have enabled a new generation of intelligent, multifunctional electronics that extend beyond conventional sensing and computing. These systems are designed to interact seamlessly with humans and the environment, providing innovative solutions for healthcare, sustainability, and autonomous operation. This keynote presents the development of functional materials and electronic platforms that emulate key sensory functions of human skin. By integrating the sensing capabilities of Pacinian corpuscles, thermoreceptors, and nociceptors within a single platform, we have created bioinspired electronic skin capable of detecting pressure, temperature, and harmful stimuli.1 Such systems offer new opportunities for advanced human–machine interfaces and continuous health monitoring. Beyond healthcare, we have developed hydrophobic and oleophilic materials integrated into an electronic dolphin platform for autonomous oil-spill remediation, achieving up to 95% oil-recovery accuracy.2 The talk will also highlight battery-free, wireless, skin-mounted electronics powered by ambient radio-frequency energy harvesting for continuous monitoring of physiological parameters, including electrocardiogram (ECG), blood oxygen saturation, and skin temperature, with real-time wireless data transmission.3,4 In addition, controlled doping of metal oxides has enabled the synthesis of ultrathin two-dimensional nanosheets with engineered crystal phases and enhanced pyroelectric properties. The engineering have facilitated self-biased photodetectors and gas sensors that operate without external power sources.5,6 Collectively, these advances demonstrate the potential of next-generation electronics for proactive healthcare, aged-care support, remote patient monitoring, environmental remediation, hazardous gas detection, and ultraviolet protection, contributing to safer, healthier, and more sustainable societies.

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Dr. Md. Ataur Rahman is an electronic materials engineer specialising in translating laboratory research into industry through prototyping and engineering wearable sensors for biosignals, airborne viruses, harmful gases, and skin-like electronics. He holds a B.Sc. from Chittagong University of Engineering and Technology, an M.Sc. from the University of Ulsan, and a Ph.D. from RMIT University. He has received the Jack Brockhoff Early Career Medical Research Grant (2022), the Heart Foundation Postdoctoral Fellowship (2023), and the ARC Early Career Industry Fellowship (2024). He is currently working as a Senior Lecturer in the School of Engineering at RMIT University.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Laser-Induced Graphene-Based Smart Sensor System

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Abstract: Laser-induced graphene (LIG), directly formed by laser processing, has emerged as a promising material platform for flexible and stretchable sensors because of its simple, scalable, and low-cost fabrication. Through the photothermal conversion of polymer substrates such as polyimide, laser irradiation can locally transform the polymer into porous, multilayered graphene. The morphology, crystallinity, thickness, and electrical properties of LIG can be tuned by laser parameters, substrate materials, and surface modifications [1-2].

In this talk, I will first discuss the fundamental mechanism of LIG formation, with particular emphasis on the incorporation of nanomaterials onto polyimide films to enhance photothermal conversion and thereby promote selective graphene formation[1-2]. Based on an understanding of these formation mechanisms, the electrical and electromechanical properties of LIG will be discussed and benchmarked, toward the realization of highly sensitive strain sensors. The effects of photothermal-enhancing nanomaterials on LIG formation and strain sensor performance will also be highlighted.

Building on these highly sensitive strain sensors, I will introduce several flexible sensor devices and integrated platforms for wearable and robotic applications. As intelligent sensor systems, reservoir computing, a machine learning framework suited for real-time time-series analysis, is further integrated with the sensor platforms. This combination enables real-time, edge-oriented processing of complex sensor signals and extract of useful information with low computational cost[3-4]. Finally, remaining challenges and future perspectives for LIG-based flexible and stretchable electronics, from material engineering to intelligent sensor systems, will be discussed.

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Kuniharu Takei is a professor at Hokkaido University in Japan since 2023. He received his Ph.D. in 2009 from Toyohashi University of Technology. Before joining Hokkaido University, he was a postdoctoral fellow at University of California, Berkeley and an assistant/associate/full professor at Osaka Prefecture University/Osaka Metropolitan University. His current research interests are to build the platforms for multimodal, high-performance flexible electronics. Furthermore, a platform for flexible edge-AI system is developed. His research has been recognized with some awards including the JSPS Prize (2025) and 35 Innovators under 35 by MIT Technology Review (2013).

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Metal–Phenolic Networks for Next Generation AgriTech

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Abstract: Metal–phenolic networks (MPNs) have emerged as a versatile class of coordination-driven materials with unique opportunities for applications beyond traditional nanotechnology and biomedical systems.[1] This keynote will discuss the development of MPN-based materials for agricultural applications, with a focus on controlled-release fertilisers, micronutrient deliveries.

Agricultural inputs must deliver nutrients efficiently while minimising losses to the environment. Conventional fertilisers often exhibit rapid dissolution and nutrient losses through leaching, volatilisation, and other pathways. Our research has explored MPNs as functional coatings and encapsulation platforms that can regulate nutrient release while providing opportunities to incorporate multiple functionalities within a single material.[2] For example, MPN chemistry provides a versatile platform for integrating hydrophobicity, responsiveness, and interfacial functionality.[3,4] These characteristics can be exploited to control water interactions, improve coating stability, and tailor nutrient release under different environmental conditions. Moreover, mechanochemistry-driven approaches have been developed to fabricate MPN-coated fertiliser particles, enabling the solid-state encapsulation of urea and the formation of robust metal–phenolic architectures without relying on conventional solution-based processing.[5]

This keynote will highlight how the molecular coordination chemistry, network structure, and interfacial properties of MPNs can be translated into practical agricultural technologies. The discussion will also consider opportunities and challenges in scaling these materials from laboratory concepts toward sustainable, multifunctional agritech solutions.



Omid Mazaheri is a Research Fellow at the University of Melbourne investigate at the interface of advanced materials, chemistry, and sustainable agriculture. His research focuses on the development of phenolic-based materials, controlled-release fertilisers, and biofertiliser technologies. He has extensive expertise in functional coatings, coordination chemistry, mechanochemistry, surface engineering, and advanced materials characterisation, including synchrotron-based techniques. His research has led to collaborations with academic and industry partners in Australia and internationally, with a focus on translating fundamental materials science into practical agricultural technologies.

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Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Interlaminar shear behaviour of additively manufactured continuous fibre reinforced composites using MWCNT-coated filaments

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Abstract: The relatively poor interlaminar performance in additively manufactured continuous fibre reinforced composites (CFRCs) remains a major challenge inherent to the printing process. Incorporating multi-walled carbon nanotubes (MWCNTs) has improved interlaminar performance in traditionally manufactured laminates. However, the use of MWCNTs in additively manufactured CFRCs remains limited. This study investigates the interlaminar shear behaviour of additively manufactured CFRCs enhanced via surface coating of MWCNTs on the continuous fibre filaments. An automatic layer-by-layer coating process was developed to coat two types of fibre filaments: glass fibre filaments (GFF) and carbon fibre filaments (CFF). Multilayer MWCNTs were deposited onto the filaments by sequentially adsorbing positively charged PEI and negatively charged MWCNT via electrostatic self-assembly process. The automatic process endorsed uniform MWCNT coating through precise control of filament speed, coating baths separation by utilizing drying stages and eliminating mechanical contact associated with conventional roller-based coating methods. The CFRC samples were printed using a Markforged® printer and MWCNT coated filaments and evaluated for their interlaminar shear properties. Scanning Electron Microscopy (SEM) observations confirmed that MWCNTs were deposited successfully on both GFF and CFF. The contribution of MWCNTs to the interlaminar shear properties differed between CFF and GFF in terms of tangent modulus, maximum load, and ultimately the short beam strength. The addition of one to five MWCNT layers enhanced the tangent modulus across all tested configurations, ranging from 12 - 20% for CFF and 320-96% for GFF. The integration of MWCNTs into additively manufactured CFRCs facilitates the production of customised lightweight components with improved interlaminar performance.



Prof. Dong Ruan is the Associate Dean, Innovation and Engagement in the School of Engineering at Swinburne University of Technology. Her research interests include: (1) mechanical properties of materials and structures under dynamic loadings; (2) additive manufacturing of continuous fibre-reinforced composite materials and structures. She has led research and industry collaboration projects and published extensively in lightweight materials and structures with a citation of over 13,000. Dong is an Associate Editor of Engineering Structures (Q1 journal). She received two prestigious national awards: • Eureka Prize in 2013 as a team member of DMTC's Armour Applications Program in the Safeguarding Australia category • AGM Michell Medal from the Institution of Engineers Australia in 2022

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Stochastic Electrochemistry and Emerging Transduction Strategies in Biosensors and Bioelectronics

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Abstract: Stochastic electrochemistry is an emerging analytical approach that transforms electrochemical fluctuations, traditionally regarded as a nuisance, into a rich source of chemical and biological information. Rather than filtering these fluctuations, their systematic analysis provides new pathways to achieve enhanced selectivity, specificity, and functional insight in biosensors and bioelectronic systems. This presentation will give an overview of the technique, its development from traditional corrosion monitoring, and recent advances demonstrating how stochastic signals can be implemented across a range of applications that go beyond conventional sensing strategies.

First, stochastic analysis enables real-time quantification of active electrode surface area, offering a means to measure biofouling as it develops and potentially recalibrate sensors dynamically during operation. This provides a new pathway to extend sensor service life, complementary to conventional anti-biofouling strategies. Second, frequency-specific features in stochastic signals offer opportunities to investigate molecular recognition and binding dynamics, introducing an additional dimension of selectivity beyond conventional electrochemical measurements. Third, these concepts open new opportunities to probe cellular activity and ion-channel behaviour through characteristic electrical fluctuations. The presentation will also introduce emerging developments in light-addressable electrochemistry, exploring opportunities for spatially resolved measurements, cellular interfacing, and bioelectronic applications.

Together, these examples highlight how stochastic electrochemistry and complementary electrochemical approaches can expand the capabilities of biosensors and bioelectronics. By extracting meaningful information from intrinsic fluctuations and introducing new strategies for controlling electrochemical interfaces, these approaches offer opportunities for more reliable, selective, and information-rich measurements across emerging bioanalytical technologies.



Sina Jamali is a senior lecturer at the School of Environment and Science, Griffith University. He completed his PhD at the University of Wollongong (2016), Australia, followed by research fellowship at University of Wollongong (2015), industry appointments (2019) and ARC DECRA fellowship at UNSW Sydney (2021) prior to joining Griffith University in 2024. He leads the ElectroBioMaterials Nexus research lab with a focus on biosensors and electroactive materials.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Light-Activated Doping and Dedoping for Precision Manufacturing of Wafer-Scale 2D TMDCs

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Abstract: 2D Transition Metal Dichalcogenides (TMDCs) have shown immense promise in next generation electronic devices. However, a major roadblock to commercialization is the lack of efficient ways to dope them with spatial precision. Doping with spatial precision can open up avenues for multi-valued logic systems, a computing paradigm where logic gates can operate with more than two logic states (e.g., ternary logic with 0, 1, and 2), instead of the conventional binary (0 and 1). Recent studies from our group have demonstrated light-activated stable, spatially precise dedoping in wafer-scale MoS_2 films, leveraging photo-induced charge transfer at the oxide interface1. While promising, these demonstrations were proof-of-concept and lacked rigorous control over the underlying mechanisms affecting the dedoping process. Here we elucidate a robust and controllable platform for dedoping 2D TMDCs at wafer scale, with spatial precision, and long-term device stability. We propose a mechanism for controlled dedoping via light-activated mechanisms and experimentally validate the proposed mechanism for light-activated dedoping. Our prior work highlighted the role of a sub-stoichiometric oxide interface and intrinsic defects in $MoS_2$1 in the light activated dedoping process. However, these critical parameters were neither intentionally engineered nor well understood. Our current results demonstrate systematic tuning of both the semiconductor and the oxide interface underneath, via defect engineering, enabling precise control over the dedoping process. The ability to reproducibly control carrier density in wafer-scale MoS2 with spatial precision is expected to open up unconventional computing paradigms hitherto unexplored.

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Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Thermal properties and applications of boron nitride nanosheets

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Abstract: As electronic devices continue to evolve toward miniaturisation and multifunctionality, overheating has become a major challenge that limits device performance, reliability, and lifespan. Addressing this issue requires materials that combine high thermal conductivity with excellent electrical insulation for efficient heat dissipation. Boron nitride nanosheets (BNNSs) are promising candidates that meet these requirements. In this presentation, we first report the in-plane thermal conductivity of atomically thin BN. Combined experimental measurements and density functional theory (DFT) calculations reveal how both layer thickness and isotopic composition influence phonon transport and thermal conductivity (1–4). Although BNNSs possess exceptional in-plane thermal conductivity, their intrinsically low cross-plane thermal conductivity results in highly anisotropic heat transport in BNNS-based composites. To address this limitation, we developed a simple and scalable mechanochemical exfoliation method to produce functionalised BNNSs with excellent dispersibility in both aqueous and organic solvents (5). These high-quality dispersions enabled the fabrication of BN spheres with high isotropic thermal conductivity. When incorporated into poly(vinyl alcohol), the BN spheres increased the composite thermal conductivity by approximately 3700%, effectively overcoming the anisotropic heat transport commonly observed in BN-reinforced polymers (6). This work provides fundamental insights into phonon transport and scattering in BNNSs while demonstrating a practical strategy for developing electrically insulating thermal interface materials with high isotropic thermal conductivity for next-generation thermal management applications.



Dr Qiran Cai is an ARC DECRA Fellow at the Institute for Frontier Materials, Deakin University, Australia. His research focuses on boron nitride nanomaterials, diamond, and advanced thermal management materials. His work spans fundamental studies of phonon transport, Raman spectroscopy, and nanomaterial mechanics, as well as the development of functional materials and devices for thermal management, sensing, and energy applications. His current research includes boron nitride-based thermal interface materials, diamond heat spreaders, and diamond-based electronic devices, with an emphasis on understanding structure-property relationships and translating materials research into practical technologies

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Application-Tailored Low-Loss MnZn Ferrites for High-Frequency Magnetic Components: Toward Additive Manufacturing

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Abstract: High-frequency magnetic components require soft magnetic materials that balance low power loss, frequency capability, thermal stability, and manufacturing cost. However, these requirements cannot generally be optimised simultaneously using a single MnZn ferrite composition. This work presents an application-tailored design framework for MHz-range MnZn ferrites through the coordinated control of dopant chemistry, microstructure, and sintering conditions.

$CaTiO_3$ (CTO) was investigated as a representative dual-ion additive for regulating grain growth, grain-boundary resistivity, and high-frequency loss. Powder-level CTO incorporation reduced the power loss to 155 mW·cm^{-3} at 1 MHz, 30 mT, and 25 °C. Further optimisation of the CTO content and sintering process achieved 94 mW·cm^{-3} under the same conditions, with the power loss remaining below 130 mW cm-3 from −20 to 100 °C. For frequency-demanding applications, nano-$LaCoO_3$ addition increased the cut-off frequency from 6.35 to 8.40 MHz while achieving 143 mW·cm^{-3} at 1 MHz and 30 mT. $SrTiO_3$ modification enabled thermally stable operation, maintaining the power loss below 225 mW·cm^{-3} from −20 to 100 °C.

These results demonstrate that MnZn ferrites can be tailored toward cost-conscious low-loss operation, extended frequency response, or wide-temperature stability. The resulting powder-chemistry and microstructure-design principles provide a foundation for developing printable magnetic feedstocks and geometry-customised components through polymer-bonded or sinterable ceramic additive-manufacturing routes.

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Mengrui Li is a Research Assistant at RMIT University and a PhD candidate at Swinburne University of Technology. Her research focuses on high-frequency low-loss MnZn ferrites, functional magnetic materials, microstructure–property relationships, and additive manufacturing of magnetic components for power electronics and wireless power-transfer applications.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

ZnS-Mediated Multi-cation Exchange toward Compositionally Complex Metal Sulphide Nanomaterials

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Abstract: Simultaneous multi-cation exchange offers a promising route to compositionally complex metal sulphide nanomaterials, but incorporation of multiple chemically dissimilar cations into a common host lattice remains challenging because of differences in ionic characteristics, precursor reactivity, and structural compatibility. High-entropy sulphide synthesis has previously been demonstrated using $Cu_{1.8}S$ nanocrystals as a parent host [1], motivating exploration of alternative sulphide frameworks capable of accommodating diverse metal species. Here, ZnS nanoparticles were investigated as a host for multi-cation exchange with V, Mo, Mn, Nb, and Ta precursors in an oleylamine (OLA)-mediated reaction environment. OLA provides a coordinating reaction medium and surface-stabilising environment during ZnS synthesis and subsequent multi-cation exchange [2]. Targeted variations in precursor composition were further employed to probe competitive interactions governing multi-cation incorporation. Energy-dispersive X-ray spectroscopy (EDS) confirmed incorporation of multiple target metals and revealed strongly element-dependent incorporation behaviour. X-ray diffraction (XRD) demonstrated systematic structural changes following multi-cation exchange, consistent with perturbation of the parent ZnS lattice upon introduction of chemically dissimilar cations. Fourier-transform infrared spectroscopy (FTIR) was employed to examine surface chemical features associated with the OLA-containing nanomaterial system. These results highlight the capacity of ZnS to accommodate chemically diverse cations through multi-cation exchange and demonstrate the interplay between elemental incorporation and structural response in compositionally complex sulphide nanomaterials.

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I graduated as the top-ranked student in Chemical Engineering, majoring in Process Design. During my master's research, I designed and developed a nanoparticle tracking device and an associated analysis program for determining the particle-size distribution of transparent and opaque nanoparticles, achieving approximately 20 nm resolution. This work received a Creativity Award at the 24th National Exhibition of Research, Technology and Tech Market Achievements. I am currently a PhD candidate at UNSW, where my research focuses on the synthesis and development of advanced nanomaterials for catalytic applications.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Universal shrink-programmed droplet-to-bead fabrication of multimodal functional microbeads

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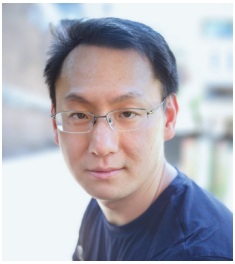
Abstract: Functional microbeads are widely used in biomedical applications, such as diagnostics, targeted delivery, cell isolation, and point-of-care testing, where they integrate target recognition, signal readout and surface functionalisation within a single particle platform. Commercial products already serve many important needs well, particularly for standardised and well-established workflows. However, when specific requirements arise, such as continuous size tunability, custom payload incorporation, multimodal functionality, or application-specific surface engineering, existing options can be less flexible or more difficult to adapt. This creates an ongoing need for on-demand, versatile, and broadly accessible fabrication methods that can produce high-quality functional microbeads and be readily adopted by different laboratories for their own purposes. Here, we report a shrink-programmed droplet-to-bead method (SPDB) that decouples final bead size from the initial droplet template. SPDB uniquely suppresses early solidification of droplets, creating a “shrink first, cure later” kinetic window that allows substantial evaporation-driven droplet contraction while preserving high sphericity and monodispersity. This programmed shrinkage acts as an active fabrication step that simultaneously miniaturises beads into the micron regime (1-20 μm) and concentrates functional payloads within the contracting droplet volume. Compatibility with diverse nanoparticle payloads, including conductive Field’s Metal nanoparticles, non-conductive silica nanoparticles, magnetic nanoparticles, and quantum dots, enables the fabrication of electrically, magnetically, and optically functionalised microbeads within a shared material agnostic method. The same strategy also supports co-encapsulation of compatible nanoparticles to generate hybrid multimodal beads. Together, this method provides a general route to miniaturised, high payload functional microbeads for multimodal biosensing and encoding bead-based readout.



Dr Shiyang Tang is a Scientia Associate Professor in the School of Mechanical and Manufacturing Engineering at the University of New South Wales (UNSW Sydney), Australia. He is also an Associate Professor in the School of Electronics and Computer Science at the University of Southampton, UK. Dr Tang is the recipient of the Future Fellowship (2023) and the Discovery Early Career Researcher Award (DECRA, 2020) from the Australian Research Council. Dr Tang received his BEng (First-Class Honours) in Electrical Engineering and PhD in Microelectromechanical Systems (MEMS) from RMIT University, Australia, in 2012 and 2015, respectively.

Following his PhD, he conducted postdoctoral research at Pennsylvania State University (PSU) and the University of California, San Francisco (UCSF), USA, focusing on advanced MEMS and bio-microfluidics. After returning to Australia, he was awarded the Vice-Chancellor's Postdoctoral Research Fellowship at the University of Wollongong (2017-2019). He then joined the University of Birmingham, UK, where he served as a Lecturer in the School of Engineering from 2020 to 2023. Dr Tang has published ~150 papers in high-impact journals, including PNAS, Nature Communications, Science Advances, Matter, and Advanced Materials. He is the Associate Editor of the Journal of Nanobiotechnology, and serves on the Editorial Board of MetalMat, Sensors, Scientific Reports, Health Nanotechnology, and Translational Medical Engineering.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Image Processing for Sensing and Assistive Navigation

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Abstract: This presentation provides an overview of our research on image processing and artificial intelligence for sensing and assistive navigation. It covers vessel detection and recognition using electro-optical satellite imagery, monitoring of oceanic internal waves using synthetic aperture radar imagery, underwater mine sensing using sonar imaging, and biosecurity screening using multispectral imaging. It also examines how depth sensing and scene perception support assistive navigation for people with vision impairment.



Son Lam Phung is a Professor and an Associate Head of School at the School of Engineering, University of Wollongong, Australia. He holds a Bachelor of Engineering with First-Class Honours and a PhD, both in computer engineering, from Edith Cowan University, Australia. He was awarded the University Medal in 2000. His research interests include image and signal processing, pattern recognition, machine learning, and artificial intelligence. He has published over 150 papers including 59 journal articles. His work has appeared in IEEE journals such as TCSVT, TNNLS, TIP, TGRS, and TPAMI, as well as in the proceedings of CVPR and ICCV. Professor Phung has served as a Chief Investigator on over 30 externally funded research grants and projects. He is a member of the Australian Research Council College of Experts.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Ultrafast Quantum Oscillations Beyond the Bloch Oscillation in Coupled Low-Dimensional Atomic Crystals

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Abstract: Bloch's seminal paper in 1929 has initiated a long history of exploration on the dynamics of electrons in a static electric field within crystals. Bloch and Zener showed that the period of the Bloch oscillation is given by $T_B=h/eFd$, where h is the Planck constant, e is the elementary electron charge, d is the lattice period, and F is the magnitude of the electric field. Because of the small lattice periods and the limitation of the field intensity that crystals can withstand, the Bloch oscillation in crystals is in the range of picoseconds, which is much larger than the electron decoherence time induced by defects, impurities, and lattice thermal vibrations, and thus has been difficult to be observed in crystals. After more than 60 years since the prediction, Bloch oscillations were first observed in 1992 in semiconductor superlattices with considerable large lattice periods and then in systems of ultra-cold neutral atoms in optical lattices with much longer decoherence time of cold atoms.

