2025 ANNUAL REPORT

ARC Centre of Excellence for
Carbon Science & Innovation

Acknowledgement of Country

The ARC Centre of Excellence for Carbon Science & Innovation acknowledges the Traditional Custodians of Country and pays its respects to Elders past and present. Australia has always been a place of teaching, learning and knowledge sharing, and that continues today. Our Centre honours the enduring connection of Aboriginal and Torres Strait Islander peoples to this land, culture and community. We recognise the ongoing presence and contributions of Aboriginal and Torres Strait Islander peoples and commit to listening, learning and walking together.

The ARC Centre of Excellence for Carbon Science & Innovation operates on the lands of the:

- Bedegal and Gadigal peoples of the Eora Nation (the University of New South Wales and the University of Sydney),
- Kaurna people (the University of Adelaide),
- Whadjuk people of the Nyungar Nation and the Noongar people (Curtin University and the University of Western Australia),
- Bunurong people of the Kulin Nation (Monash University), and
- Ngunnawal and Ngambri peoples (the Australian National University).

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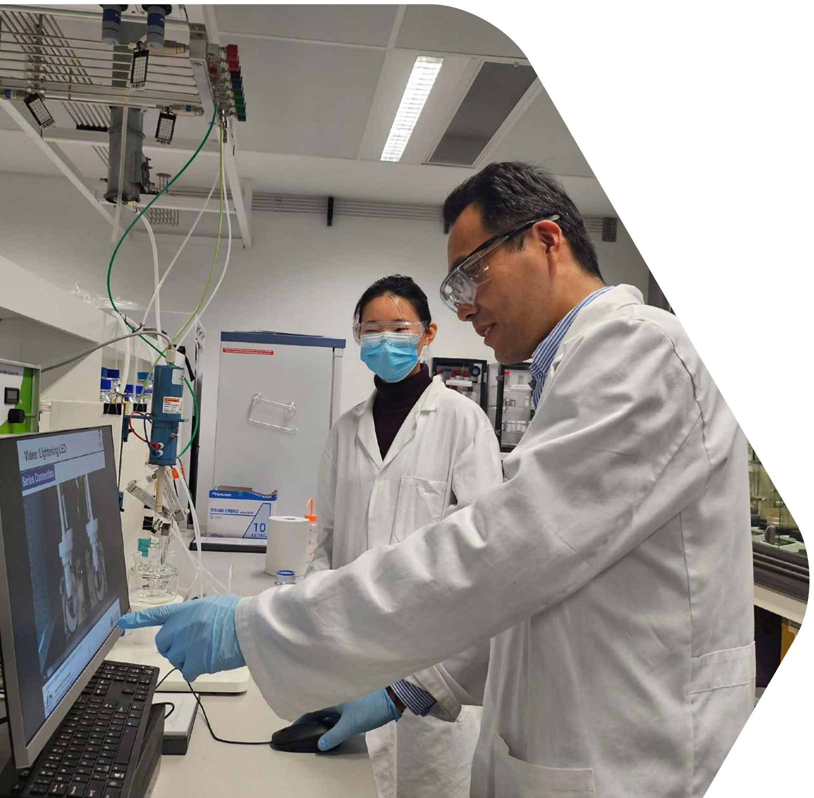


OUR CENTRE

Overview

The Australian Research Council (ARC) Centre of Excellence for Carbon Science and Innovation (COE-CSI) is a multidisciplinary collaborative centre of world-leading experts in carbon materials, catalysis, renewable energy and green chemistry. The Centre aims to create innovative carbon science and game-changing technologies for the clean production of energy and chemicals by using abundant sunlight, seawater and carbon waste feedstocks.

Supported by a $35 million ARC grant and substantial contributions from participating universities and industry partners, COE-CSI is Australia's leading program in carbon science and innovation. The Centre brings together an interdisciplinary and international coalition of scientists. This includes exceptional Australian discipline leaders as Chief Investigators from seven leading Australian universities: the University of New South Wales (UNSW Sydney), the University of Adelaide (UoA), the Australian National University (ANU), the University of Sydney (USYD), Monash University (Monash), Curtin University (Curtin) and the University of Western Australia (UWA). They are joined by experts from six Australian government and industry organisations: the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Australian Nuclear Science and Technology Organisation (ANSTO), ATCO Australia, N2N AI, HunterNet, and Rio Tinto. Our international Partner Investigators hail from seven world-class universities and national laboratories: the University of Cambridge, Rice University, Drexel University, Kent State University, Ulsan National Institute of Science and Technology, the Max Planck Institute of Colloids and Interfaces, and the United States Air Force Research Laboratory.

> “COE-CSI will train the next generation of researchers and innovators, enabling carbon industries and emerging technologies for clean energy and environmental remediation to help meet Australia's zero-carbon emissions targets.

As a global centre of international expertise in carbon science and innovation, COE-CSI will also train the next generation of researchers and innovators, enabling carbon industries and emerging technologies for clean energy and environmental remediation to help meet Australia's zero-carbon emissions targets.

Vision

The vision of COE-CSI is to revolutionise carbon science and technology for the clean production of energy and chemicals, and to provide a clean, sustainable future for Australia.

Objectives

COE-CSI has the following objectives:

- Drive a paradigm shift in carbon materials science by creating novel carbon catalysts with desired catalytic properties from carbon wastes (e.g. CO_2 emissions, biomass) through innovative precision synthesis integrated with data-driven design, and in situ (or operando) characterisation.
- Combine atomically designed and precisely controlled catalytically active centres (CACs) with a coordinated support environment to create a variety of catalysts with synergistic effects, suitable for multiple applications including renewable energy with zero emissions and green chemistry that reduces energy consumption and carbon emissions.
- Advance Australia's edge in carbon science and innovation through ground-breaking research and discoveries, and provide international leadership in a new multidisciplinary research field of carbon catalysis.
- Develop game-changing technologies with societal impact for mitigating ever-