In this talk, I will introduce our recent prediction on a novel type of periodic quantum oscillations in coupled low-dimensional atomic crystals with much shorter period beyond the Bloch oscillation, without the need of external electric fields. Using one-dimensional coupled atomic chains and bilayer/trilayer graphene systems, we show that the time evolution of electron wavepacket in the coupled low-dimensional quantum systems of mirror symmetry exhibits a periodic oscillation in both the transverse and longitudinal directions with a period determined by $T_C=h/e2u$, where u is the coupling strength between subsystems. The electron motion in the longitudinal direction is determined solely by the Hamiltonian of the subsystems, which can be used to control the oscillation length independently. Moreover, we show that the oscillation can be effectively tuned by external electric fields. Furthermore, we provide numerical evidence supporting that a universal damped oscillation occurs in disordered coupled crystals, with the decay time inversely proportional to the square of the disorder strength W and the frequency change proportional to the square of W. Unlike the Bloch oscillation driven by electric fields, the periodic oscillation induced by coupling of quantum subsystems can reach the ultrafast period from femtoseconds to attoseconds determined by the coupling strength, which is much shorter than the electron decoherence time in real materials. Our findings may pave the way for observation of ultrafast electron oscillations in low-dimensional atomic crystals.

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Liquid Metals Enabling the Fabrication and Doping of Advanced Transparent Conductive Materials

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Abstract: The complexity of current technologies poses a significant challenge in engineering the desired properties required for the advancement of transparent p-n junctions for application in transparent solar cells and optoelectronics. The fabrication of advanced ultrathin semiconductors and transparent conductive oxides (TCOs) as foundations for next-generation flexible and wearable miniature electronics and optics is currently extremely expensive and challenging, largely due to the difficulty of achieving precise atomic-level doping. In contrast, the emerging field of liquid metals addresses this complexity through the synthesis, doping, and functionalization of ultrathin structures with engineered electrical and optical properties.

The preparation of ultrathin transparent metal oxides involves exfoliating and transferring the atomically thin surface of liquid metals onto a substrate, enabling the harvesting of doped planar structures with tuneable electrical, optical, and mechanical properties. This liquid metal-based approach presents an unprecedented methodology for harvesting large areas of atomically thin doped metal oxides by leveraging the unique ability of liquid metals to selectively transfer elements to their surface, enabling controlled doping at the nanoscale. Employing a bridge-solubility mechanism also enables the dissolution of otherwise insoluble reactive nonmetals and metalloids as dopants in liquid metals. Doping with electron acceptor dopants potentially induces p-type properties in the harvested metal oxide. This liquid metal-mediated doping nanotechnology facilitates the emergence of a wide range of in-demand functional ultrathin metal oxides and TCOs with tailored properties without the need for complex and expensive vacuum-based deposition systems.

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Dr Mohammad Bagher Ghasemian is a Senior Research Fellow in the School of Chemical and Biomolecular Engineering at the University of Sydney and an Adjunct Lecturer in the School of Materials Science and Engineering at UNSW Sydney, where he received his PhD in 2018. From 2019 to 2022, he was a Postdoctoral Fellow at the Centre for Advanced Solid and Liquid Based Electronics and Optics (CASLEO). He was also a Visiting Research Fellow in the School of Chemical Engineering at UNSW Sydney between 2023 and 2025. Dr Ghasemian has additionally worked as a Researcher at the Centre for Smart Supramolecules (CSS) at Pohang University of Science and Technology (POSTECH), South Korea. His research focuses on liquid metals for the preparation and fabrication of functional materials, including nanostructures and 2D materials, with applications in semiconductors, photocatalysis, sensing, flexible devices, energy harvesting, optics, and electronics.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

A Bioinspired Micro-nano Photonic Materials

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Abstract: Controlling the interaction between light and matter through optical structures has laid the foundations for a broad spectrum of applications, ranging from colors, lasers, and optoelectronics, to quantum information processing. Optical metamaterials, 2D or 3D structures comprising subwavelength metallic or dielectric pixels, are a new class of material that enable precision tailoring of light–matter interactions. Optical metamaterials present properties beyond those found in natural materials that is possible to explore novel light–matter interaction phenomena. These salient features have unveiled an impressive assemblage of potential applications including the generation of 'flat optics' (e.g. metalenses) and 'cloaking' materials. Inspired by the natural hierarchical optical structures, we developed a series of optical metamaterials with a low spatial footprint and enhanced light-matter interaction. Deep-strong coupling of different optical structures, such as Fabry-Pérot interferometers, distributed Bragg reflectors, photonic crystals and grating structures, unlocks a large variety of novel phenomena spanning traditionally distant research areas. Moreover, we emerge compound optical structure materials with surface-functionalization, chemical regulation, and optoelectronic device which open prospects for diverse applications, including anti-counterfeiting, encryption, sensing, displays, photovoltaics and imaging.

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Mingzhu Li is a full professor at Technical Institute of Physics and Chemistry, Chinese Academy of Sciences (TIPC- CAS) and Fellow of the Royal Society of Chemistry (FRSC). Her interests lie in the design, fabrication, and application of bioinspired micro/nano photonic materials. She received her PhD degree from Institute of Chemistry, Chinese Academy of Sciences (ICCAS), and joined the Key Laboratory of Green Printing, ICCAS in 2008. In 2023, she moved to Laboratory of Bio-inspired Smart Interface Science, TIPC-CAS. She has published more than 100 peer-reviewed SCI journal articles, including Science, PNAS, Sci. Adv., and so on. She has received several awards including the National Science Fund for Distinguished Young Scholars, the first prize of Beijing Science and Technology Award, etc. She has joined the Editorial Boards of Journal of Materials Chemistry C and Materials Advances as an Associate Editor since April, 2023.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Bioinspired MXene Nanocomposites

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Abstract: High-performance nanocomposites can potentially solve the bottleneck problems of miniaturization and lightweight in the field of aerospace. The two-dimensional MXene nanosheets show excellent mechanical and electrical properties, the properties of MXene nanocomposites are much lower than expectation. It was found that the void is an essential factor to decrease the properties of MXene nanocomposites, but usually neglected in the past decades. Herein, we applied both focused ion beam and scanning electron microscopy tomography (FIB/SEMT) and nanoscale x-ray computed tomography (nano-CT) to reconstruct the void microstructure of MXene nanocomposites. These results overturned the conventional densely stacked structure model of MXene nanocomposites. We further developed a simple and effective densification strategy to cure the voids using a sequential bridging process with different interfacial interactions. The resultant sequentially bridged MXene nanocomposites[1-5] achieved dramatical improvement in mechanical properties, resistance to cyclic mechanical deformation, oxidation, and stress relaxation etc.



Professor Qunfeng Cheng is a professor in the University of Science and Technology of China. He has discovered for the first time the void defects in the 2D nanocomposites induced by capillary contraction, and developed a new strategy of sequential bridging and nanoconfinement assembly to cure the void defects for creating high performance 2D nanocomposites with excellent mechanical and electrical properties. Dr. Cheng has been awarded the XPLORER PRIZE, the Meituan Green Tech Award, the Beijing Distinguished Young Zhongguancun Award, the Mao Yi-sheng Science and Technology Award-Beijing Youth Science and Technology Award, and China Young Scientist Award of Composites Society, etc. Dr. Cheng has published more than 110 papers including 3 papers in Science, 1 paper in Nature, with over 16,000 citations, and a Google Scholar h-index of 65. He has authorized 45 Chinese patents and has authored the book "Bioinspired Layered Two-dimensional Nanocomposites".

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High-Precision 3D Printing of Micro/Nano Functional Devices: Materials, Processes, Equipment and Applications

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Abstract: Miniaturized functional devices increasingly require complex three-dimensional geometries, multiple materials, and coupled physical functions, creating simultaneous challenges in material printability, interfacial integrity, forming accuracy, and manufacturing efficiency. This work summarizes our recent progress in high-precision photopolymerization-based additive manufacturing of micro/nano functional devices from functional materials, printing processes, equipment, and applications. At the material level, magnetic, magneto-conductive, and hydrogel-based photopolymers were developed for programmable magnetic response, local electrical conductivity, and large deformation; NdFeB-Fe_3O_4 composite resins enabled ferromagnetic structures with sub-40 μm features. At the process level, micro-continuous liquid interface production (μCLIP), weak-support and water-soluble support strategies, multi-step exposure, and multi-material DLP with a common flexible interface were established to improve printing speed, unsupported-feature fidelity, heterogeneous interfacial bonding, and layer-stacking accuracy. Custom μCLIP and cross-scale multi-material DLP systems further enabled high-resolution fabrication and in situ integration of multiple materials. Representative demonstrations include magnetically actuated microgrippers, a multi-material magnetic aperture with large reversible deformation, magnetic/conductive signal-coding components, octet-truss electrodes with 50 μm struts for electrochemical energy storage, and reproducible artificial rock-core microstructures for petroleum engineering. These studies establish an integrated route from functional-material design and process/equipment development to application-oriented fabrication, providing a versatile platform for next-generation miniaturized functional devices in biomedicine, electronic information, precision optics, energy systems, and resource engineering.

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Longqiu Li is a Professor and Ph.D. supervisor at Harbin Institute of Technology, a recipient of the National Science Fund for Distinguished Young Scholars, and Deputy Director of the State Key Laboratory of Robotics and System. His research focuses on micro/nano manufacturing, additive manufacturing, robotics, and intelligent manufacturing systems.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Advanced Manufacturing of Radio Frequency Electronics

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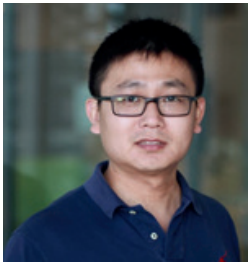
Abstract: Advanced manufacturing technologies are creating new opportunities to rethink the design, fabrication, and integration of radio-frequency (RF), millimetre-wave, and terahertz electronics. This presentation will introduce our recent advances in additive manufacturing of RF components and systems, with particular emphasis on multimaterial 3D printing, additively manufactured antennas and arrays, metasurfaces, beamforming networks, and heterogeneous RF packaging. By exploiting the geometric freedom of additive manufacturing and the co-integration of conductive and dielectric materials, complex three-dimensional electromagnetic structures can be realised that are difficult or costly to fabricate using conventional planar technologies. Recent examples include wideband multimaterial antenna arrays, 3D-printed millimetre-wave beamforming components, filtering metasurfaces with integrated polarization and frequency control, and compact multibeam RF networks. The presentation will further discuss emerging antenna-in-package concepts that combine additively manufactured electromagnetic structures directly with semiconductor devices, enabling new approaches to beamforming, beam steering, thermal management, and system integration. Looking beyond conventional 3D printing, emerging 4D printing and shape-morphing structures offer opportunities for dynamically reconfigurable RF systems. These advances demonstrate a pathway from materials and manufacturing processes to highly integrated RF hardware, providing scalable and cost-effective solutions for future 5G/6G communications, sensing, satellite systems, and intelligent wireless platforms.



Yang Yang was born in Bayan Nur, Inner Mongolia, China and received a PhD degree in Electronic Engineering from the Department of Electrical and Computer Systems Engineering, Monash University, Clayton, Australia, in 2013. In December 2016, Dr. Yang joined the University of Technology Sydney (UTS), Australia. He joined The University of Sydney in March 2026 as a Full Professor in RF Electronic Engineering. His research interests include additively manufactured electronics, millimetre-wave and sub-terahertz technologies in 5G and beyond and biomedical applications. He has over 300 international publications in microwave, millimetre-wave and terahertz circuits and antennas. Dr Yang is the Australian Research Council Mid-Career Industry Fellow (2025-2029). He was selected as one of the "Top 2 % Most Highly Cited Scientists by Stanford" every year since 2019. He received many distinguished awards, including the 2025 Advanced Materials Innovation Award by the International Association of Advanced Materials (IAAM), 2024 IEEE MTT-S IMS First Place in the Early Career Award Competition (serving as the ECR advisor), 2023 IEEE NSW Section Outstanding Service Award, 2023 IEEE AP-S Outstanding Chapter Award and 2022 IEEE MTT-S Outstanding Chapter Award. He is an Associate Editor of IEEE Transactions on Microwave Theory and Techniques (from October 2022), an Associate Editor of IEEE Microwave and Wireless Technology Letters (from October 2024), a Guest Editor of Proceedings of the IEEE (2024), an Area Editor of Microwave and Optical Technology Letters (2019-2024), an Associate Editor of IEEE Access (2018-2022), and a Guest Editor of IEEE Antennas and Wireless Propagation Letters (2022). Dr Yang is the Inaugural Chair of IEEE MTT-S TC-17 Microwave Materials and Processing Technologies. He is a committee member of IEEE AP-S TC-8 Wireless Communication and IEEE MTT-S TC-28 Biological Effects and Medical Applications. During 2022-2024, he was a committee member of the AP-S Technical Committee on Antenna Measurements and the AP-S Technical Directions Committee. His appointments at IEEE NSW Section, Region 10, include the committee member of the IEEE NSW Section, the Treasurer (2018-2019) and the Chair/Vice Chair (2020-2024) of the IEEE NSW AP/MTT Joint Chapter, the Secretary (2019) of IEEE NSW PH/ED/SSC/CAS Joint Chapter, the Inaugural Committee/Treasurer (2020) and Vice Chair (2022-2024) of IEEE NSW Electron Devices Chapter. He also volunteered in various conference organizing committees, such as the General Co-Chair of the 2025 Australian Microwave Symposium, General Co-Chair (Executive Chair) of the inaugural annual international conference on IEEE Additively Manufactured Electronic Systems (AMES2025) and General Chair of IEEE MTT-S International Microwave Workshop Series on Advanced Materials and Processes for RF and THz Applications (IMWS-AMP 2026). Dr. Yang serves as the Secretary of the Administrative Committee for the 2026 IEEE MTT-S.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Can Individual Struts Serve as Surrogate Specimens for Additively Manufactured Titanium Microlattices?

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Abstract: Additively manufactured metallic microlattices derive their mechanical response from submillimetre struts whose properties can differ substantially from those of bulk material. Because direct mechanical testing of struts within a microlattice is impractical, separately printed individual struts are used as surrogate specimens, although their representativeness has not been established. Here, hot-isostatically pressed Ti6Al4V individual and microlattice struts produced by electron beam powder bed fusion were compared at matched vertical and inclined orientations using X-ray micro-computed tomography and electron backscatter diffraction. Individual struts reproduced the principal orientation-dependent trends in surface roughness, cross-sectional geometry, average porosity and microstructure observed in microlattice struts. However, microlattice struts contained larger and more irregular defects, demonstrating that similar average porosity does not imply equivalent defect populations. Tensile testing of individual struts further revealed strong orientation dependence in strength and failure strain, while their effective elastic modulus remained substantially below bulk Ti6Al4V values. These findings establish both the usefulness and limitations of individual microstruts as experimentally accessible surrogates for constitutive characterisation of additively manufactured microlattices.



Dr Olga Zinovieva is an ARC DECRA Fellow, Senior Lecturer in Mechanical Engineering and Mechanical Engineering Program Coordinator (Acting) at UNSW Canberra. Her research focuses on additive manufacturing, mechanics of materials, digital engineering and multiscale modelling, with particular emphasis on linking manufacturing conditions, microstructure and defects to mechanical performance. She combines computational materials science, high-performance computing and advanced experimental characterisation to develop predictive approaches for the design and manufacture of high-performance engineering materials. Her current research includes metal additive manufacturing, architected materials and structures for extreme loading, and simulation-led process–structure–property optimisation.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

2D materials based homologous metal heteromaterials with chemically bonded metallic interface for stable high-current-density electrocatalysis

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Abstract: 2D materials possessing large surface area, tunable electronic and chemical properties, and can be massively produced at low cost. There are important class of materials for various catalysis. In this talk, I will introduce our works in the mass production of 2D materials. Then, I will talk about the use of such massively produced 2D materials in large current density electrolysis including fundamental understanding of the process, interfacial engineering, and electrolyzer performance. Finally, I will introduce our latest progress in synthesizing a family of 2D materials based homologous metal heteromaterials (HMHs) featuring chemically bonded and metallic interface, which endow them with strong interfacial binding force and metallic conductivity for stable high current density water electrolysis.

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Dr. Bilu Liu is a full Professor of Tsinghua University. He works on the mass production of 2D materials and their applications in electrocatalysis, electronics, and optics. He obtained bachelor's from USTC, and PhD degree from Institute of Metal Research, CAS. He worked as a postdoctoral researcher and research assistant professor in University of Southern California from 2012 to 2016, and then jointed to Tsinghua University in 2016. He is a recipient of several awards including the Young Science Innovation Award of Guangdong Province, Excellent teacher of Shenzhen Municipality, Excellent Advisor Award of PhD and Master students of Tsinghua University, etc.

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Biomimetic Design and High-Precision Additive Manufacturing of Bioactive Dental Structures

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Abstract: Tooth loss remains a major clinical challenge, while conventional dental restorations mainly recover morphology and mechanical function but cannot fully reproduce the hierarchical structure and biological activity of natural teeth. This work presents our recent progress in biomimetic design and high-precision vat photopolymerization additive manufacturing of bioactive teeth. A systematic route integrating dental scanning and model reconstruction, biomimetic root topology design, high-solid-loading ceramic slurry formulation, photopolymerization, debinding and sintering, and biological functionalization was established. Printability-constrained porous root architectures were optimized to increase root surface area and provide interconnected microenvironments for tissue integration. Zirconia-based photocurable ceramic slurries with solid loading up to 50 vol.% were developed, while equipment and process optimization reduced the printing layer thickness from 40 to 30 μm and improved interlayer consistency. Custom-developed photopolymerization systems further enabled rapid, high-precision and multi-material fabrication, achieving a forming accuracy of 10 μm and arbitrary integration of three materials. Representative demonstrations include full-tooth fabrication, porous biomimetic roots with minimum sintered pores of approximately 230 μm, high-precision dental veneers, crown–root multi-material structures, intralayer hard–tough architectures, and porous ceramic scaffolds for osteogenic and dental-pulp cell culture. These studies establish an integrated design–material–process–equipment–biofunctionalization framework, providing a pathway from conventional dental replacement toward structurally biomimetic, multi-material and biologically active tooth restoration.

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Zhiyuan Huang is an Associate Research Fellow at the School of Mechatronics Engineering, Harbin Institute of Technology. His research focuses on high-precision 3D printing, multi-material additive manufacturing, and miniature functional devices.

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Confined Polymerisation: A New Strategy for High-performance Membranes

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Abstract: Polymer membranes underpin a wide range of resource separation, energy and environmental technologies. Their performance is fundamentally governed by polymer structure and molecular organisation, yet conventional fabrication approaches provide limited control over polymer formation at the nanoscale. Here, we introduce confined polymerisation as a new strategy for membrane fabrication, in which nanoscale confined spaces serve as reaction environments to regulate polymerisation and tailor membrane structure and functionality. We recently demonstrated that polymerisation within sub-2-nm nanochannels can profoundly alter polymer formation, producing highly compact polymer networks with properties distinct from their bulk counterparts. Spatial confinement regulates polymer growth and molecular organisation, enabling membranes with high mechanical strength, flexibility and chemical stability. Incorporation of functional monomers further creates selective ion-transport pathways, demonstrating the potential to couple confined synthesis with membrane functionality. Building on this concept, we have extended confined polymerisation to a broader range of materials, polymer chemistries and membrane architectures. These results demonstrate the versatility of nanoconfinement for controlling polymer formation and accessing membrane structures and properties difficult to achieve using conventional approaches.

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Prof. Xiwang Zhang is the Dow Chair Professor at the University of Queensland, Director of UQ Dow Centre, and Director of ARC Centre of Excellence for Electrochemical Transformation of Carbon Dioxide (GetCO2). He was the Founding Director of ARC Industry Transformation Research Hub for Energy-efficient Separation (EESep). His research focuses on membrane and advanced oxidation technologies for energy-efficient separation, resource recovery, green chemical synthesis, carbon dioixde conversion and renewable energy generation.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Topology Optimisation and Advanced Manufacturing for High-Performance Architectural Structures

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Abstract: The performance of architectural structures depends not only on material properties, but also on how materials are distributed, fabricated and assembled. Connecting computational design with advanced manufacturing offers opportunities to improve structural efficiency while reducing material consumption. This presentation explores this connection through research integrating topology optimisation, robotic fabrication and additive manufacturing for architectural applications. Particular attention is given to bi-directional evolutionary structural optimisation (BESO) as a method for generating efficient structural forms, and to the manufacturing and assembly constraints that influence their physical realisation. Drawing on research in generative design, additive manufacturing and robotic construction, the presentation examines how material characteristics, fabrication processes and structural geometry can inform one another throughout the design process. Physical prototypes and architectural applications provide a basis for discussing the translation of computational outcomes into buildable systems, including challenges associated with geometric complexity, connection design and construction scale. The presentation highlights the importance of integrating performance evaluation and fabrication considerations from the outset, and identifies opportunities for collaboration between architecture, structural engineering and materials science. It outlines a design-to-fabrication approach towards high-performance, resource-efficient construction, in which material placement and manufacturing strategies are developed together.

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Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Fab-Compatible Platform with 2D Integration and Monolithic 3D CMOS

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Abstract: Two-dimensional (2D) semiconductors are promising candidates for future electronics because their atomic-scale thickness enables excellent electrostatic control [1]. However, their chemically inert surfaces and limited process tolerance hinder the transition from academic lift-off-based processing to fab-compatible integration. A tier-level platform for heterogeneous M3D CMOS must additionally provide a planar surface, local electrostatic control, and sufficient flexibility to match heterogeneous device characteristics. Here, we integrate a planar local-back-gate (LBG) array on a completed p-type Si FinFET tier. A TiN LBG is integrated above the first metal layer and planarized to provide a planar surface for 2D-material transfer. Building on this platform, continuous MoS_2 FETs are fabricated using an 8 inch DUV-lithography-based, fab-compatible subtractive process flow. The MoS_2 nFETs employ a dual-gate configuration comprising a top gate and an LBG. Independently biasing the two gates enables threshold-voltage tuning and electrical matching of the MoS_2 nFETs to the lower-tier p FinFETs, thereby allowing co-optimization of inverter switching characteristics and voltage gain. The resulting inverter achieves a peak voltage gain of 56 V/V at VDD =1.8 V. This platform connects 2D process development with functional M3D CMOS integration, providing a practical route to evaluate and extend emerging channel materials on Si-compatible circuitry.

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Chi-Chun Cheng is a PhD candidate in the Department of Electrical Engineering at National Tsing Hua University, Taiwan. His research focuses on two-dimensional semiconductor devices, fab-compatible process integration, and monolithic 3D CMOS. His recent work spans electrostatic engineering, heterogeneous 2D/Si integration, and emerging memory devices.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Highly conductive carbon nanotube fibers

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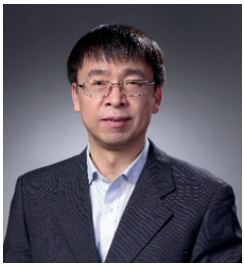
Abstract: Single-wall carbon nanotubes (SWCNTs) with unique one-dimensional tubular structure and excellent physicochemical properties are an ideal building block for the fabrication of high-performance fibers with a wide range of applications. We prepared high purity, high-crystalline SWCNTs efficiently using a floating catalyst CVD method, and the as-prepared SWCNTs had a purity higher than 96 wt.%. Using the as-prepared high-quality SWCNTs, we spun macroscopic SWCNT fibers with diameters of several to 30 microns by a wet-spinning process. The resulting fibers had a high electrical conductivity of 6.67×10^6 S/m. We further developed a dry-jet wet spinning method, producing double-wall CNT fibers with a high electrical conductivity of 1.1×10^7 S m^{-1} and an ampacity of 8.0×10^8 A m^{-2}. A SWCNT/Cu core-shell fiber was prepared by a combined magnetron sputtering and electrochemical deposition method, which showed an ultra-high specific electrical conductivity of 1.15×10^4 S m^2 kg^{-1}. To improve the carrier density of CNT fibers, $FeCl_3$ nanoparticles were filled inside the cavity of the composing individual CNTs. The $FeCl_3$-filled CNT fibers showed a high electrical conductivity of 1.35×10^7 S m^{-1} and a tensile strength of 2.54 GPa. Moreover, an ultrathin CNT fiber with a diameter of ~3 microns and high electrical conductivity was fabricated using water as a coagulation bath. In addition, a high-efficiency photo detector was fabricated using the CNT fiber as an infrared light emitter.



Dr. Chang Liu is a professor at the Shenyang National Laboratory of Materials Science, Institute of Metal Research, Chinese Academy of Sciences (IMR, CAS). He received his Ph.D. in materials science at IMR, CAS in 2000. During 2004-2005, he worked at the International Center for Young Scientists, National Institute for Materials Science, Japan as a research fellow. His research interest focuses on the preparation, properties and applications of carbon nanotubes and their hybrids. He has published more than 200 peer-reviewed papers with more than 20000 citations. He has authorized more than 40 patents and has given more than 50 invited talks at international conferences. He is currently an Editor of Carbon and an Associate Editor of Nano Materials Science.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Ion track technology for the design and fabrication of nanolattice mechanical metamaterials

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Abstract: Advanced manufacturing technologies are driving the development of new materials. Beam nanolattices are a new class of mechanical metamaterials with characteristic size on the order of hundreds of nanometers. Owing to their pronounced size effects, unique structural characteristics, and material selection, these porous materials exhibit mechanical properties that differ substantially from those of their bulk counterparts. In some cases, they can even achieve superior mechanical performance while maintaining a lower weight, making them promising candidates for revolutionary applications in high-performance functional materials. However, to date, the fabrication of metallic beam nanolattices with beam diameters below 100 nm remains challenging, and their mechanical properties are ambiguous.

Here, ion-track technology is established as a versatile approach for the design and fabrication of a new type of quasi-body-centered-cubic (quasi-BCC) beam nanolattice mechanical metamaterial. The nanolattices were experimentally fabricated using ion-track technology at the Heavy Ion Research Facility in Lanzhou (HIRFL). The beam diameter of the quasi-BCC beam nanolattice can be reduced to as small as 34 nm, thereby overcoming the previously reported size limitation of beam nanolattice mechanical metamaterials. In situ compression experiments demonstrate that the energy-absorption capacity of the copper quasi-BCC beam nanolattice surpasses that of previously reported beam nanolattices. This work provides a new design and fabrication strategy for the development of beam nanolattices with ultrahigh energy-absorption capacity.

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A/Prof. Dr. Hongwei Cheng of the Institute of Modern Physics conducts systematic research on the construction of 3D micro-/nanomaterials based on ion-track technology and their mechanical properties.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

AI Across the Lifecycle: Security, Safety, and Accountability

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Abstract: The rapid evolution of AI has shifted systems from passive models to agentic AI capable of autonomous reasoning, code generation, and interaction with real-world environments. While these advances enable powerful applications, they fundamentally challenge existing assumptions in security, software engineering, and governance. This talk synthesises recent research that reframes AI security as a cross-layer lifecycle problem, spanning learning models, LLM-enabled software, autonomous agents, and cyber-physical systems. These studies are organised around three connected questions: what sensitive information models and retrieval-augmented systems can expose; how model behaviour and security mechanisms can be manipulated, and how such manipulation can be detected; and how data and creative assets can be protected and their use audited. As AI systems increasingly operate in IoT and safety-critical environments, this talk argues for trustworthiness by design, integrating agent-aware threat models, continuous auditing, and robust learning foundations across the AI lifecycle, and aims to inspire the next generation of research in trustworthy and resilient AI.



Professor Yang Xiang is currently a full professor at Faculty of Information Technology, Monash University, Australia. His research interests include the broad area of Cybersecurity and AI, which covers the security and algorithms of software, systems, networks, and applications to solve the security, privacy, reliability, responsiveness, and robustness challenges. In the past 20+ years, he has published more than 300 research papers in conferences and journals, such as ACM CCS, IEEE S&P, Usenix Security, NDSS, IEEE TDSC, and IEEE TIFS. He is the Editor-in-Chief of the SpringerBriefs in Information Security and Cryptography. He is serving as the Associate Editor of the ACM Computing Surveys. He served as the Associate Editor of IEEE Transactions on Dependable and Secure Computing, IEEE Internet of Things Journal, IEEE Transactions on Computers, and IEEE Transactions on Parallel and Distributed Systems. He is a current member of College of Experts (CoE) of the Australian Research Council (ARC). He is a Fellow of the IEEE.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Designing with Scent: Coffee-Ground Composite Filaments for 3D-Printed Multisensory Wall Skins

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Abstract: This paper proposes an integrated material–design–performance workflow for developing modular 3D-printed wall skins using spent coffee ground (SCG)-based composite filaments. Scent, tactile qualities, acoustic properties, and surface texture are considered as functional attributes for interior applications, such as coffee retail, wellness environments, and exhibitions. The workflow covers material preparation, computational design, and fabrication. Spent coffee grounds are pre-treated and compounded with a biodegradable polymer matrix to produce printable composite filament. Material preparation and characterisation establish a controlled process, supporting empirical evaluation across the prototype set. Computational design is used to parametrically control surface micro-relief, texture, and internal porosity while maintaining printability. A series of 3D-printed specimens is produced to investigate relationships between material characteristics, geometric parameters, and functional performance. Evaluation includes (i) acoustic oriented geometries to explore sound absorption potential, (ii) geometric descriptors correlated with tactile preference, and (iii) semi-quantitative monitoring of scent intensity over time. This research highlights the potential of waste-derived composite filaments for customised and circular additive manufacturing applications.

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Kang Liu is a PhD candidate in Architecture at RMIT University, Australia. His research focuses on computational design and additive manufacturing for lightweight architecture using biowaste-derived materials. His work integrates topology optimisation, TPMS geometries, material informed design, and 3D printing to investigate relationships between geometry, material performance, fabrication, and architectural application.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Utilising Neural Networks and Neural Operators to Accelerate Forecasting of Precipitate Growth in Binary Alloys

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Abstract: The mechanical properties of metals are highly influenced by the microstructural evolution of the material in production. It is, therefore, critical to simulate the material system evolution to be able to predict the final microstructure. Phase field models are typically the best physics-based models to predict the microstructure evolution of materials; however, they are computationally expensive and preclude long-term, large-scale simulations. We have investigated the use of physics informed machine learning techniques, including Physics Informed Neural Networks and Fourier Neural Networks.We have used the precipitation growth in a binary alloy system as the basis to develop phase field models.These models used a coupled second order Allen-Cahn and fourth-order Cahn-Hillard system to model the precipitation evolution. This paper will outline our use of neural networks and neural operators to explore accelerated simulations, zero-shot super-resolution, and extended domain predictions.
This work will show the narrow accuracy of the Physics Informed Neural Networks, and the improvements Fourier Neural Operators made over other leading models (Long Short-Term Memory and Recurrent Neural Operators).



Professor Bernard Rolfe is a Professor of Advanced Manufacturing at Deakin University and a recognised researcher in metal forming, additive manufacturing, lightweight structures and computational materials modelling. His research combines advanced manufacturing, finite element analysis, artificial intelligence and materials engineering to improve the manufacturing and performance of advanced metallic materials for automotive and aerospace applications. Over the past two decades, his work has focused on sheet metal forming processes, including roll forming, flexible forming, metal 3D printing, and lightweight structural design, with particular emphasis on predicting material behaviour, shape defects and manufacturability through computational modelling and simulation.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Privacy in Data Publishing

Hua Wang

This talk shows the fundamental challenge of optimizing the privacy utility trade-off in data publishing, specifically sensitive medical data, trajectory data, and differentially private ML. An extensive analysis is conducted to examine how the privacy-utility trade-off can be achieved through standard privacy-preserving measures. Additionally, it examined how Evolutionary Algorithms have been used in the literature across various scenarios. Finally, a detailed analysis of DP design and its use in ML and data mining was conducted, in which the performance of existing DP algorithms in balancing privacy and accuracy was described. This talk demonstrates that evolutionary optimization techniques offer a robust and adaptable framework for managing privacy–utility tradeoffs in various data publishing scenarios. This study makes significant contributions to the field of PPDP, establishing a strong foundation for future investigations into adaptive, optimization-driven privacy mechanisms in increasingly intricate and data-intensive contexts.

Abstract: Hua is an IEEE Fellow as his contributions for contributions to evolutionary computation algorithms for data quality and applications. He carries out research on machine learning and data analysis, with a particular focus on data mining, artificial intelligence, deep learning, big data, privacy preserving, access control and cyber security. Hua is now a full time professor in the Institute for Sustainable Industries and Liveable Cities (ISILC) at Victoria University. As a Chief Investigator, Hua has successfully received 12 Australian Research Council (ARC) grants including seven discovery grants and five linkage grants with over $10M since 2006. He is also a successor for international grants such as two grants from Japan Society for the Promotion of Science (JSPS), one German-Australian grant (DAAD), one Norwegian government grant, three grants from Hong Kong. Hua has published over 400 refereed scholar papers, including 81 Q1 (ERA2018 ranked) Journal papers in machine learning, cyber security, Artificial Intelligence, privacy preserving and data analysis. Representative publications are on: ACM Transactions on Internet Technology ACM Transactions on Information Systems ACM Transactions on Knowledge Discovery from Data IEEE Transactions on Dependable and Secure Computing IEEE Transactions on Knowledge and Data Engineering IEEE Transactions on Automation Science and Engineering IEEE Transactions on Evolutionary Computation IEEE Transactions on Services Computing Proceedings of ACL, AAAI, CIKM, ICDE, ICDM and PAKDD. Hua's h-index is 78 based on Google Scholar website. As a principal supervisor, he currently has 14 PhD students at VU. Hua has been appointed as a College of Expert by the ARC since 2021, and has already been an ARC reviewer since 2009. He reviews various proposals each year for ARC DP, LP, DECRA, LIEF. Hua is Editor-in-Chief, Featured Journals, European Alliance for Innovation (EAI) Transactions on Scalable Information Systems, and also editor for IEEE Transactions on Cybernetics, IEEE Transactions on Technology and Society, ACM Transactions on Social Computing, World Wide Web Journal and so on.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Interfacial Coupling in MoS2 Hydrogen Evolution

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Abstract: Electrocatalytic activity in MoS2 is strongly influenced by its local surface environment and electronic structure. Single-particle interferometric scattering microscopy directly resolves heterogeneous activity among individual MoS2 particles, distinguishing active and inactive surface domains that are obscured in ensemble measurements. Extending this surface-level picture to hydrogen evolution, phase-controlled hydrothermal MoS2 shows that even within metallic 1T- MoS2, conductivity, accessible surface area, and surface-normalized HER activity vary substantially with synthesis conditions, demonstrating that phase identity alone is insufficient to describe catalytic performance. Upon heterostructuring with CoS2, the role of the interface becomes dominant. Metallic 1T- MoS2 forms a more homogeneous, strongly coupled interface with CoS2, suppressing interfacial polarization and stabilizing HER performance, whereas the electronically asymmetric 2H-MoS2/CoS2 interface undergoes progressive Co loss and degradation. KPFM, impedance spectroscopy, and DFT collectively reveal stronger charge redistribution and more favourable interfacial energetics for the 1T-based heterostructure. Together, these results highlight the coupled roles of surface heterogeneity, charge transport, and interfacial electronic structure in governing MoS2 electrocatalysis.



Dr Naimeh Naseri is an Alexander von Humboldt Experienced Research Fellow and a TWAS/UNESCO Young Affiliate with over 15 years of academic experience in applied nanophysics, electrochemical energy systems, advanced materials and functional devices. She is currently a Senior Research Fellow at RMIT University, where she co-leads research on AI-assisted battery repurposing and recycling within the QUAD project. Previously, at Monash University, where she led research at the interface of physics and engineering, including water-splitting electrocatalysis, printable energy-storage devices and the development of 2DProtoPrint, a research initiative focused on rapid prototyping of printable devices using next-generation nanomaterials. Her research bridges fundamental surface and nanoscale phenomena with real-world applications in clean energy, sustainability and advanced device technologies.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Hierarchical Ti–Ta Materials from Additive Manufacturing and Nanofabrication for Implant Applications

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Abstract: The surface topography of orthopaedic implants plays a critical role in the early biological response following implantation. Nanoscale surface feature influence protein adsorption, cell adhesion, and osteoblastic differentiation, key processes for successful osseointegration. Titanium and its alloys remain the material of choice for orthopaedic implants owing to their low density, high strength, corrosion/wear resistance, and biocompatibility [1]. Ongoing efforts to improve the long-term biological, chemical, and antibacterial performance of titanium implants have centred on surface modification strategies for generating nanotopography or hierarchical (micro/nano) topographies [2]. This review examines the principal techniques used to engineer such features on Ti and Ti alloys, liquid metal dealloying (LMD), micro-arc oxidation, laser surface modification, acid etching, alkali–heat treatment, anodisation, and electrochemical dealloying, comparing their mechanisms and resulting nanotopographies, alongside their in vitro and in vivo and antibacterial performance. Across these approaches, hierarchical micro/nanostructures consistently outperform single-scale micro- or nanotopographies, an effect generally attributed to their closer replication of the extracellular matrix, which promotes more favourable cell–surface interactions, including greater filopodia extension, and enhanced osteoblastic differentiation [1]. Among the techniques compared, LMD uniquely enables independent control over surface morphology and composition [3]. Building on this, LMD was selected to engineer the present Ti–50Ta system, generating a Ta rich nanoporous surface via selective dissolution on LPBF-fabricated components with controlled microscale architecture [3]. Preliminary results show ligament sizes of 42.29 ± 9.15 nm and 81.82 ± 19.96 nm, offering a promising route to hierarchical Ti–Ta implants with enhanced mechanical compatibility, osseointegration, and antibacterial resistance.

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Lily Margareth Arrieta is a PhD candidate in Mechanical and Manufacturing Engineering at RMIT University. Her research focuses on developing hierarchical (micro/nano) Ti–Ta alloys for orthopaedic implant applications using laser powder bed fusion and liquid metal dealloying. Her research interests include biomaterials, surface engineering, additive manufacturing, and cell–material interactions.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Optically Controlled InGaAs Thin-Film Terahertz-Wave Modulator

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Abstract: High-speed terahertz modulators are critical components for enabling high-speed wireless communication and advanced terahertz signal processing applications. Recently, an optically controlled terahertz modulator was demonstrated on a substrate-less silicon platform. However, its modulation speed was limited by the relatively long carrier lifetime of silicon. In this work, we propose a high-speed optically controlled terahertz modulator based on an InGaAs thin-film. The material is integrated onto a conductive slotline formed through a mode converter designed on a substrate-less silicon waveguide. This proposed topology enables a high modulation depth under moderate optical excitation power. Experimentally, we achieve a modulation depth of 13.1 dB at a carrier frequency of 242 GHz, with an optical excitation power of 0.138 W. The proposed modulator demonstrates significant potential for integration into advanced terahertz systems requiring compactness, energy efficiency, and high-speed modulation for next-generation wireless communication applications.

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Molecularly Imprinted Polymer-Functionalised Lateral-Flow Membrane for Highly Sensitive and Selective Per- And Polyfluoroalkyl Substances Detection in Water

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Abstract: Per- and polyfluoroalkyl substances (PFAS) contamination in water demands broad, accurate trace detection, yet current quantification relies heavily on laboratory-based liquid chromatography-tandem mass spectrometry with complex sample preparation and data processing, limiting rapid compliance screening and event-scale surveillance. In this work, we develop a novel PFAS sensor using a lateral-flow membrane functionalized with a chemiresistive molecularly imprinted polyaniline film for rapid, selective, and highly sensitive PFAS detection in water. Using perfluorooctanoic acid (PFOA) as the template, molecular imprinting endowed the polyaniline film with PFOA-specific adsorption. As capillary-driven transport carries the sample through the functionalized zone, PFOA is selectively adsorbed within molecularly imprinted cavities, and its carboxylic acid functionality then induces local protonic doping of polyaniline, thereby converting binding events into a large change in conductance. This sensing platform delivered a limit of detection of 3.1 pM (1.3 ng L^{-1}) and reliable readout within 15 min. The developed functionalized film exhibits remarkable selectivity toward structurally related PFAS compounds and shows robust resistance to interference from both other PFAS compounds and common environmental ions. Validation in drinking water, lake water, and river water samples confirmed high matrix spike recovery (95.0-107.1%) and minimal matrix effects, highlighting the sensor's applicability for real-world environmental monitoring. This work demonstrates a simple, cost-effective, and portable strategy for on-site ultra-trace PFAS detection in diverse water matrices, supporting rapid environmental monitoring and compliance screening.



Ming Zhou is an ARC Early Career Industry Fellow and Lecturer in the School of Environment and Science at Griffith University, where he also leads the Environmental Nanomaterials and Sensing Laboratory (ENS-Lab). His research focuses on developing field-deployable sensing technologies and intelligent monitoring systems for water-quality assessment, environmental protection, and emerging industrial challenges. His program spans three interconnected areas: (i) field-based chemical, microbiological, and nanotechnology-enabled sensing; (ii) intelligent monitoring and decision-support systems; and (iii) advanced water treatment and resource recovery from wastewater and industrial effluents. Ming's research has resulted in international patents and lead-author publications in leading journals across sensing and environmental technologies, including ACS Sensors, Sensors and Actuators B: Chemical, Analytical Chemistry, Environmental Science & Technology, and Applied Catalysis B: Environmental. He has demonstrated continued success in attracting competitive research support from government, industry, and commercial partners, securing more than $1 million in research funding over the past five years as Lead CI. Ming serves as a member of Griffith University's Research Committee, Vice Chair of the Australian Water Association Queensland Subcommittee, and Griffith University Representative to Water Research Australia. He is also an Early-Career Editorial Board Member of Eco-Environment & Health and a Founding Editorial Board Member of Global Environmental Science.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Programmable Electromechanical Networks for Intelligent and Energy-Efficient Vehicle Suspension Systems

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Abstract: Future intelligent vehicles require suspension systems that can simultaneously improve ride comfort, handling stability and energy efficiency under changing operating conditions. Conventional passive, semi-active and hydraulically interconnected suspensions remain constrained by fixed mechanical characteristics, limited coordination among vehicle corners or high energy consumption. This keynote presents electrically interconnected suspension systems based on controllable electromagnetic dampers and mechanical-electrical network synthesis. Through electromechanical energy conversion and power-electronic circuit control, an electromagnetic damper can realise programmable damping, stiffness and inertance while enabling vibration-energy regeneration. Interconnecting multiple dampers through electrical networks further coordinates forces and energy across the vehicle. Appropriate network synthesis and admittance control can decouple heave, pitch and roll modes, supporting integrated optimisation of ride comfort, road holding and handling stability. Recent advances in circuit-topology optimisation, disturbance-compensation control, model predictive control and energy-flow management will be discussed. Experimental studies using half-vehicle, full-vehicle and real-vehicle platforms demonstrate substantial improvements over conventional passive suspension while maintaining low energy consumption and enabling energy recovery. Future directions include smart electromechanical devices, AI-enhanced predictive control, road-preview sensing and vehicle-to-vehicle coordination. These developments transform suspension from an isolated mechanical component into a programmable, energy-aware and networked chassis platform for next-generation intelligent mobility.

Haiping Du is Chair Professor in the School of Engineering at the University of Wollongong, Australia. His research interests include vehicle dynamics and control, intelligent suspension systems, vibration control, robust and predictive control, and advanced mechatronic systems. He has led extensive research on electromagnetic dampers and electrically interconnected suspension systems, spanning mechanical-electrical network synthesis, multifunctional control, energy regeneration and experimental vehicle implementation.

Theme 7: Nano-Atom-fabrication Advanced Manufacturing and AI

Predicting Solvent-Dependent Molecular Gelation through Self-Assembly-Informed Machine Learning

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Abstract: Molecular gelation involves the self-assembly of low molecular weight gelators (LMWGs) into three-dimensional networks, yet solvent selection remains a challenging trial-and-error process. In this study, the solvent-dependent gelation of N-lauroyl-L-glutamic acid di-n-butylamide (GP-1) is investigated using Hansen solubility parameters (HSPs), molecular dynamics (MD) simulations, Kamlet–Taft (KT) parameters and machine learning (ML). A dataset of 17 solvents covering gel (G), precipitate (P) and solution (S) states is used for model development. HSPs provide an initial description of solvent–gelator compatibility but cannot reliably distinguish the three states. MD simulations capture solvent-dependent aggregation behaviour, while KT parameters provide additional information on solvent interactions. Combining MD and KT descriptors with an L2-regularized logistic regression model improves the prediction of GP-1 gelation outcomes. The model is further evaluated using nine independent validation solvents. This self-assembly-informed ML framework provides a practical approach for predicting solvent-dependent molecular gelation and reducing experimental solvent screening.

Zhihong Zhang is a PhD candidate at the Institute for Frontier Materials, Deakin University, Australia. His research focuses on molecular gels, molecular self-assembly, molecular dynamics simulations and machine learning for predicting solvent-dependent gelation and designing functional soft materials.



Theme 8

Critical Minerals, Resource Recovery and Circular Economy

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Nitric Acid Decomposition in Nickel-Cobalt Leaching

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Abstract: Leaching processes based on nitric acid (HNO_3) are emerging as a promising alternative to high-pressure acid leaching (HPAL) for extracting critical minerals, particularly nickel (Ni) and cobalt (Co), offering a potentially less environmentally intensive route. A key challenge in these systems is the thermal decomposition of HNO_3 at elevated temperatures, which can cause reagent loss, reduced leaching efficiency, and generation of NO_x gases requiring capture and recycling within closed-loop acid circuits. While HNO_3 decomposition has been studied for decades, most prior work focused on atmospheric-pressure, non-pressurised systems. This study addresses that gap by examining HNO_3 thermal decomposition under autoclave conditions using a sealed 1.2 L Parr reactor, testing 10-40 wt.% HNO_3 at 190-225 °C, building on earlier low-temperature trials (150-175 °C) that showed negligible decomposition, attributed to the inhibitory effect of high-water content on the decomposition equilibrium at these dilute concentrations. Residual HNO_3 was quantified via acid-base titration, liquid-phase nitrate/nitrite speciation was assessed using Spatially Offset Raman Spectroscopy (SORS), and gas-phase NO_x species were characterised by FTIR. SORS spectra were dominated by nitrate and molecular HNO_3 signatures, consistent with limited decomposition and the absence of visible colour change in samples. Despite this, measurable shifts in HNO_3 concentration were recorded, and trace NO_x was detected even at lower concentrations, with FTIR confirming NO, NO_2, and minor N_2O_4 signals in the headspace. Higher concentrations (50-99 wt.%) at the same temperatures are expected to show more substantial decomposition. Results show decomposition rate depends on both temperature and acid concentration, consistent with kinetic calculations. This is among the first systematic kinetic studies of HNO_3 decomposition under pressurised conditions, providing insight directly relevant to hydrometallurgical process design and NO_x management in mining.



Deus Albert Msumange is a PhD candidate in Applied Chemistry at RMIT University, Australia, focusing on industry-collaborative solutions for critical mineral extraction. Before joining RMIT, he worked in both academia and the mining industry, including roles as an Assistant Lecturer in Mineral Processing and Hydrometallurgy at Mbeya University of Science and Technology (MUST) and as an Underground Mining Engineer at Avesoro Resources, Liberia. He holds an MSc in Mining Engineering (Mineral Processing) from Karadeniz Technical University, Türkiye, and a BSc in Geology from Badji Mokhtar Annaba University, Algeria. Deus is interested in sustainable mineral processing, hydrometallurgy, green & industrial chemistry.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Molecular and Structural Engineering of High-Performance Sustainable Polymers

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Abstract: Developing high-performance polymers with enhanced sustainability and multifunctionality is increasingly important for advanced material applications. This presentation will highlight our recent advances in the molecular and structural design of sustainable polymer materials, focusing on two representative systems. First, strong, recyclable, bio-based vitrimers are developed through tailored rigid-flexible structures, achieving excellent mechanical properties and recyclability for advanced carbon fibre-reinforced composites. Second, inspired by the adhesion mechanisms of ticks, multifunctional coatings are designed to integrate strong adhesion, self-healing capability, biodegradability and phosphorus-free fire retardancy. These studies demonstrate how rational molecular and structural engineering can overcome conventional trade-offs between mechanical performance, functionality and sustainability. The findings provide new insights into the development of next-generation sustainable polymers for advanced engineering applications.

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Dr Siqi Huo is a Senior Lecturer and ARC DECRA Fellow at the University of Southern Queensland, Australia. His research focuses on flame-retardant polymers, sustainable thermosets, dynamic covalent polymers and advanced polymer composites. He has published over 200 peer-reviewed journal articles in leading international journals, including Progress in Polymer Science, Advanced Materials, and Nature Communications, as well as three book chapters. His publications have received over 13,500 citations, with an h-index of 67 (Google Scholar). As a Chief Investigator, he has successfully secured competitive research funding from the Australian Research Council (ARC), including Discovery Early Career Researcher Award (DECRA), Discovery Project (DP) and Linkage Project (LP).

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Artificial ion channel membranes for efficient ion separation

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Abstract: Artificial ion channels with angstrom-scale pores and tunable surface chemistry offer promising platforms for challenging industrial separations. Inspired by biological ion and molecular channels, our group has developed a series of metal–organic framework (MOF)-based channels, membranes, and adsorbents for water–ion, ion–ion, and chiral separations. These include stimuli-responsive MOF adsorbents for water desalination; sub-nanofluidic ZIF-8 membranes for lithium extraction; UiO-66-X (X = $(COOH)_2$, COOH, $(SH)_2$, or NH_2) channels and membranes for monovalent/divalent metal-ion sieving; UiO-66-NH-SAG channels for highly selective proton conduction; and UiO-66-X (X = NH_2 or $N^+(CH_3)_3$) channels for rapid fluoride-ion conduction. Together, these studies demonstrate how pore dimensions and surface chemistry can be tailored to control molecular and ionic transport, providing design principles for next-generation technologies in water treatment, critical-mineral recovery, and energy conversion.

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Huacheng Zhang is a Full Professor in Electrical and Computer Systems Engineering at Monash University and an Adjunct Professor in Chemical and Environmental Engineering at RMIT University. She received her PhD in Physical Chemistry from the Institute of Chemistry, Chinese Academy of Sciences (CAS), in 2014, and subsequently worked as an Assistant Professor at the CAS Technical Institute of Physics and Chemistry. In 2015, she joined Monash University as a postdoctoral research fellow and was awarded an ARC Discovery Early Career Researcher Award (DECRA) Fellowship in 2017. She moved to RMIT University in 2020, where she held an RMIT Vice-Chancellor's Research Fellowship and an ARC Future Fellowship. Her honours include the 2021 RMIT Vice-Chancellor's Award for Research Excellence (Early Career Researcher), the 2022 Membrane Society of Australasia Membrane Science Award, the 2023 J&J WiSTEM2D Scholars Award, and a 2024 NHMRC Investigator Grant. She returned to Monash University in November 2026.

Prof. Zhang leads a research group focused on bioinspired sub-nanofluidic membranes for separation, biosensing, energy harvesting, and neural signalling. She has published more than 80 journal articles, including papers in Nature Materials, Science Advances, Nature Sustainability, Nature Communications, Advanced Materials, Journal of the American Chemical Society, and Angewandte Chemie International Edition. Her work has received more than 9,100 citations, and she has an h-index of 46.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Magneli-phase titanium suboxide ceramic electrodes for resource recovery from urban wastewater

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Abstract: Magneli-phase titanium suboxide (Ti_4O_7) has emerged a novel conductive material for applications in electrochemical oxidation[1]. It is produced from titania at high temperatures (1,200) in the presence of hydrogen. In this work, our group explored two uses of this material related to resource recovery from urban wastewater. A tubular, flow-through Magneli-phase ceramic membrane of 20 m pore size was used as the anode in an electrochemical system. In the first application, the system was used to electrolyse human urine at the source – the toilet. Electrolysis at a 5V enabled the quantitative oxidation of urea to nitrogen gas, seemingly a waste of resource, which however if scaled to >50% of urban toilets would enhance the longevity of wastewater treatment plants (WWTPs) and increase biosolids production by 50%, augmenting their potential for reuse as nitrogen and phosphorus fertilisers in agriculture. In a second application, the tubular ceramic membrane was operated at a current density of 20 mA/cm^2 to assess its ability to oxidise perfluoroalkyl substances (PFAS) in urban wastewater, a key requirement for biosolids acceptance in agriculture. Removal of 80% of PFOA and 60% of PFOS was measured from initial concentrations of 5 g/L, which are typical of sewage pre-concentrated by foam fractionation.



Stefano Freguia is a Professor at the Department of Chemical Engineering at the University of Melbourne. He obtained his PhD in 2008 from the University of Queensland and later received a fellowship from the Japan Society for the Promotion of Science (JSPS) to undertake his post-doctoral studies in bioelectrochemistry at Kyoto University (2008-10). From 2010 to 2019 he was a researcher at the Australian Centre for Water and Environmental Biotechnology at the University of Queensland. Stefano's research focuses on the development of novel processes to address the current needs of the water industry, with a particular focus on technologies for the removal of persistent contaminants and for nutrient recovery into market-ready fertilisers.

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Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Accelerating the Circular Economy for Lithium-Ion Batteries: Microwave Enhanced Deep Eutectic Solvents for Critical Metal Recovery

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Abstract: The rapid growth of lithium-ion batteries (LIBs) is creating both an increasing waste challenge and an urgent demand for sustainable sources of critical metals.[1] Deep eutectic solvents (DESs) offer a promising alternative to conventional acid-intensive recycling; however, their high viscosity and associated mass-transfer limitations can hinder efficient metal dissolution.[2] Here, we demonstrate a microwave-assisted solvo-metallurgical strategy that integrates rational DES design with rapid volumetric heating to overcome these limitations.[3] Using industrial LIB black mass, a choline chloride-lactic acid DES achieved >99% extraction of Co and Mn and >92% extraction of Li and Ni within 30 min at 200 °C. Spectroscopic analyses revealed a ligand-assisted dissolution mechanism in which proton-mediated cleavage of metal-oxygen bonds is coupled with stabilization of dissolved metal species through chloride-lactate coordination. Microwave irradiation further enhanced the leaching process via rapid and uniform heating, reducing DES viscosity and facilitating mass transfer between the black mass and leaching medium. Beyond efficient leaching, the process enabled downstream metal recovery through selective precipitation and demonstrated sustained performance over repeated DES reuse. Life cycle and techno-economic assessments further highlighted the potential benefits of solvent reuse and process scale-up, while identifying energy consumption as a key area for further optimization. Overall, this work demonstrates how solvent chemistry, microwave process intensification and solvent circularity can be integrated to advance rapid, recyclable and potentially scalable recovery of critical metals from spent LIBs.



DYuan (Helena) Wang is a Senior Lecturer, Group Leader of Renewable Resources & Sustainability (R2S), and an ARC-DECRA Fellow at the Department of Chemical Engineering at the University of Melbourne. She completed her PhD in Chemical Engineering at the University of New South Wales (UNSW) in 2018. She held prestigious fellowships: the Alfred Deakin Research Fellowship-2022 at Deakin University and the International Hydrogen Research Fellowship-2023 at the National University of Singapore. She was also a DAAD Visiting Scholar at the Fritz Haber Institute of Max Planck-Berlin (2018). Her research focuses on green hydrogen production, carbon dioxide conversion and utilization, metal recovery and recycling, and the circular economy. She was awarded the 2025 Nicklin Medal by the Institution of Chemical Engineers (IChemE), 2026 Selby Research Award and 2026 VIC Young Tall Poppy Award.

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Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Strategic Minerals in a Circular Economy: An Australian Perspective

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Abstract: Demand for minerals and metals – including lithium, copper, nickel – is rising, driven by the rapid global deployment of technologies underpinning renewable energy and electrification.

This paper explores the role of 'responsible sourcing' in trajectories of future supply of minerals and metals, considering both voluntary certifications such as the Initiative for Responsible Mining Assurance (IRMA) and The Copper Mark, alongside the increasing role of recycled metals.

Taking both an Australian and global perspective, the paper provides an overview of the evolution of the discourse regarding responsible minerals and identifies the importance of developing a comprehensive and contemporary evidence base of local data to support claims of environmental performance, for example regarding the carbon footprint of Australian mining and processing – particularly in light of a future trajectory which will see mined ore grades decline (increasing the carbon footprint) and the increased adoption of renewable energy (reducing the carbon footprint).

Finally, opportunities for Australia in a circular economy for strategic minerals and metals are presented and discussed.



Professor Damien Giurco is the inaugural Chair of Circular Economy at the University of Melbourne. His research with government and industry partners spans responsible minerals and metals; material requirements for the clean energy transition and advancing a circular economy to support sustainable consumption and production. He was a theme lead in the Future Battery Industries CRC and NSW Decarbonisation Innovation Hub and is a Fellow of the Australasian Institute of Mining and Metallurgy.

Damien is currently Deputy Director - Sustainability in the Australian Research Council's Training Centre for Resource Efficient Alloys in a Circular Economy and the Program Leader for Circular Economy within the Solving Plastic Waste Cooperative Research Centre.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

A Sustainable Process for Critical Metals Recovery from Mine Waste

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Abstract: According to the Australian Government's Critical Minerals Strategy 2023-2030, it is essential to build up advance sustainable extractive processes by recovering valuable metals from waste and critical minerals using innovative techniques. Bauxite residue is an alkaline solid waste generated in the processing of bauxite to alumina using the Bayer. During the Bayer process bauxite digestion stage, reactive silica phases such as kaolin dissolve into the highly alkaline solution and precipitate as an insoluble sodium aluminate silicate known as the DeSilication Product (DSP) which can encompasses a range of phases including sodalite and cancrinite [1, 2]. DSP is a significant source of alkalinity which buffers the pH above 10 in the residue exiting the process. Much of the focus of bauxite residue reuse has been on direct utilization of bauxite residue such as in cement production or the extraction. But to truly produce a zero-waste procedure there is a need to develop a process that utilizes all the components within the residue and is staged logically to maximise process efficiency.

Through detailed research on the complex mineralogy of bauxite residue [3, 4], we quantified the special protocol on how to control early precipitation of silica gel during acid treatment of bauxite residue [5] and developed the low-cost way to utilise bauxite residue[6, 7] as rare earth resource. These new understandings provide the fundamental basis for the utilisation and neutralisation of bauxite residue. This work will summarise these findings to reveal a sustainable process on the extraction of valuable elements from bauxite residue through selective leaching followed by further processing to obtain an economic process flow that could be used in industry as a potential basis for a zero-waste utilization roadmap of bauxite residue.

Dr Peng is Group Leader of Sustainable Extraction Engineering Laboratory (SEE Lab) and Senior Research Fellow in the School of Chemical Engineering at The University of Queensland (UQ). Dr Peng is CI for the national grants (ARC DP; ARC LIEF grant, ARC Research Hub for PVRS and ARC Training Centre for the Global Hydrogen Economy), Leading CI for three RTCM Trailblazer projects and other industry-funded projects from Rio Tinto, Newcrest, Origin energy and Maaden. His research focuses on critical metals recovery from mine waste and urban mining on solar panel and lithium battery recycling. Dr Peng has authored more than 100 peer-reviewed publications including 80 journal papers; 11 book chapters/edited books, 8 conference proceedings, 7 patents (4 licensed to the industry partners).



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Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Turning Water Treatment Sludge into Self-healing Concrete

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Abstract: Concrete sewer infrastructure is highly susceptible to carbonation-induced deterioration under elevated CO_2 concentrations (up to 3%), microbial activity, and corrosive by-products. This study develops and evaluates an innovative autonomous self-healing system based on engineered capsules containing drinking water treatment sludge (DWTS), steel slag, calcium hydroxide, and expansive polymers for enhanced crack sealing under CO_2-rich conditions. DWTS, a waste-derived precursor rich in amorphous alumina and silica, was calcined and combined with $Ca(OH)_2$ and either microcrystalline cellulose or sodium polyacrylate before encapsulation with ethyl cellulose to minimise premature hydration. Mortar specimens incorporating 4 vol.% capsules were pre-cracked and exposed to 3% CO_2 to accelerate the healing process. Carbonation kinetics and reaction products were characterised using FTIR, TGA/DSC, X-ray diffraction, and X-ray micro-computed tomography, while crack closure, water-tightness recovery, and mechanical performance were evaluated after 3, 7, and 28 days. The DWTS–$Ca(OH)_2$ cores exhibited high carbonation reactivity, achieving 12.15% CO_2 uptake and forming 7.88 wt.% $CaCO_3$ after 28 days. The capsule-containing mortars effectively healed cracks up to 1.0 mm wide, achieving approximately 70% and 60% crack closure for medium (0.2–0.6 mm) and large (0.8–1.0 mm) cracks, respectively, after 7 days, with crack closure exceeding 90% after 28 days. Water-tightness recovery reached 60% after 7 days and 100% after 28 days, accompanied by substantial compressive strength recovery, with improvements of up to 164% relative to the corresponding control specimens. Microstructural analyses identified rhombohedral calcite, aragonite, and alumina-containing phases as the predominant healing products, indicating synergistic carbonation and pozzolanic reactions. Overall, the results demonstrate the potential of DWTS-based engineered capsules to provide rapid and autonomous self-healing under CO_2-aggressive conditions while simultaneously valorising water-treatment waste. The proposed system provides a promising sustainable strategy for extending the service life and reducing maintenance requirements of sewer infrastructure.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Refining of spodumene into lithium chemicals

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Abstract: Spodumene is one of the most important sources of lithium, providing about half of global lithium supply [1]. Refining of lithium from spodumene involves a sequence of high-temperature and chemical processing steps to produce lithium hydroxide or lithium carbonate. Calcination and acid, alkaline or sulphation roasting induce mineralogical transformations that control lithium recovery, leaching selectivity and by-product value but are poorly understood. Here, we present microscopic, ex-situ and in-situ observations that document the reaction sequences and mechanisms underpinning lithium extraction and the development of more sustainable refining processes.

The conventional sulfuric acid process achieves high lithium recoveries and high lithium hydroxide purities but large energy, chemical and by-product footprints, as well as inflexibility to accommodate lower grade sources warrant further investigation. Lithium can also be efficiently extracted by pressure leaching with NaCl and NaOH, providing some flexibility to produce different by-products [2]. K_2SO4 roasting of α-spodumene progresses through ion exchange and reconstructive transformation of α-spodumene, that is mediated by a K-Li-sulfate melt and results in marketable leucite as a by-product [3]. This work demonstrates that understanding of mineralogical transformations is not only critical for impurity rejection and lithium recovery but also for the manufacturing of by-products with various functional properties, uses and markets.

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My research addresses two of modern society's most pressing problems - safe and permanent sequestration of CO_2 and supply of critical metals for renewable energy technology. Using field-based, modelling and experimental approaches in combination with a wide range of modern chemical, isotopic, physical and crystallographic characterisation techniques, I investigate interactions between CO_2 and ultramafic rocks, as well as the formation and alteration of critical metal deposits and the extraction of critical metals from them. I am also applying in-situ analysis to industrial processes to reveal reaction sequences and mechanisms to inform process development and improve process sustainability. I publish my work in both basic and applied science and engineering journals of high international standing and have contributed to more than 80 conferences and workshops. I value and actively engage in collaborative research with partners in academia, government and industry including projects focused on lithium, nickel, REE, copper and mine waste valorisation.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Accelerating green hydrogen production through low-cost electrode development and scalable manufacturing

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Abstract: The transition towards sustainable hydrogen production requires not only highly active and durable electrocatalysts, but also low-cost electrode materials and scalable manufacturing technologies capable of translating laboratory discoveries towards practical applications. [1-2] This work presents our progress in bridging atomic-scale catalyst engineering, interface design, and scalable electrode manufacturing for efficient green hydrogen production.

At the atomic scale, we developed a dual-anchoring strategy to address the stability–activity challenge of Pt single-atom catalysts for the hydrogen evolution reaction (HER).[3] A $Co(OH)_x$/PtSA/$Ni(OH)_x$ architecture was constructed through sequential electrodeposition, creating strengthened Pt–O–M (M = Co, Ni) coordination environments that stabilise isolated Pt atoms while regulating their electronic structure. Combined experimental and theoretical investigations reveal enhanced Pt binding and optimised hydrogen adsorption, enabling a current density of 100 mA cm^{-2} at an overpotential of only 116.1 mV in 1 M KOH, together with durability exceeding 110 h durability.

Beyond atomic-scale catalyst design, we are developing low-cost multicomponent transition-metal catalysts and scalable electrode fabrication strategies to reduce reliance on precious metals and address manufacturing barriers. Magnetron sputtering and roll-to-roll manufacturing provide a versatile platform for controlling catalyst composition, interfaces and surface structures while enabling continuous fabrication over large-area substrates. Integration of catalyst discovery with scalable manufacturing provides a pathway to translate high-performance materials from laboratory-scale electrodes towards practically relevant hydrogen-production systems. By connecting fundamental catalyst design with manufacturability, this approach aims to accelerate the development of efficient, durable and economically viable electrodes for large-scale green hydrogen production.

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Dr. Doudou Zhang is an outstanding early-career researcher, leading an independent SunCatFuels Group in the School of Engineering. Her group focused on (photo)electrochemical materials, scalable device fabrication, and renewable energy technologies. Prior to joining Macquarie University, she worked at Australian National University for five years on solar-to-hydrogen technologies and contributed world-leading solar-to-hydrogen efficiencies. Dr. Zhang has published over 42 peer-reviewed papers, two book chapters. She has secured more than A$2 million in competitive funding as Lead or Co-Investigator, including an ARC Discovery Project, ARENA-supported hydrogen commercialisation projects, and major research infrastructure grants.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

From Metallurgical Residues to Critical-Metal Resources: Integrated Valorization of Bauxite Residue and Nickel HPAL Tailings

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Abstract: The rapid expansion of clean-energy technologies and advanced manufacturing is increasing global demand for critical metals while generating growing volumes of metallurgical residues. This creates an opportunity to reconsider conventional waste management and develop these residues as engineered secondary resources. Bauxite residue and nickel laterite high-pressure acid leaching (HPAL) residues are particularly important because of their large volumes, complex mineralogy, and potential to host strategically valuable elements. This study presents selected results from our work on the characterization, extraction, separation, and valorization of metals from these two residue streams. In bauxite residue, scandium, vanadium, gallium, and other valuable elements occur at relatively low concentrations within complex Fe-, Al-, Si-, Ti-, and Ca-bearing matrices. Their recovery therefore requires integrated approaches combining mineralogical transformation, selective leaching, impurity rejection, precipitation, solvent extraction, and ion exchange. Our studies on scandium recovery, including selective leaching and sulfation-assisted processing, highlight the importance of metal deportment and matrix transformation in improving separation efficiency. Nickel HPAL residues provide complementary opportunities for recovering value from iron-rich residues and intermediate precipitates. Our work on iron recovery and conversion into iron phosphate demonstrates how residue valorization can extend beyond trace critical-metal recovery toward functional-material production. Future residue processing should move beyond single-element recovery toward integrated multi-product valorization, combining critical-metal recovery, major-element utilization, impurity management, reagent recycling, and residue stabilization. This transition from “waste treatment” to “resource engineering” can strengthen circular extractive metallurgy and improve the resilience of critical-mineral supply chains.



Mohammad Zaki Mubarok got his Bachelor and Master Degree from Bandung Institute of Technology, Indonesia in 1997 and 2001, respectively. He got his PhD from Department of Nonferrous Metallurgy, University of Leoben, Austria in 2005. During 2006-2007 he worked as postdoctoral fellow in the same department. Since 1999 until now, Dr. Mubarok is an academic staff at Deparment of Metallurgical Engineering, Bandung Institute of Technology (ITB). Since 2014 until now, he is Head of Laboratory of Hydro-electroetallurgy at Deparment of Metallurgical Engineering, ITB. He is full professor in the aforementioned Department and Faculty since August 2019. Since 2022 he has been appointed as guest professor at Central South University (CSU), China for the period of 2022-2027.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Circular Resource Engineering: Electrochemical and Membrane Technologies for Critical Mineral and Nutrient Recovery

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Abstract: The growing demand for critical minerals and nutrients, together with increasing pressures on natural resources and waste management, is driving a transition from conventional treatment towards resource recovery and circular utilisation. Water and waste streams represent increasingly important secondary resource reservoirs; however, their complex compositions create significant challenges for selective separation, efficient concentration, and energy-effective recovery.

Electrochemical and membrane technologies provide a versatile pathway to address these challenges through controlled ion transport, selective material-ion interactions, and electrically driven separation. In saline and mineral-rich waters, these principles can be applied to selectively extract critical elements such as lithium from competing ionic species, creating opportunities to utilise unconventional and low-grade mineral resources. The same separation principles can be extended to nutrient-rich waste streams, where biological and membrane processes can be integrated with electro-membrane technologies to recover and concentrate nitrogen, phosphorus, potassium, and other valuable constituents for beneficial reuse.

By linking selective materials and membrane interfaces with electrochemical separation processes, valuable ionic resources can be recovered across diverse aqueous environments. Such integration provides a pathway towards more selective, energy-efficient, and adaptable resource recovery systems, supporting the transition from wastewater treatment towards circular resource engineering.

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Dr Hanwei Yu is a researcher in environmental engineering at the University of Technology Sydney (UTS), specialising in electrochemical and membrane technologies for resource recovery and circular economy applications. Her research focuses on the selective recovery of critical minerals and nutrients from complex water and waste streams, with particular expertise in capacitive deionisation, electrodialysis, functional materials, and membrane processes. Her work spans fundamental material and separation mechanisms through to process integration and pilot-scale applications, including selective lithium recovery from saline waters and nutrient recovery from wastewater.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Bioinspired Metal–Organic Framework Channel Membranes for Selective and Gated Ion Transport

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Abstract: Biological ion channels achieve remarkable ion selectivity and dynamic regulation through precisely organized chemical functionalities and confined transport pathways. Translating these principles into synthetic membranes offers opportunities for selective resource recovery and advanced ionic devices. Here, we develop bioinspired metal–organic framework (MOF) channel membranes by integrating tailored pore structures and functional groups within polymer nanochannels to regulate ion transport through complementary mechanisms [1].

Thiol-functionalized UiO-66-$(SH)_2$ membranes enable efficient lithium extraction from challenging brines by combining angstrom-scale molecular sieving with preferential interactions between thiol groups and divalent cations [2]. Molecular dynamics simulations reveal substantially higher energy barriers for Mg^{2+} transport than for Li^+. The membranes achieve Li^+/Mg^{2+} selectivity of up to 1,516 under dual-ion conditions and maintain effective separation in highly concentrated brines, including those with Mg^{2+}/Li^+ ratios of 30 and Mg^{2+} concentrations up to 3.5 M.

Building on this framework-based ion-regulation strategy, crown ether-coordinated UiO-66-COOH membranes are also developed to further mimic biological NaK channels through the synergistic integration of carboxyl groups and carboxybenzo-15-crown-5 [3]. The resulting membranes exhibit a record-high Na^+/K^+ selectivity exceeding 6,000 under mixed-ion conditions and Mg^{2+}-responsive gating with sustained on–off ratios of approximately 30.

Together, these studies demonstrate how molecular recognition, pore confinement and functional-group engineering can be combined to achieve highly selective and dynamically regulated ion transport. This MOF channel membrane strategy provides a versatile platform for next-generation membranes for critical-metal recovery and biomimetic ionic technologies, with potential applications in resource sustainability, artificial cells and intelligent ion-transport systems.

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Dr Zhao is a Research Fellow at RMIT University, Australia. She received her PhD in Chemical Engineering from Monash University in 2019. Her research focuses on bioinspired ion channels, metal–organic framework membranes, selective ion transport, and sustainable metal recovery. Her work integrates membrane engineering, molecular-level transport mechanisms, and functional materials design to develop advanced separation technologies for resource recovery and biomedical applications.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Engineering Interfaces, Creating Function: New Opportunities in Advanced Materials

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Abstract: The performance of advanced materials is often determined not simply by their bulk properties, but by what happens at their surfaces and interfaces. Understanding and controlling these interfaces provides opportunities to improve existing materials while introducing entirely new functionality. This presentation will explore how surface and interface chemistry can provide a platform for the design of advanced and multifunctional materials.

Drawing on examples from our research, I will discuss approaches to modifying carbon fibre and other material surfaces to control interfacial interactions, improve performance and introduce functionality beyond traditional structural roles. These examples will span fundamental surface chemistry, multifunctional composites, structural energy storage and emerging electromechanical behaviour in unconventional material systems. Particular emphasis will be placed on how relatively small changes in interfacial chemistry can produce significant changes in macroscopic material behaviour.

The presentation will also consider the translation of fundamental chemical discoveries into practical materials technologies and the importance of interdisciplinary collaboration in achieving this. Many of the most interesting research questions emerge at the boundaries between disciplines and through interactions with researchers and industry partners who bring different capabilities, perspectives and challenges.

Rather than presenting a single research story, this keynote will highlight our capabilities, recent discoveries and emerging research directions. Importantly, it is also an invitation to collaborate and explore how complementary expertise in chemistry, materials science, engineering, characterisation and manufacturing can create new opportunities in advanced materials.



Professor Luke Henderson is a materials chemist at Deakin University's Institute for Frontier Materials, internationally recognised for his research in surface and interface chemistry, carbon fibre composites and multifunctional materials. His work focuses on using chemistry to control material interfaces, improve performance and introduce new functionality, with research spanning advanced composites, structural energy storage and emerging functional material systems. He has published more than 200 peer reviewed papers and has extensive experience translating fundamental research through collaborations with industry. He is an ARC Mid Career Industry Fellow and recipient of the 2025 RACI R.K. Murphy Medal.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Selective Lithium Recovery from Spent Lithium-Ion Batteries via Stepwise Transition Metal Crystallization

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Abstract: The rapid growth of lithium-ion batteries has created an urgent need for sustainable technologies that selectively recover critical materials from complex end-of-life battery streams.[1] Conventional hydrometallurgical processes typically co-leach lithium and transition metals, requiring multiple downstream separation steps, with lithium generally recovered only at the final stage.[2] Here, we report a natural deep eutectic solvent (DES)-based strategy that enables selective lithium recovery through controlled transition-metal chemistry and stepwise crystallization.[3] The DES environment regulates metal reduction, complexation and hydrolysis, driving transition metals into crystalline phases while maintaining lithium in the liquid phase. Mechanistic investigations combined with density functional theory calculations reveal the chemical pathways governing this selective separation. The strategy achieves high lithium recovery while strongly suppressing transition-metal dissolution and is applicable to diverse cathode chemistries, including layered, spinel and olivine structures. Importantly, the DES can be regenerated and reused while retaining high lithium-leaching efficiency, and the process has been demonstrated at an enlarged scale. This work establishes a mechanistically guided approach for controlling metal speciation and crystallization in complex battery materials, providing new opportunities for selective critical-material recovery and sustainable closed-loop battery recycling.

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Dr Jingxiu Wang is an ARC Early Career Industry Fellow in the School of Chemical Engineering at Adelaide University, Australia. Her research focuses on the sustainable recycling and processing of secondary resources, including metallurgical wastes, ores, coal, e-waste and end-of-life solar panels. Her current research centres on the recycling, regeneration and upcycling of spent lithium-ion batteries, with particular interests in selective critical-metal recovery, deep eutectic solvent chemistry and direct regeneration of degraded cathode materials. Her work aims to understand and engineer chemical pathways for selective resource recovery and closed-loop recycling of advanced battery materials.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Solid-state lithium-metal batteries need new materials innovation

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Abstract: Solid-state lithium metal batteries (SSLBs) represent a groundbreaking advancement in energy storage technology, offering significantly higher energy densities and improved safety compared to traditional Li ion batteries. However, solid state electrolytes (SSEs) face critical challenges, including low ionic conductivity, poor stability at the electrode electrolyte interface, and the formation of Li dendrites, which can lead to short circuits and battery failure. To address these issues, various strategies have been developed. One notable approach involves the use of a nitrogen doped Li oxide film, synthesized via anodizing oxidation of pure Li in a liquid electrolyte. This film forms a uniform surface on the Li metal anode, effectively suppressing dendrite growth while enhancing Li ionic conductivity. [1] Another transformative strategy is the incorporation of additives into SSEs. These additives, ranging from inorganic and organic materials to nanostructures, significantly enhance ionic conductivity, bringing it closer to that of liquid electrolytes. [2] Additionally, they improve the mechanical properties of SSEs, preventing cracking and ensuring stable interfaces. Voids and gaps at the SSE electrode interfaces also hinder the performance of SSLBs. To overcome this limitation, a void free design has been developed, combining an inorganic gel hybrid electrolyte with in-situ polymeric interlayers. This hybrid SSE facilitates efficient Li+ ion conduction, while the in-situ fabricated solid polymer electrolyte improves interfacial compatibility,ensuring better performance and stability in SSLBs. [3.4]



Ying Ian Chen is a Deakin Distinguished Professor, Chair of Nanotechnology, and Director of the Australian Research Council (ARC) Research Hub for Safe and Reliable Energy Storage and Conversion Technologies, based at the Institute for Frontier Materials, Deakin University. A Clarivate Highly Cited Researcher with over 400 publications, he holds a Ph.D. in Chemistry from the University of Paris-Sud, Orsay, France. Prof Chen's research has generated three start-up companies in nanomaterials and lithium–sulphur batteries. His current research focuses on fundamental studies of nanomaterials for hydrogen storage and advanced battery technologies.

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Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Sustainable critical mineral supply futures for Australia: Reconciling resource abundance with supply risks and transparency

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Abstract: Australia hosts substantial critical mineral resources yet produces minimal refined supply, exporting billions of dollars' worth of unprocessed ore annually. This keynote examines the tensions between primary supply and circularity for resource-rich, low-population economies like Australia. Material flow analyses of indium and other by-product metals reveal that Australia's circular economy strategy must diverge from conventional recycling narratives. Supply resilience can emerge from primary extraction efficiency and domestic refining capacity alongside consumer-side recovery. Australia's mineral resources and processing wastes contain vastly larger critical metal quantities than in-use stocks, yet these also remain economically invisible.

This presentation also addresses key barriers to sustainable supply, including supply chain opacity and unquantified risks. Mining sector water footprints, environmental liabilities, and social impacts remain poorly disclosed at the site level. Mandatory, standardised transparency is essential to de-risk capital flows and build social licence for expanded domestic processing.



Dr. Tim Werner is a Senior Lecturer in Energy Transition at the University of Melbourne, where he coordinates the Responsible Mining and Energy Transition Research Group. His research expertise encompasses environmental engineering, geographical science, economic geology, industrial ecology and conservation biology. His interests span many topics, including mineral supply chain resilience and dynamics, land use changes, resource economics and governance, material recycling and waste management, and energy transition pathways. He collaborates widely with government, industry and international partners on topics of mining and supply chain sustainability. His research and commentary feature in over 100 published outputs and he is a regular contributor to media on topics of metal supplies and mining.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Ion Partitioning and Transport in Advanced Membrane Materials

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Abstract: Efficient ion transport through nanostructured membranes underpins next generation technologies for water purification, resource recovery and energy storage. Graphene oxide membranes (GOMs) are particularly promising due to their ability to facilitate molecular sieving with ultrafast transport through the nanochannels. However, the mechanisms governing ion sorption and transport within their nanochannels are inadequately understood.

In this work, we systematically examine the ion sorption and diffusion behaviour of GOMs for NaCl, Na_2SO_4, $NaNO_3$, $MgCl_2$ and $MgSO_4$ across a range of external salt concentrations. It was found that Mg^{2+} uptake in the $MgSO_4$ system is lower than that observed for $MgCl_2$, while co-ion concentrations remained comparable within experimental error. Counter-ion sorption was sufficiently described by the Donnan model, whereas accurate representation of co-ion partitioning in GOMs required a modified Donnan framework using the mean membrane ion activity coefficient as the only fitting parameter. Ion-pair formation in the sulfate system was evidenced, as the amount of proton released during ion sorption decreased with increasing external salt concentration, suggesting suppressed deprotonation at high concentrations. This behaviour, however, was not observed for chloride and nitrate electrolytes. We also found that counter-ion diffusion coefficients are largely insensitive to both co-ion identity and external salt concentration. In contrast, co-ion diffusion exhibited a dependence on the external concentration, with a decrease observed at 0.1 M in sulfate systems, providing additional evidence for ion pairing within the GOM structure. The results offer valuable guidance for the rational design of advanced membrane materials for regulating co-ion transport in sustainable water treatment, ion recovery, and electrochemical energy technologies.



Dr George Chen is a Senior Lecturer in the Department of Chemical Engineering at the University of Melbourne and a Board Director at the Membrane Society of Australasia. His research integrates molecular scale understanding of ionic and molecular transport in membranes with process design to advance separation technologies for industrial applications across food and bioprocessing, water purification, resource recovery and decarbonisation. Dr Chen currently leads a research group comprising over ten PhD students.

His work has been recognised with many awards, including the 2023 Influential Researcher Award from the ACS Ind. & Eng. Chem. Res., the 2022 ICM Agrifood Award from ASTE, and the 2025 Collaboration Award and the 2022 Applied Research Award from the Membrane Society of Australasia.

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Theme 8: Critical Minerals, Resource Recovery and Circular Economy

From Particles to Processes: Understanding Complex Particle–Fluid Systems Across Scales

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Abstract: Particle–fluid systems are found across a wide range of natural and industrial processes, from metallurgical reactors and fluidised beds to recycling technologies and drug delivery. Their behaviour is often difficult to predict because particles can vary substantially in size and shape, while particle–fluid interactions occur across multiple length and time scales. Developing reliable tools to understand these systems is therefore essential for improving process efficiency, scale-up and sustainability.

This keynote presents our recent progress in developing particle-scale modelling approaches for complex particle–fluid systems. For systems containing particles spanning a wide range of sizes, smoothed and hybrid CFD–DEM approaches have been developed to better capture particle–fluid interactions across different scales. To represent realistic particle shapes, superquadric DEM has been developed to better represent non-spherical and irregular particles. At the same time, coarse-grained modelling and machine-learning-based approaches have been explored to reduce computational cost and enable simulations of larger and more complex systems.

These modelling developments are illustrated through applications including pulverised-coal injection and reacting flows in blast-furnace raceways, particle–fluid dynamics in fluidised beds, particle separation in end-of-life photovoltaic module recycling, and nanoparticle transport for drug delivery.

Together, these studies demonstrate how understanding particle-scale behaviour can help explain process-scale performance. The presentation will also discuss future opportunities for combining advanced modelling, data-driven methods and process optimisation to support more efficient industrial processes, resource recovery and circular-economy technologies.



Dr Zhouzun Xie is an ARC DECRA Fellow in Chemical Engineering at the University of New South Wales (UNSW), Australia. His research focuses on advanced computational modelling of complex particle–fluid systems, with applications in process metallurgy, photovoltaic module recycling, drug delivery, and other multiphase processes. Dr Xie received his PhD in Chemical Engineering from UNSW in 2022, following his MEng and BEng degrees from Northeastern University, China, in 2018 and 2015, respectively. His research aims to bridge fundamental particle-scale understanding with practical process design and optimisation for industrial and sustainable applications.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Transforming Complex Wastes into High-Performance Nano- and Advanced Materials

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Abstract: Complex wastes combine metals, oxides and organics, making printed circuit boards, batteries, multilayer packaging and polymer-rich e-waste difficult to recycle. Their heterogeneity nevertheless offers a rich chemical inventory for circular materials manufacturing. This keynote presents a source-to-product platform combining thermal disengagement, thermal micronising and selective thermal transformation. Controlled temperature and atmosphere activate waste-derived carbon, reducing gases and trace elements as in situ reagents, selectively reorganising waste into functional materials.

Outcomes include Sn- and Cu-based alloys from printed circuit boards, with recovered Cu reaching approximately 80% IACS conductivity and the Sn alloy showing approximately 30% higher ultimate tensile strength than a benchmark solder [1]; approximately 99.6% pure Cu and O/N-doped activated carbon delivering 244 F g^{-1} and approximately 97% retention after 2000 cycles [2]; and approximately 96% pure Co from spent Li-ion batteries [3]. Waste-derived ZnO/graphene and NiO-CuO nanostructures enabled room-temperature NO_2 and NH_3 sensing [4,5]. Multilayer coffee capsules yielded γ-Al_2O_3 nano-adsorbents with 9.60 mg g^{-1} fluoride capacity [6], while waste coffee powder enabled 89.23% Li and 93.27% Co recovery and regeneration of electroactive $LiCoO_2$ [7]. Carbon from discarded compact discs further demonstrated tunable Li^+/Na^+ storage [8]. Most recently, mixed black mass from Li-ion, Ni-MH and alkaline batteries was directly converted into NICOM 622, a Ni-Co-Mn superalloy. Together, these studies establish complex waste as a feedstock for high-performance nano- and advanced materials, reducing virgin extraction and enabling distributed circular manufacturing.



Dr Rumana Hossain is an environmental materials scientist at UNSW Sydney's SMaRT Centre. Her research combines selective thermal transformation, advanced characterisation and circular manufacturing to recover critical materials and transform complex wastes into high-value metals, carbons, nano-adsorbents, sensors and energy materials, with a strong focus on translation through government and industry partnerships.

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Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Low-Carbon and Circular High-Temperature Recycling of End-of-Life Batteries

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Abstract: Sustainable processing routes for production and recycling critical metals are important for energy transition efforts. It is imperative that these processes are energy efficient, robust and not further contributing to the CO_2 emission. This presentation will discuss the general approach for low/zero carbon metal production and recycling processes. Examples from the author's group are discussed, this includes on the use of concentrated solar thermal for recycling of black mass of alkaline and Lithium-ion batteries are discussed. Recovery of Zn micro/nano powders from alkaline battery black mass was demonstrated using concentrated solar thermal as a heat source; and technoeconomic assessment showed that a small modular process (200 tonnes/year) is economically feasible[1]. It is expected that the generated income of the 200 tonnes/year plants are about $1.8 million and in the range of $0.5-0.6 million for Zn and ZnO recovery, respectively. In another example, a non-carbon reductant (aluminium) was also used to recover cobalt from LCO cathode materials. The reaction exhibited a thermal runaway which allows the process to occur at very high temperature where the sample is smelted forming liquid metal droplets and lithium vapour which later condensed[2]. The process was demonstrated at 750-1020°C and showed that Al was effective in separating Li and Co from LCO. Li was distributed into gas and slag while the Co could be obtained as Co metal or Co-Al alloy depending on the amount of Al added in the sample.

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Muhammad Akbar Rhamdhani is a Professor of Sustainable Metallurgy and Metals Recycling at Swinburne University of Technology, Australia. Akbar obtained his PhD from McMaster University Canada in Materials Science and Engineering. Akbar's research expertise is on high temperature processes, advanced metal/material refining and impurities removal; development of new processes for metal production; thermodynamics and kinetics of high temperature metal and chemical processes; and physical chemistry of interface. Akbar's current research directions include: (1) Recycling and recovery of metals from urban resources; (2) Decarbonisation and Hydrogenation of metallurgical processes; (3) Solar metallurgy; and (4) Astro metallurgy. Akbar is currently a Co-Editor-in-Chief Journal of Sustainable Metallurgy, TMS Springer, USA. He and his team have been awarded prestigious international award, including the most recent; 2027 TMS EPD Distinguished Lecturer Award and 2026 TMS EPD Science Award.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Flocculation-flotation for improved recovery of fine critical minerals

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Abstract: Recovery of valuable critical mineral particles by froth flotation is most efficient when the particle size is between about 50 and 150 microns. Finer particles lack the inertia to successfully collide with and attach to the air bubbles. Between 5 to 30% of the valuable mineral can be lost as fine tailings. Improving recovery of fine particles will increase the amount of metal recovered from a resource so less ore is needed to meet demand. Flocculation-flotation is investigated to improve recovery of fine hematite, chalcopyrite, and spodumene, that are typically discarded during desliming. Techno-economic analysis indicates that the additional value can be on order $10-50 M per year depending on the commodity and mineralogy. The first step is selective aggregation of the valuable mineral particles in order to produce aggregates with size amenable to recovery by flotation. Inexpensive commercial polyacrylamide flocculants are suitable for this purpose. The aggregate size and structure are characterized using an in-situ probe using image derived chord length distributions. Then the aggregates are made hydrophobic by addition of an appropriate collector. The approach is successful in improving flotation recovery of hematite and spodumene (from quartz). In other cases, such as chalcopyrite, the polymer is not effective in improving recovery, even when the valuable particles are aggregated because the hydrophilic polymer limits the aggregate hydrophobicity. The key challenge for this technology is the unwanted entrapment of gangue particles within the aggregates (such as feldspar in spodumene) of the valuable minerals resulting in reduced concentrate grade.

Biography

George Franks degrees are in Materials Science and Engineering (Bachelor MIT, 1985 and PhD UCSB, 1997). His research includes minerals processing, ceramic powder processing and suspension rheology. His work in minerals processing relates to development and application of novel polymeric reagents in solid/liquid separation and froth flotation. His work in materials processing is related to processing of complex shaped ceramics with unique microstructures such as 3D printed multi-scale porous ceramics. He is co-Deputy Director of the ARC COE for Enabling Eco-Efficient Beneficiation of Minerals. He has 161 papers in international peer reviewed journals, 7 book chapters and four patents with 7050 citations and h-index = 47. He is Associate Editor of the Journal of the American Ceramic Society and Advisory https://chemical.eng.unimelb.edu.au/ceramics)

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Towards Sustainable NMC Recycling: Lower-Emission Reduction Pathways for Critical-Metal Recovery

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Abstract: The rapid expansion of lithium-ion battery technologies is intensifying the need for recovery processes that retain critical metals efficiently while lowering energy demand and process-related emissions. This study compares hydrogen and carbon reduction of commercially available NMC cathode material using thermodynamic equilibrium analysis, focusing on Li, Ni, Co and Mn behaviour, phase transformations, lithium retention and gaseous products [1,2]. For hydrogen reduction, a favourable intermediate-temperature region of approximately 700 -1100 °C was identified. Co and Ni were predominantly stabilised in a metallic Co-Ni phase, while Mn remained largely as MnO. Lithium transformed from LiOH(s) to LiOH(l) and subsequently to Li2O(s), while remaining predominantly in condensed phases across this range. H_2 consumption was accompanied by H2O as the dominant calculated gas-phase species, indicating the potential of hydrogen to minimise direct carbon-containing process emissions, particularly when low-carbon hydrogen is used. Carbon reduction showed a promising region of approximately 700-1000°C, characterised by formation of a Ni-Co-Mn-C containing metallic/carbide phase, while lithium remained mainly as condensed Li2CO3 and Li2O. In contrast, CO dominated the calculated gas phase as carbothermic reduction progressed, resulting in a greater carbon-containing off-gas burden. At higher temperatures, both systems became less favourable because of increased energy demand and a greater tendency for lithium volatilisation. Overall, intermediate temperature processing provided the most favourable balance between transition-metal reduction and lithium retention. The contrasting H2O and CO dominated gas chemistries further highlight the potential advantages of hydrogen as a lower-emission reductant and provide a thermodynamic basis for targeted experimental validation under realistic operating conditions.

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Dr Chitra Sulkan is a Postdoctoral Research Fellow at Swinburne University of Technology, Australia, working on sustainable recycling and critical-material recovery from end-of-life lithium-ion batteries. She completed her joint PhD through AcSIR, India, and RMIT University, Australia, with research focused on recycling end-of-life crystalline silicon photovoltaic modules. Dr Sulkan also has industry experience in solar-panel recycling, contributing to applied process development, material recovery, and circular economy solutions for end-of-life PV modules. Her research integrates high-value material recovery, materials characterisation, process optimisation, emissions assessment, and sustainability evaluation to develop scalable and environmentally responsible recycling pathways. Dr Sulkan is a recipient of the Prof. Govardhan Mehta–Prof. Robin Batterham Award for Eco Sustainability and Impact and has contributed to peer-reviewed publications and patented technologies in solar-panel recycling and resource recovery. Her broader research interests encompass photovoltaic waste management, lithium ion battery recycling, and sustainable critical-material recovery.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

The Role of Microbial Systems in Shaping the Future of Sustainable Mining

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Abstract: The transition to a circular economy for critical minerals requires mining to be conceived as an integrated system rather than a linear sequence of extraction and disposal. This keynote will present a systems perspective that integrates waste prevention, resource recovery, material recycling and mine rehabilitation. It will examine how microbial systems, through their ecological interactions and metabolic capabilities, contribute across the mining life cycle. Biohydrometallurgy illustrates one such application, using biologically mediated dissolution, transformation and separation to support the selective recovery of critical minerals, rare earth elements and base metals from low-grade ores and secondary resources (Park et al., 2017; Han et al., 2023). Microbial–rhizosphere processes can also be harnessed to promote pedogenesis in mine wastes, facilitating the transformation of tailings and other residues into functional technosols that support revegetation and nutrient cycling (Huang et al., 2012). By linking prevention, recovery, recycling and rehabilitation, this framework moves beyond the extract–produce–dispose model towards more resource-efficient and sustainable critical-mineral production.



Dr Jing Camille Zhao is a Lecturer and DECRA Research Fellow in the School of Minerals and Energy Resources Engineering at UNSW Sydney. She received her PhD from the University of Queensland's Advanced Water Management Centre in 2022 and previously worked as a Research Fellow at UQ's Sustainable Minerals Institute. Her research focuses on sustainable and safe mining, including microbial systems, biohydrometallurgy, critical-mineral recovery, mine-waste rehabilitation, resource-efficient processing and MEMS-based gas sensors for real-time monitoring. Her interdisciplinary work integrates microbiology, biotechnology, mineral processing, environmental engineering and advanced materials. Dr Zhao's research has been published in leading journals, including Environmental Science & Technology, Nature Communications and Water Research. She is also an inventor on 29 patents.

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Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Hydrogen-Assisted Recovery of Critical Metals from NMC Black Mass: Thermodynamic Modelling and Experimental Validation

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Abstract: Demand for critical metals is increasing rapidly due to the growth of portable electronics and electric vehicles. This rising demand is placing significant pressure on the supply of valuable metals such as Li, Mn, Ni, and Co, creating a strong need for alternative and sustainable sources. Recycling end-of-life batteries is therefore an important pathway for recovering these materials, reducing carbon emissions, and establishing a secondary resource stream. The use of H2 as a cleaner reductant offers further potential to reduce the carbon footprint of metal recovery and support lower-emission recycling processing routes. This study investigates the flash H2 reduction behaviour of NMC black mass through systematic thermodynamic assessment supported by selective experimental validation. The analysis compares NMC black mass reduction with and without H_2. It shows that increasing H_2 decreases oxide stability and the persistence of solid phases, increases gas generation, promotes liquid-phase formation, and shifts phase transitions to lower temperatures. Phase distributions and Li-Co-Mn-Ni partitioning are assessed alongside XRD and SEM results. Li was mainly recovered in the LiAlO2-rich slag phase, while Co, Mn, and Ni were concentrated in the alloy phase. Increasing temperature further enhanced the overall reduction process. This preliminary study provides insight into flash H_2 reduction behaviour and establishes a basis for further development under conditions relevant to practical NMC black mass processing.



Dr Sazzad Ahmad is currently working as a Research Fellow in Green Metal Production and Recycling, focusing on sustainable metallurgical processes for critical metal recovery and battery material recycling. He is also a Professor in the Department of Materials and Metallurgical Engineering at Chittagong University of Engineering and Technology (CUET), Bangladesh. His research focuses on thermodynamic modelling, hydrogen-assisted reduction, phase transformation analysis, green metal production, and low-carbon recovery of critical metals from end-of-life lithium-ion batteries.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Upcycling E-Waste-Derived Copper into Cu/Ni Foam Electrodes for High Current-Density Glucose Electrooxidation to Formate

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Abstract: Electronic waste (e-waste) represents a valuable secondary source of copper, providing opportunities for metal recovery and reuse [1]. Although Cu/Ni-based catalysts have shown promising performance for glucose electrooxidation to formate [2], integrating e-waste-derived copper into high-current-density electrocatalytic electrodes remains an important research opportunity. Herein, copper recovered from waste printed circuit boards by dilute aqua regia leaching was electrodeposited onto nickel foam to fabricate Cu-modified nickel foam (Cu/NF) electrodes for the electrochemical oxidation of glucose to formate. The electrodes were characterized by XRD, SEM and XPS. In 1 M KOH containing 100 mM glucose, linear sweep voltammetry showed current densities of up to 1200 mA cm^{-2}. During galvanostatic electrolysis at 500 mA cm^{-2}, HPLC analysis showed a formate Faradaic efficiency of 98.5% at 200 s (9.18 mmol h^{-1} cm^{-2}), decreasing to 75.5% at 1200 s (7.04 mmol h^{-1} cm^{-2}). Chronopotentiometry with periodic electrolyte refreshment maintained potentials of approximately 1.5 V vs. RHE at 250 mA cm^{-2} over 7.8 h and approximately 1.6 V at 500 mA cm^{-2} over 3.3 h. XPS analysis showed that surface Cu(I) was oxidized to Cu(II) and subsequently returned to Cu(I), consistent with reversible Cu(I)/Cu(II) redox cycling at the Cu/Ni interface, motivating further mechanistic study of Cu redox chemistry during glucose oxidation. This work demonstrates that e-waste-derived copper can be upcycled into high-rate electrodes, linking metal recovery with value-added chemical production.

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Fatima Arshia is a PhD researcher in the Department of Chemistry at The University of Hong Kong. Her research focuses on the recovery of valuable metals from electronic waste and their upcycling into functional electrocatalytic materials. Her research interests include electrochemistry, sustainable metal recovery, electrocatalysis, and catalyst surface chemistry.

Theme 8: Critical Minerals, Resource Recovery and Circular Economy

Carbon-based nanomaterials for selective gold extraction from e-waste

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Abstract: Efficient gold extraction from electronic waste (e-waste) is critical for securing a sustainable gold supply and advancing e-waste recycling[1-4]. This presentation discusses the development of carbon-based materials for recovering gold from complex waste streams, focusing on the relationships between carbon structure, surface chemistry and extraction performance. Reduced graphene oxide achieves highly efficient and selective gold recovery from real e-waste leachates. Its graphene domains enable the spontaneous reduction of gold ions to metallic gold, while oxygen-containing regions improve dispersibility and interfacial contact. Building on this concept, our recent work has explored waste-derived hierarchical porous carbons as low-cost platforms for selective gold extraction. Preliminary results suggest that pore architecture and electron-rich sp^2 carbon domains contribute to gold capture and reduction, even with limited oxygen-containing functionalities. Beyond metal recovery, gold–carbon composites can be directly upcycled into functional materials for water purification application. Overall, this research demonstrates a sustainable strategy for recovering and upcycling precious metals from e-waste.

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Dr Fei Li is currently a Postdoctoral Research Fellow at the University of New South Wales, working under the supervision of Prof Rose Amal and Prof Rakesh Joshi. He received his PhD from Tsinghua University in June 2024, where he was supervised by Prof Yang Su and Prof Hui-Ming Cheng. During his doctoral studies, he also undertook visiting research at the National University of Singapore (NUS) under the guidance of Nobel Laureate Prof Konstantin Novoselov and Prof Daria Andreeva. After completing his PhD, he worked as a Senior Materials R&D Engineer at Huawei. His research focuses on the controlled synthesis of carbon-based materials for precious metal recycling and their subsequent upcycling for applications in water purification and catalysis.

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Poster Abstract

From Fire Protection to Fire Detection: Graphene Metamaterial-Coated Cotton for Smart Fire Safety

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Abstract: Cotton is a highly flammable material with a limiting oxygen index (LOI) of 18%. Conventional flame-retardant materials protect cotton from fire, yet they cannot detect it. Hence, a coating that both provides active fire retardancy and passive fire alarm response is critical in the field. In this study, graphene metamaterials are deposited on a cotton substrate using the layer-by-layer deposition. Graphene metamaterials shift cotton from flaming combustion to char formation, where increasing the bilayer count increases the amount of char. During TGA under an inert atmosphere, graphene metamaterial coatings shift the pyrolysis mechanism from volatile products to char. Under air, the graphene metamaterial-coated cotton increases the burn-off temperature by ~70-110 °C. Graphene metamaterials-coated fabric retains its skeleton as char architecture, whereas the uncoated cotton collapses into ash. Due to the brick-wall effect associated with the coating, the dominant mechanism is the formation of a condensed-phase barrier, which slows combustion and chars the substrate rather than self-extinguishing. Graphene metamaterial can intrinsically sense temperature because its electrical resistance decreases with increasing temperature via thermally activated hopping. When the rGO metamaterial-coated fabric is wired to a comparator threshold, the fabric acts as a low-power passive alarm that triggers in ~1s. The fabric can withstand an alarming response during and after the fire propagation, while the alarm response is repeatable during the pre-combustion stage. The investigation provides evidence of the integration of flame retardancy with a fast passive fire alarm within a single graphene-based metamaterial architecture.



Ransini Dahanayake is a PhD student at RMIT University, working under the supervision of Distinguished Professor Baohua Jia. She is a researcher in materials science with a focus on functional textiles, wearable electronics and energy systems. Her current research explores integrated smart textile-based systems for wearable applications.

Poster Abstract

Design of radiative cooling covers for automobiles with maximized cooling power

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Abstract: Due to the capability of cooling objects without energy consumption by emitting thermal radiation into outer space, radiative cooling technologies have found broad applications in different scenarios. Despite the high demand for cooling automobiles under sunlight, there is no specialized design of a radiative cooling cover for automobiles. This paper demonstrates the first specialized radiative cooling cover for automobiles. As the overall cooling power is linearly proportional to the surface area, we designed a conch-shaped foldable radiative cooling film car cover to maximize the surface area within a limited space, resulting in a total cooling power of 5,726.8 W. As a result, the maximum temperature drop can reach 27 °C under strong solar irradiance (800 Wm-2). In addition, we further demonstrate the effects of the surface coverage on the cooling performance by measuring the temperature drop at different surface coverages (100%, 90%, 40%, and 10%). It is found that the radiative cooling cover can effectively cool the inner temperature of a car even with a small surface coverage. In addition, it confirms that enlarging surface area is an effective way to improve cooling performance. Our results open new possibilities in designing radiative cooling covers that can achieve large cooling power within a limited footprint. The design principle can be extended and generally applied to other radiative cooling devices for various applications.



Tao Wu is a PhD candidate in Applied Chemistry at RMIT University, Australia. His research focuses on radiative cooling materials, optical and thermal devices, and their practical applications. He has experience in material fabrication, optical characterization, experimental design, data analysis, and system development. He has published several peer-reviewed journal papers and holds multiple granted patents related to passive cooling technologies. He has also led or participated in national and provincial research projects. In addition, he has experience mentoring undergraduate research teams, supporting laboratory management, and developing practical solutions for energy saving, thermal management, and sustainable technology

Poster Abstract

Transparent Radiative Coolers: Material Strategies, Optical Design, Emerging Applications and Beyond

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Abstract: Transparent radiative cooling offers a passive route to thermal management by transmitting visible light while emitting heat through the mid-infrared atmospheric window. This review establishes a unified framework for the materials, optical design principles, and emerging applications of transparent radiative coolers (TRCs). Current approaches are classified into intrinsic, nanoparticle-enhanced, and micro-/nano-structured TRCs. Across these categories, we examine how molecular vibrations, particle scattering, and photonic structures regulate visible transmittance, haze, ultraviolet/near-infrared response, and 8-13 micrometre emissivity. We further discuss their potential to reduce building cooling loads, improve photovoltaic efficiency, mitigate overheating in electronics, and regulate greenhouse environments. The analysis highlights persistent trade-offs between transparency and thermal emission, together with challenges in durability, scalable fabrication, standardized performance evaluation, and system-level thermal coupling. Promising directions include morphology-engineered nanomaterials, hierarchical and multifunctional hybrid structures, bio-derived materials, adaptive spectral control, and machine-learning-assisted inverse design. By connecting fundamental mechanisms with material selection, manufacturability, and application requirements, this review provides practical guidance for developing next-generation TRCs that combine optical clarity, passive cooling, and energy sustainability.

Huize He received her Master's degree from Ocean University of China in 2024 and is currently a Ph.D. student in Applied Chemistry at RMIT University. Her research focuses on colored and transparent radiative cooling, luminescent materials, and nanocomposite materials.

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Angle-resolved photodetection via metallic nanogap plasmons

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Abstract: Angle-resolved photodetection is essential for applications such as surface plasmon resonance (SPR) biosensing, nanophotonic characterization, and beam steering. Traditional angle-resolved methods rely on bulky rotating platforms or complex imaging spectrometers, which are difficult to achieve portability or integration into on-chip platforms. Here, we propose a miniaturized and integrated angle-resolved strategy to control the light field distribution through the strong coupling effect between metal nanogap surface plasmon resonances (SPPs), thereby achieving sensitive response to the incident angle. The near-field coupling effect of the metal nanogap SPPs mode is analysed. The influence of the nanogap spacing width and number of nanogaps on the near-field fringe distribution is studied. The simulation results show that with the change of the incident angle, the near-field fringe distribution and the electric field intensity change significantly, and the incident angle can be precisely controlled in the range of -30° to +30°. Furthermore, by combining the mapping relationship between the incident angle and the electric field distribution, a neural network algorithm is used to achieve accurate reconstruction of different incident light angles. This study provides a new method for realizing miniaturized and integrated angle-resolved photodetection devices.



Feiying Sun received her Ph.D. from the University of Chinese Academy of Sciences in 2019. She worked as a postdoctoral fellow at Shenzhen University from 2019 to 2022. In December 2022, she joined the Chongqing Institute of Green and Intelligent Technology, Chinese Academy of Sciences as an associate researcher. Her research interests are nanoscale light field control methods and efficient photoelectric conversion devices. In 2024, she was selected as a key young talent by the Chinese Academy of Sciences and recognized as a New Chongqing Youth Innovation Talent.

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Self-Aligned Lithography for Large-Area Asymmetric Subwavelength Metal Nanoslits

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Abstract: Subwavelength asymmetric nanoslits, with strong electromagnetic field localization and composed of metals with different work functions, are the core components of surface-enhanced spectroscopy and high-performance nano-optoelectronic devices. Existing preparation schemes are mainly based on electron beam lithography technology. Although this technology can achieve nanoscale exposure accuracy, it is limited by low production capacity and insufficient substrate compatibility, which makes it difficult to expand to large-scale preparation. This paper proposes a self-aligned lithography strategy suitable for large-area asymmetric nanoslit preparation. This method achieves bimetallic self-alignment through coordinated etching and stripping processes. The control of nanoslit width can be achieved by regulating the development time of the double-layer photoresist, the type of etching process and the etching time. Based on this process strategy, asymmetric nanoslits with a slit width of <100 nm was prepared using ultraviolet exposure equipment, and large-area controllable preparation of gratings, rings, squares and composite structures containing Au-Pd nanoslits was achieved. Furthermore, the experimental results show that the nanoslit structure has a significant enhancement effect on the Raman signal of two-dimensional materials. This provides a key technical solution for the development of new high-performance optoelectronic devices.



Changbin Nie received his master's degree from Changchun University of Science and Technology in 2017 and joined the Chongqing Institute of Green and Intelligent Technology of the Chinese Academy of Sciences as an assistant researcher. His research interests include low-dimensional materials, micro-nano devices and new photodetectors. In recent years, he has made breakthroughs in key processes such as clean transfer of graphene under complex interfaces and high-mobility graphene patterning, developed heterogeneous integration technology of photosensitive materials, and realized the processing and preparation of low-dimensional material infrared detection chips with array scales of 384×288 and 640×512.

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Poster Abstract

Structural and Compositional Engineering of Lead-Free Double Perovskites toward UV–Vis–NIR Broadband Photodetectors

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Abstract: Broadband photodetectors (PDs) with ultraviolet–visible–near-infrared (UV Vis–NIR) response are essential for applications such as communications, imaging, and biosensing, as they enable simplified and cost-effective multispectral systems. Lead-free halide double perovskites are attractive candidates due to their non-toxicity and stability; however, conventional films suffer from high dark current, low photocurrent, and limited spectral range.[1,2] Here, we report a self-powered broadband PD based on Sn2+-doped Cs2AgBiBr6 (CABB-Sn) integrated with the conjugated polymer diketopyrrolopyrrole terthiophene (PDPP3T) to form an efficient heterojunction. Sn2+ doping narrows the bandgap of CABB and optimizes the energy-level alignment with PDPP3T, while also inducing a porous morphology that enhances carrier extraction and transport. The device exhibits a response from 350 to 950 nm with an average detectivity exceeding 1.0 × 1011 Jones (1.09 × 1012 Jones at 808 nm). Additionally, an optical information transfer and encryption system was demonstrated.[3] To further address the limitations of disordered porous films, a polystyrene sphere soft template was employed to construct an ordered inverse opal (IO) CABB-Sn structure. This approach improved film quality, suppressed non-radiative recombination, and enhanced light trapping via the photonic crystal framework. Combined with polymer coupling, these improvements led to a 7.75-fold increase in photocurrent and a nearly 2-fold reduction in dark current. As a result, the CABB-Sn IO/PDPP3T heterojunction achieved broadband detection from 265 to 1000 nm under zero bias, with a record detectivity of 1.40 × 1013 Jones at 808 nm. The device also demonstrates long-term stability, flexibility, and accurate pulse monitoring, highlighting its strong potential for wearable biosensing. This work demonstrates structural and compositional engineering as an effective strategy for realizing next-generation high-performance broadband lead-free perovskite photodetectors.

Keywords: perovskite inverse opal, heterojunction, structural design, self-powered optoelectronic devices, broadband photodetectors

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Poster Abstract

AI-assisted Photonic Structure Design and Fabrication for Photothermal Management

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Abstract: Photothermal management has emerged as a critical research area for enhancing energy efficiency and sustainability across a wide range of applications, from solar energy harvesting to passive cooling. Conventional approaches to designing photonic structures for solar absorption and radiative cooling often rely on iterative trial-and-error methods, which are limited in efficiency and scalability. Recent advances in artificial intelligence (AI) and machine learning (ML) provide powerful tools to accelerate the inverse design, optimization, and fabrication of complex photonic structures with tailored spectral properties. This research seeks to develop an AI-assisted framework for the design and fabrication of photonic structures tailored for advanced photothermal management. By integrating ML algorithms with physics-based modeling, we present a method for the efficient inverse design of nanophotonic structures with optimized spectral selectivity. Furthermore, we propose fabrication strategies that bridge computational design and experimental realization, ensuring practical applicability and scalability. Ultimately, we aim for this work to accelerate the development of next-generation photonic technologies for energy-efficient and sustainable thermal management systems.

Hongyang Chen is a PhD student in Applied Chemistry at RMIT, specializing in AI-assisted photonic structure design and fabrication for photothermal management. He obtained his Master's degree in Software Engineering from Wuhan University, 2017. His current research emphasizes solar absorbers and radiative cooling, aiming to integrate machine learning with nanophotonic design and practical fabrication strategies. His broader interests include nanophotonics, energy harvesting, and advanced thermal management technologies.

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Poster Abstract

Laser-nanoprinted broadband flat optics in liquid-metal-derived 2D tin oxide

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Abstract: Two-dimensional (2D) metal oxides grown at liquid-metal (LM) interfaces offer a scalable route to ultrathin, transparent, and chemically tunable materials for next-generation optoelectronics. Yet their translation into functional flat optics remains constrained by a central challenge: a continuous few-nanometer film cannot shape light unless its optical phase and amplitude are spatially programmed. Conventional routes rely on multi-step nanolithography to define subwavelength structures, but these processes are costly, slow, and often incompatible with fragile LM-derived oxides. Here, we demonstrate a scalable, lithography-free strategy, converting LM-printed 2D SnOx directly into broadband flat micro-optics using femtosecond (fs) laser nanoprinting. Localized laser irradiation interacts uniquely with the naturally stratified printed SnOx, inducing nanoscale thinning, progressive oxidation, and the generation of densely distributed SnOx nanoparticles. Operating in the Rayleigh-scattering regime, these subwavelength scatterers produce an amplitude-dominated modulation of the local complex transmission, accompanied by a smaller phase variation, which is exploited to build binary diffractive elements. By spatially encoding these laser-induced structures, we fabricate planar diffractive SnOx micro-lenses with broadband focusing and subwavelength-resolution imaging across visible spectrum, capable of programmable 1D and 2D diffraction gratings. Our results establish LM-derived oxides as scalable platform for integrating ultrathin, customizable and broadband flat optics without conventional nanolithography.

Xiangyang Guo is a Postdoctoral Research Fellow at RMIT University, Melbourne, Australia. He received his PhD in Electronic and Telecommunications Engineering from RMIT University in 2024. His research focuses on advanced functional materials, two-dimensional materials, laser micro/nanofabrication, and optoelectronic devices.

His research interests include the synthesis and characterisation of liquid-metal-derived two-dimensional materials, laser–matter interactions, piezoelectric materials, flexible sensors, and nanophotonic devices. He has expertise in femtosecond laser processing, thin-film fabrication, micro/nanofabrication, and advanced materials characterisation. His work aims to develop innovative material-processing strategies and integrate functional materials into next-generation sensing and photonic technologies.

Poster Abstract

Probe-Illumination History Reshapes Recombination Dynamics and Nonradiative Losses in 3D Halide Perovskites

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Abstract: Photoluminescence (PL)-based measurements are routinely used to assess nonradiative recombination in halide perovskites. However, the probe light can modify the emissive state of the material during measurement. Here, we track PL, time-resolved PL (TRPL), and absolute PL quantum yield (PLQY) under continuous illumination in $FAPbI_3$ and $(FA_{0.85}MA_{0.15})Pb(I_{0.85}Br_{0.15})_3$ films. Both materials become brighter and exhibit slower PL decay, with PL intensity increasing by up to 5.02-fold. Within 200 s, the PLQY increases from 1.05% to 1.85% in the mixed-halide film and from 1.27% to 1.48% in $FAPbI_3$. This evolution reverses their initial performance ranking and corresponds to quasi-Fermi-level-splitting gains of approximately 14.6 and 4.0 meV, respectively. Dark-recovery and excitation-power- and temperature-dependent measurements reveal persistent optical memory. The response is detectable at 80 K but becomes considerably stronger at 300 K, consistent with a rapid electronic trapping response followed by slower, thermally activated defect–ionic–lattice reconfiguration. Local halide redistribution may also contribute in the mixed-halide film. These findings show that PL-derived metrics depend strongly on illumination history. Reliable comparisons therefore require careful control and reporting of probe flux, acquisition time, cumulative dose, measurement sequence, and recovery conditions.



Guijun Zhang is a PhD candidate at RMIT University under the supervision of Dr Xiaoming Wen. His research focuses on perovskite materials and solar cells, with particular emphasis on excited-state photophysics and ultraslow carrier dynamics.

Poster Abstract

Dynamic regulation of lattice-energy evolution by PbS quantum dots enables reduced operating temperature and enhanced stability in perovskite solar cells

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Abstract: Perovskite solar cells are highly susceptible to light- and heat-induced structural and electronic evolution during operation, which can accelerate nonradiative recombination and compromise photovoltaic performance and operational stability. However, conventional additive strategies primarily focus on static defect passivation, while the dynamic evolution of the perovskite lattice and carrier-recombination landscape under operating conditions remains poorly understood. Here, we introduce PbS quantum dots into the perovskite absorber to dynamically regulate lattice-energy evolution rather than merely passivate defects. Under continuous illumination, PbS incorporation slows the evolution of the perovskite, as evidenced by enhanced photoluminescence, prolonged carrier lifetime, and emission-peak evolution. Electrical measurements further reveal a more pronounced increase in recombination resistance under blue-light bias, together with enhanced EQE and a greater improvement in PCE during continuous illumination.These results demonstrate that PbS modifies the evolution rate of the lattice and the associated carrier-recombination environment, consistent with the LER framework, thereby promoting carrier transport and collection. This work establishes dynamic lattice-energy regulation as an alternative to conventional defect passivation and provides a new strategy for maintaining favorable carrier dynamics and stable photovoltaic performance under realistic operating conditions.

Binghao Du received his Bachelor of Engineering degree from Southwest Forestry University in 2024. He is currently a Master's candidate in Materials Engineering at Yunnan University, and his research focuses on the optoelectronic performance and dynamic photophysics of perovskite solar cells.

Poster Abstract

Inkjet-Printed Graphene Electrodes for Flexible Surface Electromyography Monitoring

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Abstract: Surface electromyography (sEMG) is widely used to monitor muscle activity in rehabilitation, sports science and human–machine interfaces. However, conventional gel-based Ag/AgCl electrodes can cause skin irritation, signal degradation and discomfort during prolonged use. This study investigates inkjet-printed graphene as a flexible, lightweight and potentially customisable electrode material for wearable sEMG monitoring.

Water-based graphene ink was deposited onto flexible substrates using drop-on-demand inkjet printing. Printing parameters, including droplet formation, substrate temperature, printing layers and thermal treatment, were investigated to improve pattern continuity and electrical conductivity. Preliminary electrical characterisation showed that increasing the number of printed graphene layers reduced the sheet resistance, with ten-layer patterns exhibiting approximately 60–70 Ω/sq. The printed patterns remained flexible and could be fabricated in customised electrode geometries without masks or complex processing.

The next stage will evaluate the skin–electrode contact impedance and sEMG signal quality of the printed graphene electrodes. Their performance will be compared with commercial Ag/AgCl electrodes using signal-to-noise ratio, root mean square amplitude and frequency-domain features during controlled muscle contractions. This work provides a fabrication strategy for developing conformable, gel-free and personalised bioelectronic electrodes, with potential applications in long-term physiological monitoring and wearable human–machine interfaces.

Keywords: inkjet printing; graphene electrode; surface electromyography; flexible electronics; wearable biosensor

Poster Abstract

ZnS-Mediated Multi-cation Exchange toward Compositionally Complex Metal Sulphide Nanomaterials

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Abstract: Simultaneous multi-cation exchange offers a promising route to compositionally complex metal sulphide nanomaterials, but incorporation of multiple chemically dissimilar cations into a common host lattice remains challenging because of differences in ionic characteristics, precursor reactivity, and structural compatibility. High-entropy sulphide synthesis has previously been demonstrated using $Cu_{1.8}S$ nanocrystals as a parent host [1], motivating exploration of alternative sulphide frameworks capable of accommodating diverse metal species. Here, ZnS nanoparticles were investigated as a host for multi-cation exchange with V, Mo, Mn, Nb, and Ta precursors in an oleylamine (OLA)-mediated reaction environment. OLA provides a coordinating reaction medium and surface-stabilising environment during ZnS synthesis and subsequent multi-cation exchange [2]. Targeted variations in precursor composition were further employed to probe competitive interactions governing multi-cation incorporation. Energy-dispersive X-ray spectroscopy (EDS) confirmed incorporation of multiple target metals and revealed strongly element-dependent incorporation behaviour. X-ray diffraction (XRD) demonstrated systematic structural changes following multi-cation exchange, consistent with perturbation of the parent ZnS lattice upon introduction of chemically dissimilar cations. Fourier-transform infrared spectroscopy (FTIR) was employed to examine surface chemical features associated with the OLA-containing nanomaterial system. These results highlight the capacity of ZnS to accommodate chemically diverse cations through multi-cation exchange and demonstrate the interplay between elemental incorporation and structural response in compositionally complex sulphide nanomaterials.

Maryam Jamshidi graduated as the top-ranked student in Chemical Engineering, majoring in Process Design. During my master's research, I designed and developed a nanoparticle tracking device and an associated analysis program for determining the particle-size distribution of transparent and opaque nanoparticles, achieving approximately 20 nm resolution. This work received a Creativity Award at the 24th National Exhibition of Research, Technology and Tech Market Achievements. I am currently a PhD candidate at UNSW, where my research focuses on the synthesis and development of advanced nanomaterials for catalytic applications.

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Suppression of the Field Crowding Effect Using White Graphene, High-k and Low-k Dielectric Stack in p-Type h-BN Schottky Barrier Diode

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Abstract: In this work, a systematic study is conducted to mitigate the field crowding effect in hexagonal-Boron Nitride based power diode. The ultrawide-bandgap semiconductors, such as BN and AlN, have significant attention in power electronics applications due to their unique properties such as higher critical electric field, ultra-wide bandgap energy and good thermal conductivity [1], [2]. BN crystallises primarily in a hexagonal form at room temperature. It also exists in metastable wurtzite and cubic phases, the latter offering near diamond thermal conductivity [3]. The breakdown voltage
of the p-type h-BN Schottky Barrier Diode (SBD) is improved by incorporating a dielectric stack with high-k, low-k and 2D h-BN as the field plate dielectric. The electrical characteristics of the device were studied via 2D simulations performed in Silvaco TCAD. The unterminated device exhibited a breakdown voltage of 578 V, whereas the device with the field plate edge termination technique using a stacked dielectric structure composed of $SrTiO3$, $SiO2$ and 2D h-BN showed a 700 V breakdown voltage. Further, the impact of the thickness of low-k and high-k dielectrics on the breakdown voltage is studied. The results show that for a low-k dielectric, such as $SiO2$, the breakdown voltage dropped significantly beyond the 75 nm thickness, whereas a high-k dielectric, such as $HfO2$, has shown a monotonic increase in breakdown voltage for the range 25–100 nm. The stack dielectric of $SrTiO3$, $SiO2$ and multi-layer white graphene with thicknesses of 50, 25 and 5 nm, respectively, has shown higher rectification [4].

Shaik Yezazul Nishath is pursuing a joint PhD in Electrical & Electronics Engineering at the RMIT University (Australia) and AcSIR (India). She received her master's degree (M.Tech) in VLSI Design and worked as a Member of Technical staff. Her research interests include design and fabrication of Wide Band Gap (WBG) and Ultra-Wide Band Gap (UWBG) based devices for next-generation power, RF, sensing, and energy-efficient applications.

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Poster Abstract

High-Performance Antibacterial and Antifungal Starch-Based Adhesives Enabled by Citric Acid-Mediated Physicochemical Crosslinking

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Abstract: Starch-based adhesives are promising sustainable alternatives to petroleum-derived adhesives, but their practical application is limited by poor water resistance, thermal stability, and susceptibility to microbial degradation. Here, a physicochemical dual-crosslinking strategy was developed for starch-based wood adhesives. Citric acid was used as an environmentally friendly esterifying and crosslinking agent, while sodium trimetaphosphate further reinforced the crosslinked network. The resulting adhesives were evaluated for chemical structure, interfacial morphology, bonding performance, water resistance, thermal stability, and antimicrobial activity. XPS and FTIR confirmed the formation of ester linkages after citric acid modification, while SEM revealed effective adhesive penetration into the wood structure. Among the formulations investigated, SEA-15 showed the best overall performance, achieving a wet shear strength of 1.21 MPa, representing a 98.36% improvement over the unmodified starch adhesive. SEA-15 also improved water resistance and heat resistance by 47.6% and 31%, respectively. In addition, the citric acid-containing adhesives inhibited Escherichia coli and Staphylococcus aureus and showed enhanced resistance to white- and brown-rot fungi. These results demonstrate that citric acid-mediated physicochemical crosslinking provides a simple approach for developing multifunctional, formaldehyde-free starch-based adhesives for wood bonding applications.



Mengyao Liu is a PhD researcher working in materials science and engineering, with research interests in sustainable bio-based materials and functional polymeric systems.

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Poster Abstract

Photoreduction-Controlled Ion–Electron Transport in Janus GO/rGO-Coated Cotton Fabrics for Hydrovoltaic Energy Harvesting

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Abstract: Hydrovoltaic electricity generation relies on the coupled transport of water, ions, and electronic charge at solid–liquid interfaces. In this work, Janus graphene oxide/reduced graphene oxide (GO/rGO)-coated cotton fabrics are prepared by selective one-sided UV photoreduction to investigate how the reduction state governs hydrovoltaic performance. The hierarchical fibre–yarn structure of cotton provides continuous capillary water transport, while asymmetric photoreduction introduces a through-thickness difference in oxygen-containing functional groups, wettability, and electrical conductivity. A series of samples with different photoreduction degrees are characterised by Raman spectroscopy, Fourier-transform infrared spectroscopy, X-ray photoelectron spectroscopy, contact-angle and capillary-transport measurements, and electrical resistance tests, together with hydrovoltaic voltage and current measurements. The GO-rich region retains hydrophilic oxygen functionalities that favour water uptake and ionic transport, whereas photoreduction progressively restores sp^2-conjugated carbon domains and improves electronic conduction. These competing effects are examined to determine how the balance between interfacial ion transport and electronic conductivity influences charge separation and electrical output. This work aims to establish a reduction-dependent structure–property–performance relationship in GO/rGO textile hydrovoltaic systems and to clarify how controlled photoreduction can be used to tune transport asymmetry in flexible fabric-based energy harvesters.



Suyi Zhao's research at RMIT University focuses on Janus graphene oxide/reduced graphene oxide-coated cotton fabrics for hydrovoltaic energy harvesting. The work examines how controlled UV photoreduction modifies surface chemistry, wettability, and electrical conductivity, and how these changes influence water and charge transport in textile-based devices.

Poster Abstract

Construction of Carbon-Assisted Graphitic Carbon Nitride and Cobalt Oxide Composites via a Hydrothermal–Carbonization Synergistic Strategy for High-Performance Supercapacitors

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Abstract: Developing heterostructured electrode materials with efficient charge transport and robust interfacial architectures is essential for high-performance supercapacitors. Herein, a synergistic hydrothermal–carbonization strategy was developed to construct a carbon-assisted graphitic carbon nitride/cobalt oxide (g-C_3N_4/Co_3O_4/C) composite. In this architecture, Co_3O_4 nanoparticles are uniformly anchored on layered g-C_3N_4 and interconnected through a cotton-derived conductive carbon framework. The resulting tightly integrated heterostructure provides abundant electrochemically active sites, improves interfacial contact, and facilitates efficient charge transport. Consequently, the optimized composite delivers a specific capacitance of 346.22 F g^{-1} at 1 A g^{-1}, together with 84.91% capacitance retention when the current density increases from 1 to 2 A g^{-1}. Importantly, the electrode maintains 87.95% of its capacitance after 10,000 cycles at 15 A g^{-1}, demonstrating excellent long-term cycling stability. These results demonstrate that integrating metal oxide nanoparticles with graphitic carbon nitride and a biomass-derived conductive carbon framework provides an effective and scalable strategy for constructing high-performance supercapacitor electrodes.



Jia Li is a PhD candidate at UNSW Sydney. His research focuses on the design and development of functional nanomaterials for energy storage and high-performance gas sensing. His research interests include metal oxide/carbon nanocomposites, interfacial engineering, supercapacitors, and nanomaterial-based gas sensors.

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Poster Abstract

Nickel–Molybdenum-Based Selenide Catalysts for Hydrogen Production via Urea/Seawater Electrolysis

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Abstract: Water electrolysis is considered the most promising way to produce hydrogen. However, in addition to the problems of expensive precious metal catalysts and poor catalyst stability, the strain on freshwater resources further limits its development. Therefore, it is particularly important to develop non-precious metal based catalysts with high catalytic activity, long-term stability and broad application scenarios (e.g. urea, seawater). We prepared NiSe2/MoSe2 Mott-Schottky heterojunction catalysts for urea electrolysis by interfacial engineering. The directional electron transfer from the Mott-Schottky junction can modulate the electronic structure, optimize the d-band centers and promote surface reconstruction. In addition, Fe-NiMoSe@C was prepared by ion exchange method and subsequent selenization process with simultaneous morphology modulation, Fe doping, and carbon composite. The Fe doping optimizes the electronic environment and accelerates the reaction kinetics, while the carbon layer is resistant to seawater corrosion. Our work provides new insights and approaches to alleviate pressure on freshwater resources and facilitate the realization of electrolytic urea/seawater.



Xiaocheng Xu is a PhD candidate in the School of Science at RMIT University. His research focuses on electrocatalysis, water electrolysis for hydrogen production, and integrated CO_2 capture and conversion. He is particularly interested in the development of non-noble metal selenide catalysts for efficient water splitting, as well as the direct electrolysis of amine-captured CO_2. His work emphasizes mechanistic understanding and electrolyte regulation to optimize catalytic performance. He has published four first-author papers in Q1 SCI journals, including one highly cited paper, highlighting the impact and relevance of his research

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Xiaocheng Xu, ShuZhuang Zhang, Qihang Zhang, Sijie Chen, Yanxue Wu, and Zhipeng Sun. ACS Sustainable Chem. Eng. 2023, 11, 15338

Poster Abstract

Enhancing Oxygen Evolution Electrocatalysis in Heazlewoodite: Unveiling the Critical Role of Entropy Levels and Surface Reconstruction

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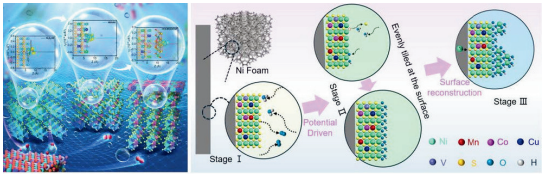
Abstract: Entropy engineering has proven effective in enhancing catalyst electrochemical properties, particularly for the oxygen evolution reaction (OER). Challenges persist, however, in modulating entropy and understanding the dynamic reconfiguration of high-entropy sulfides during OER. In this study, an innovative in situ corrosion method is introduced to convert low-valent nickel on a nickel foam substrate into high-entropy heazlewoodite (HES/NF), significantly boosting OER performance. By synthesizing a series of low-, medium-, and high-entropy heazlewoodites, the intrinsic factors influence catalyst surface evolution and electrocatalytic activity is systematically explored. Employing a combination of in situ and ex situ characterization techniques, it is observed that HES/NF dynamically transforms into a stable hydroxide oxide (MOOH)-sulfide composite under OER conditions. This transition, coupled with lattice distortion, optimizes the electrostatic potential distribution, ensuring superior catalytic activity and preventing surface sulfide deactivation through the formation of stable HES-MOOH species. This synergy enables HES/NF to achieve remarkably low overpotentials: 192.0 mV at 100.0 mA cm−2 and 229.0 mV at an extreme current density of 300.0 mA cm−2. When paired with a Pt/C cathode,HES/NF exhibits rapid kinetics, outstanding stability, and exceptional water-splitting performance. The scalable, cost-effective approach paves the way for advanced electrocatalyst design, promising breakthroughs in energy storage and conversion technologies.



Hangning Liu is currently a HDR student at RMIT University, Australia. His research focuses on electrocatalysis, CO_2 capture and conversion, and interfacial microenvironment engineering for selective multicarbon product synthesis. He has published multiple journal articles in Advanced Materials, eScience, Advanced Functional Materials and other leading journals.

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Poster Abstract

Engineering Active Sites and Heterointerfaces on MXene for Efficient Electrocatalytic Water Splitting

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Abstract: Electrocatalytic water splitting offers a promising pathway for sustainable hydrogen production, yet its efficiency is limited by sluggish reaction kinetics and inefficient utilization of active species. Here, we demonstrate MXene as a versatile platform for engineering catalytic structures from atomically dispersed active sites to heterointerfaces for efficient water splitting. High-density Pt and Ni dual single atoms are stabilized on Ti3C2Tx MXene through a fluorine-free molten-salt-assisted strategy. The proximity of Pt and Ni enables cooperative catalysis, where Ni facilitates water activation while Pt provides favourable hydrogen adsorption and evolution kinetics. The resulting PtSAsNiSAs/MXene exhibits pH-universal hydrogen evolution activity, requiring overpotentials of only 23 and 59.4 mV to reach 100 mA cm-2 in acidic and alkaline electrolytes, respectively, together with excellent long-term stability. In situ synchrotron FTIR spectroscopy and theoretical calculations further reveal the roles of interfacial water and Pt-Ni cooperation during hydrogen evolution. Extending from atomic-site to interface engineering, a Co-TiS2/Ti3C2Tx heterostructure is constructed to regulate the electronic structure and local coordination environment of catalytic sites through strong interfacial coupling, resulting in enhanced electrocatalytic activity and stability. Together, these studies establish MXene as a versatile platform for multiscale catalytic engineering and provide insights into the rational design of efficient and durable electrocatalysts for sustainable hydrogen production.



Jianan He is a final-year PhD candidate in Chemical Engineering at the University of Melbourne, Australia. Her research focuses on the design and development of advanced electrocatalytic materials for sustainable hydrogen production, with particular interests in MXene-supported single- and dual atom catalysts and heterostructures. Her work integrates materials synthesis, electrochemical evaluation, synchrotron-based characterization, in situ/operando spectroscopy, and theoretical calculations to understand structure-performance relationships in electrocatalysis. She has published research on MXene-based electrocatalysts and is particularly interested in engineering atomic active sites and heterointerfaces for efficient water splitting**.**

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Poster Abstract

Magnetic-Field-Assisted Enhancement of Chiral Selectivity at Elevated Temperatures

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Abstract: Magnetic-field-assisted synthesis has emerged as a promising strategy for regulating reaction pathways [1,2]. However, its application has been largely limited to near-ambient conditions, as maintaining a stable external magnetic field under elevated-temperature reaction environments remains experimentally challenging. Here, we demonstrate a magnetic-material-enabled strategy for introducing magnetic effects into hydrothermal synthesis, enabling magnetic-field-assisted control of chiral selectivity under elevated-temperature conditions.

Chiral molecules have attracted increasing interest in electrocatalysis [3], where their spin-selective interactions can influence interfacial reaction processes. Previous studies have shown that the two enantiomers can exhibit distinct electrocatalytic behaviour [4,5], highlighting the importance of controlling molecular chirality during synthesis. In the absence of a magnetic source, hydrothermal synthesis produces the two enantiomers with comparable yields, indicating limited intrinsic chiral selectivity under these conditions. Remarkably, incorporation of a magnetic component into the reaction environment leads to a pronounced enhancement in the formation of the preferred enantiomer.

These findings demonstrate that magnetic materials can provide a practical route for extending magnetic-field-assisted synthesis to elevated-temperature environments and offer a new approach to manipulating molecular chirality. This strategy may provide opportunities for the spin-engineered synthesis of chiral functional materials for applications in electrocatalysis and beyond.

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Poster Abstract

Low-Temperature Conversion of PTFE into Functional Materials Using Li–Ga Liquid Metal

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Abstract: Polytetrafluoroethylene (PTFE) is a highly persistent fluoropolymer whose exceptional chemical stability and strong C–F bonds make conventional recycling difficult and often energy-intensive. Here, we demonstrate a low-temperature approach for converting PTFE into value-added materials using a gallium–lithium (Ga–Li) liquid-metal alloy as a reactive medium. Lithium dissolved in the gallium matrix diffuses to the alloy–polymer interface, promoting PTFE adsorption and C–F bond cleavage through favourable Li–F interactions. Density functional theory calculations confirm that surface lithium acts as the chemically active site and substantially alters the reaction energy landscape compared with pure gallium. The process operates at 30–65 °C and ambient pressure, producing amorphous carbon and lithium fluoride (LiF) nanocrystals while retaining gallium as a recoverable metallic phase. Nearly complete conversion was achieved after approximately 12 hours at 65 °C, with XPS, SEM/EDX, TEM/EDX, Raman spectroscopy and XRD confirming C–F bond cleavage and product formation. The reaction generates a porous carbon/LiF crust on the conductive gallium surface, enabling direct use as a binder-free nano-interface with excellent pseudocapacitive properties. The resulting supercapacitor electrode achieved a high areal capacitance of 240.58 μF cm^{-2} and excellent cyclic stability. This work demonstrates a promising liquid-metal platform for PTFE upcycling, resource recovery and functional energy-storage applications.



Sina Mehdifar is a PhD researcher at RMIT University, specialising in corrosion protection and electrochemical systems. He holds a Master of Chemical Engineering (with Distinction) from the University of Melbourne, with research experience in electrochemistry, recycling and sustainability, liquid metals, and clean energy technologies. His recent achievements are 2026 Net Zero Tech International Contest Championship, University of Melbourne Endeavour Boeing Award (2025), Endeavour Chemical Engineering Discipline Award (2025) and 1st place in Australia in AspenTech Academic Innovators Challenge (2025).

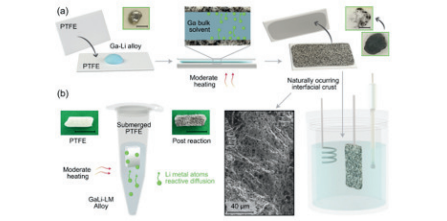

Fig. 1. Overview of PTFE conversion using GaLi-LM and prospective application. a) GaLi-LM is enclosed between two PTFE sheets and products are formed as a black crust on the surface of alloy (used as supercapacitor electrode). Optical photos of GaLi-LM before reaction and after removing top PTFE are shown. SEM image of the surface of the alloy after reaction is presented. b) PTFE is inserted into GaLi-LM inside an Eppendorf tube (used in the kinetics experiment). Optical photos of PTFE before and after submerging into GaLi-LM are presented. The migration paths (indicated by arrows) show the reactive diffusion of Li metal atoms to the surface of PTFE. Optical photos' scale bars are 0.5 cm.

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Electroacoustic Copper Restructuring for Highly Selective CO_2 Reduction to Methane

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Rising atmospheric CO_2 concentrations have intensified interest in converting CO_2 into value-added fuels such as methane (CH_4). Cu catalysts can steer the electrochemical CO_2 reduction reaction (CO_2RR) through facet-dependent pathways, but high CH_4 selectivity requires densely packed Cu (111)/(100) facet intersections and suppression of the competing hydrogen evolution reaction (HER)[1,2]. Such intersections are difficult to obtain with conventional Cu nanocubes, which remain predominantly (100)-terminated[3], and alternative morphologies typically rely on complex, non-scalable syntheses[1,2]. Here, we report that coupling surface reflected bulk waves (SRBWs), generated on a piezoelectric lithium niobate substrate, into an electrochemical cell directs the electro-dissolution and subsequent redeposition of a Cu film. In the absence of capping agents, this yields truncated Cu nanocubes with a mean lateral dimension of approximately 25 nm after 30 min of exposure. Electron backscatter diffraction (EBSD) revealed a higher (111)/(100) facet intersection density relative to the electrochemical control, while spectroscopic analyses showed SRBW-induced formation of Cu^{2+}/Cu^{+} co-existence at the surface. Under a transient potential-cycling protocol, the restructured films achieved a high CH_4 Faradaic efficiency of approximately 70%, with stable operation beyond 34 h. These findings establish acoustic-field-assisted restructuring as a scalable strategy for facet and intersection engineering in selective electrocatalyst design.



Dr. Caiden J. Parker is a upcoming researcher by conducting postdoctoral research in electrochemistry and is currently investigating CO_2 reduction to high valued products. During their PhD they investigated fundamental liquid metal chemistry involving dissolution and crystallisation of solid metals within liquid metal media with in-situ heating via TEM.

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Poster Abstract

Stretchable and Fibrous Strain Sensor with high sensitivity and large range by constructing Mutually Non-Interfering Conductive Networks

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Abstract: Most crack-based sensors face a trade-off between sensitivity and detection range in physiological monitoring, soft robotics, and human-machine interaction, as few devices reconcile ultralow strain resolution with large deformation tolerance.[1] This paper present a simple and efficient method to fiber-shaped wearable strain sensor with dual conductive network. It comprise a hollow polydimethylsiloxane (PDMS) microtube partially filled with eutectic gallium-indium liquid metal and surface-functionalized with carbon nanotubes (CNTs) via hydrolysis condensation. The two conductive networks are spatially decoupled and activated at distinct strain regimes, suppressing mutual interference. At small strains, the percolating surface CNT network dominates transduction, and its progressive microcrack evolution confers a low detection limit and high gauge factor. [2] Upon further stretching, the rigid surface network fractures and switches off, while volumetric compression drives the initially disconnected internal liquid metal to coalesce into a continuous channel, converting the device into a liquid metal conductor with a wide working range and a stable, hysteresis tolerant response. [3] This strain partitioned, self-switching mechanism decouples low limit sensitivity from large range stretchability within a single continuous fiber that is readily woven into textiles and conforms to curved skin. The sensor consequently resolves subtle physiological signals pulse, respiration, and phonation alongside large joint motions across a broad strain window, establishing a scalable route toward.



Min Liu is a first year Ph.D. student at RMIT, Melbourne, Australia. Her research focuses on flexible and wearable strain sensors and her current work explores strain partitioned dual conductive network architectures that reconcile high sensitivity with a wide sensing range.

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Poster Abstract

Titanium Alloys with Nanotopography for Orthopaedic Implant Applications

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Abstract: The surface topography of orthopaedic implants plays a critical role in the early biological response following implantation. Nanoscale surface feature influence protein adsorption, cell adhesion, and osteoblastic differentiation, key processes for successful osseointegration. Titanium and its alloys remain the material of choice for orthopaedic implants owing to their low density, high strength, corrosion/wear resistance, and biocompatibility [1]. Ongoing efforts to improve the long-term biological, chemical, and antibacterial performance of titanium implants have centred on surface modification strategies for generating nanotopography or hierarchical (micro/nano) topographies [2]. This review examines the principal techniques used to engineer such features on Ti and Ti alloys, liquid metal dealloying (LMD), micro-arc oxidation, laser surface modification, acid etching, alkali–heat treatment, anodisation, and electrochemical dealloying, comparing their mechanisms and resulting nanotopographies, alongside their in vitro and in vivo and antibacterial performance. Across these approaches, hierarchical micro/nanostructures consistently outperform single-scale micro- or nanotopographies, an effect generally attributed to their closer replication of the extracellular matrix, which promotes more favourable cell–surface interactions, including greater filopodia extension, and enhanced osteoblastic differentiation [1]. Among the techniques compared, LMD uniquely enables independent control over surface morphology and composition [3]. Building on this, LMD was selected to engineer the present Ti–50Ta system, generating a Ta-rich nanoporous surface via selective dissolution on LPBF-fabricated components with controlled microscale architecture [3]. Preliminary results show ligament sizes of 42.29 ± 9.15 nm and 81.82 ± 19.96 nm, offering a promising route to hierarchical Ti–Ta implants with enhanced mechanical compatibility, osseointegration, and antibacterial resistance.



Lily Margareth Arrieta is a PhD candidate in Mechanical and Manufacturing Engineering at RMIT University. Her research focuses on developing hierarchical (micro/nano) Ti–Ta alloys for orthopaedic implant applications using laser powder bed fusion and liquid metal dealloying. Her research interests include biomaterials, surface engineering, additive manufacturing, and cell–material interactions.

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Poster Abstract

Heavy Ion Irradiation Defect Engineering for Solar-Blind Photodetection and Neuromorphic Synapses in Two-Dimensional Transition Metal Dichalcogenides

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Abstract: This work unifies heavy ion irradiation strategies to simultaneously enable solar-blind ultraviolet photodetection and optoelectronic synaptic functions in two-dimensional transition metal dichalcogenides. In $MoS_2/SnSe_2$ heterostructures, controlled irradiation introduces latent track defects in the channel and trap states at the interface. The engineered defects extend the photoresponse to 200 nm with a responsivity of 19.2 A/W, setting a new benchmark for solar-blind detection in 2D materials. The interfacial trap states realize optoelectronic synaptic operations exhibiting short-term and long-term plasticity at 255 nm and 532 nm, paired-pulse facilitation, and long-term potentiation under repeated light stimuli with clearly enhanced state stability. In WSe_2 memtransistors, swift heavy ion irradiation creates complex defects including the 1T phase and concentric-circle vacancies, which substantially lower the Schottky barrier at the metal/semiconductor interface. This results in low-resistance-state to low-resistance-state switching under illumination and distinct photocurrent responses to different spike trains, successfully emulating enriched neuromorphic behaviors for radiation-tolerant aerospace sensing and computing. These findings demonstrate that heavy ion irradiation is an atomic-scale defect engineering tool capable of reshaping the band structure for solar-blind ultraviolet detection while constructing interfacial charge storage for neuromorphic computation, thereby offering a universal pathway to multifunctional 2D devices that merge conventional optoelectronics with bio-inspired architectures.

Poster Abstract

Designing with Scent: Coffee-Ground Composite Filaments for 3D-Printed Multisensory Wall Skins

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Abstract: This paper proposes an integrated material–design–performance workflow for developing modular 3D-printed wall skins using spent coffee ground (SCG)-based composite filaments. Scent, tactile qualities, acoustic properties, and surface texture are considered as functional attributes for interior applications, such as coffee retail, wellness environments, and exhibitions. The workflow covers material preparation, computational design, and fabrication. Spent coffee grounds are pre-treated and compounded with a biodegradable polymer matrix to produce printable composite filament. Material preparation and characterisation establish a controlled process, supporting empirical evaluation across the prototype set. Computational design is used to parametrically control surface micro-relief, texture, and internal porosity while maintaining printability. A series of 3D-printed specimens is produced to investigate relationships between material characteristics, geometric parameters, and functional performance. Evaluation includes (i) acoustic oriented geometries to explore sound absorption potential, (ii) geometric descriptors correlated with tactile preference, and (iii) semi-quantitative monitoring of scent intensity over time. This research highlights the potential of waste-derived composite filaments for customised and circular additive manufacturing applications.

Keywords: spent coffee grounds, composite filament, additive manufacturing, fused deposition modelling, computational design, advanced manufacturing



Kang Liu is a PhD candidate in Architecture at RMIT University, Australia. His research focuses on computational design and additive manufacturing for lightweight architecture using biowaste-derived materials. His work integrates topology optimisation, TPMS geometries, material informed design, and 3D printing to investigate relationships between geometry, material performance, fabrication, and architectural application.

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Poster Abstract

Synthesis and analysis of Borophene-based single-atom materials

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Abstract: Borophene is an emerging two-dimensional (2D) material that exhibits unique structural and electronic properties, distinct from those of traditional 2D materials. It holds great potential for integration with various metal elements to achieve diverse functionalities and applications. In this study, we propose a facile and scalable strategy for the synthesis of borophene-based single-atom catalysts (SACs) and investigate their atomic and electronic structures using synchrotron-based X-ray absorption spectroscopy (XAS). The valence state of SAC was estimated by XANES, and their coordination structure with 2D borophene were revealed by EXAFS. The results demonstrate that borophene-supported single-atom catalysts can effectively modulate the electronic structure of the metal centers, thereby enhancing their catalytic activity, which is further supported by experimental observations. This study highlights the crucial role of synchrotron spectroscopy in elucidating the atomic and electronic structures, as well as the structure–property relationships, of borophene-based single-atom materials.

Poster Abstract

Enhancing Polarization and Reliability in HZO-Based Ferroelectric Tunnel Junctions via WOx Electrode Thickness Engineering

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Abstract: HfO_2-based ferroelectric devices have gained significant attention due to their excellent scalability and compatibility with CMOS processes, making them promising for future memory and logic technologies. While Atomic Layer Deposition is currently the most widely used method for fabricating these devices, this study explores Radio-Frequency sputtering as an alternative, owing to its low carbon contamination, industrial relevance, and the advantage of room-temperature deposition [1]. TiN is commonly used as an electrode in HfO_2-based devices because it facilitates the stabilization of the orthorhombic phase, which is essential for ferroelectricity [2]. However, part of this stabilization arises from oxygen vacancies induced by TiN's oxygen scavenging behaviour [3]. While beneficial to some extent, excessive oxygen deficiency can introduce point defects and negatively impact device reliability, especially in ferroelectric tunnel junctions (FTJs), where direct tunnelling is the desired conduction mechanism. To mitigate this issue, we investigate the use of WO_x-based electrodes that acts as an oxygen reservoir [4], compensating for the oxygen vacancies. Various device structures were fabricated using a ferroelectric Hf0.5Zr0.5O2(HZO) layer, incorporating different thickness of electrodes, to study its impact on ferroelectric properties, structure, chemistry, and interfacial states of HZO devices. Initial electrical measurements indicated promising ferroelectric behavior and enabled the identification of an optimal WOx electrode thickness. Structural characterization using X-ray diffraction was performed to identify phase composition, while X-ray photoelectron spectroscopy and High-Resolution Transmission Electron Microscopy were used to analyse chemical states and interfacial behaviour. Electrical characterizations were carried out to further evaluate polarization performance and overall device behaviour. The results were compared to reference samples with TiN top electrode. These findings offer valuable insights into optimizing sputtered HZO devices for reliable FTJ applications and present a foundation for developing artificial synapses in neuromorphic computing systems.

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Poster Abstract

Water Inhibition of Nitric Acid Decomposition: Effects of Concentration and Temperature

Deus Albert Msumange,1 Hamidreza Arandiyan,1*
1Centre for Advanced Materials and Industrial Chemistry (CAMIC), School of Science, RMIT University, Melbourne, VIC 3000, Australia Email: hamid.arandiyan@rmit.edu.au ABSTRACT

Abstract: Nitric acid (HNO3)-based leaching is being considered as an alternative to high-pressure acid leaching (HPAL) for recovering critical metals such as nickel and cobalt from laterite ores. However, the thermal decomposition of HNO3 at elevated temperatures can lead to acid loss and NOx generation, which may create challenges for acid recycling. Water plays an important role in nitric acid stability, but its inhibiting effect under pressurised conditions is not fully understood. This study investigates the effect of nitric acid concentration and temperature on decomposition behaviour in aqueous solutions, with a focus on identifying conditions where water inhibition becomes weaker. Experiments were carried out in a sealed 1.2 L Parr autoclave using HNO3 concentrations of 10, 20, 30, and 40 wt.% at temperatures of 190, 205, and 225 °C. Pressure and temperature were continuously recorded and compared with vapour-liquid equilibrium (VLE) predictions. Residual nitric acid was measured using acid-base titration, while Raman spectroscopy and FTIR were used to examine chemical changes. At 225 °C, the 10 and 20 wt.% solutions remained mainly VLE-dominated, while the 30 and 40 wt.% solutions showed progressive excess pressure attributable to decomposition, stabilising at approximately 4 and 5 bar, respectively. The decomposition rate increased with HNO3 concentration, reaching 3.00 x10-4 mol L-1 s-1 at 40 wt.%, while the apparent activation energy decreased from 202.06 to 174.70 kJ mol-1. These results improve understanding of nitric acid decomposition behaviour and provide useful information for assessing acid loss and recycling challenges in critical mineral processing.



Deus Albert Msumange is a PhD candidate in Applied Chemistry at RMIT University, Australia, focusing on industry collaborative solutions for critical mineral extraction. Before joining RMIT, he worked in both academia and the mining industry, including roles as an Assistant Lecturer in Mineral Processing and Hydrometallurgy at Mbeya University of Science and Technology (MUST) and as an Underground Mining Engineer at Avesoro Resources, Liberia. He holds an MSc in Mining Engineering (Mineral Processing) from Karadeniz Technical University, Türkiye, and a BSc in Geology from Badji Mokhtar Annaba University, Algeria. Deus is interested in sustainable mineral processing, hydrometallurgy, green & industrial chemistry.

Microwave-Enabled Deep Eutectic Solvent Leaching for Rapid Recovery of Critical Metals from Spent Lithium-Ion Batteries

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Abstract: The rapid growth of lithium-ion batteries (LIBs) is intensifying the demand for sustainable recovery of critical metals from end-of-life batteries. Conventional hydrometallurgical recycling commonly relies on strong mineral acids and energy-intensive processing, which motivates the development of alternative leaching technologies that combine effective metal recovery with improved process sustainability. This study investigates a microwave-assisted deep eutectic solvent (DES) approach for the rapid recovery of lithium and transition metals from industrial LIB black mass. Choline chloride was combined with different hydrogen-bond donors to tailor the acidity, coordination environment and physicochemical properties of the DES. Choline chloride-lactic acid exhibited the most effective leaching performance and was subsequently evaluated under microwave irradiation. More than 99% of Co and Mn and over 92% of Li and Ni were extracted within 30 min at 200 °C. Microwave irradiation promoted rapid volumetric heating and improved solvent-solid contact, that overcame mass transfer limitations associated with the relatively high viscosity of DESs. Spectroscopic investigations indicated that metal dissolution involves proton-assisted disruption of metal-oxygen bonds, followed by stabilization of dissolved species through chloride and lactate coordination. The DES could also be regenerated and reused while maintaining high metal extraction performance, demonstrating the potential for solvent circularity. Selective precipitation further enabled recovery of dissolved metals from the leachate. These results demonstrate that combining microwave process intensification with tunable DES chemistry can provide a rapid and recyclable pathway for LIB recycling. This work offers a promising platform for more sustainable recovery of critical metals from battery waste.



Thilini Gunawardhana is a PhD student in the Department of Chemical Engineering at the University of Melbourne, supervised by Dr. Helena Yuan Wang in the Renewable Resources & Sustainability (R2S) group. She earned her BSc (2020) and MSc (2022) degrees from the University of Peradeniya, Sri Lanka, and completed a second MSc at Southeastern Louisiana University, USA, in 2025. Her current research focuses on microwave-assisted deep eutectic solvent-based recycling of spent lithium-ion batteries, with an emphasis on sustainable critical metal recovery and green solvo-metallurgical processes.

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Poster Abstract

Advanced Membranes for Selective Ammonium Recovery from Wastewater

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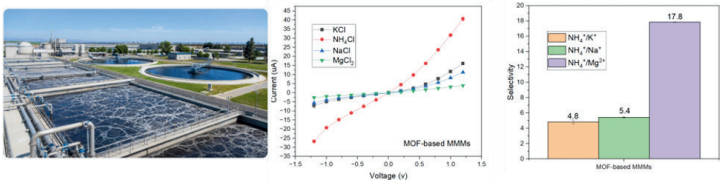
Abstract: Ammonia/ammonium NH_4^+ recovery from wastewater is crucial for sustainable nitrogen management and environmental protection. However, selective separation of NH_4^+ from competing ions remains a major challenge for membrane-based technologies due to the similar physicochemical properties of NH_4^+ and K^+, as well as the typically high concentrations of Na^+ in real wastewaters.

Herein, we developed a functionalized Metal-Organic Framework (MOF) based mixed matrix membranes (MMMs) platform for electrically driven, selective ammonium transport and recovery. By integrating tailored functional materials into a polymer membrane matrix, the properties and ion transport behavior were effectively regulated. Electrochemical investigations revealed a favorable ion selectivity sequence of $NH_4^+ > K^+ > Na^+ > Mg^{2+}$, demonstrating the potential of the developed membrane platform for selective ion separation. The synthesized MOF nanoparticles and fabricated MMMs were systematically characterized using XRD, FTIR, and SEM. Results showed that the structural and chemical functionalization with carboxylic groups significantly enhanced membrane hydrophilicity. The optimized membrane achieved NH_4^+/Mg^{2+}, NH_4^+/K^+, and NH_4^+/Na^+ selectivity of 17.8, 4.8, and 5.4, respectively. This work highlights the great potential of dicarboxylic MOF-based membranes for precise monovalent and ammonium ion separation from complex wastewater streams.





Yunzhao Fan is currently a PhD candidate in the School of Science at RMIT University, Australia. His research focuses on membrane science and environmental engineering, particularly the development of advanced membrane materials for selective ammonium recovery from wastewater. Prior to his doctoral studies, he gained extensive research and development experience as a research engineer at the Chinese Academy of Sciences and Contemporary Amperex Technology Co., Limited (CATL), specializing in advanced battery technologies and materials chemistry. His interdisciplinary background spans materials science, electrochemical processes, and environmental engineering, with a strong interest in developing innovative solutions for sustainable resource recovery and environmental protection.

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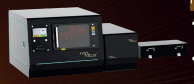

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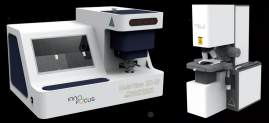

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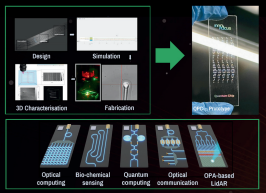

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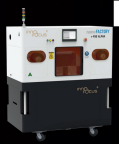

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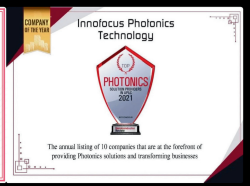

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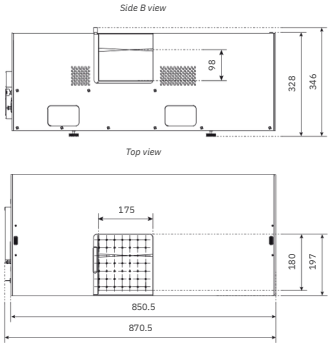
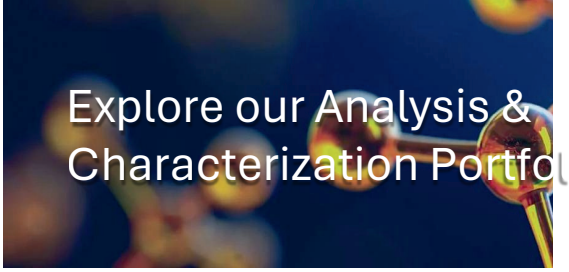
Probe polarization control	Linear (0 – 180°)
Pump wavelengths	515 nm, 343 nm
Delay range (resolution)	7.5 ns (10 fs)
Temporal resolution	≤ 290 fs
Laser repetition rate	60 kHz, any fundamental repetition rate division
Maximum data acquisition rate	3850 Hz
Dimensions	870.5 × 388 × 346 mm

Drawings

HARPIA-LIGHT



CLASS 1
LASER PRODUCT



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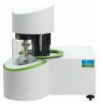

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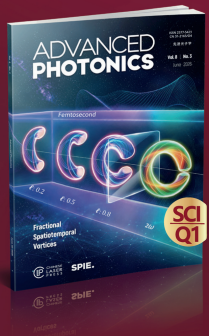


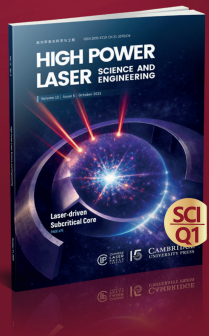
2025 Impact Factor 7.1



2025 Impact Factor 6.3



2025 Impact Factor 6.1



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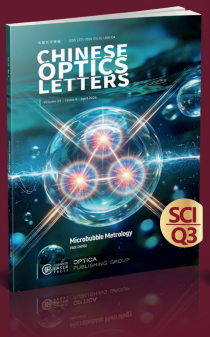

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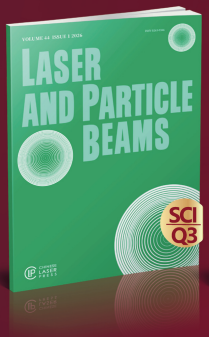

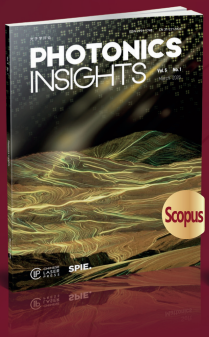





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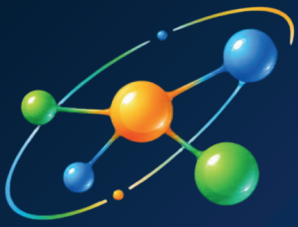

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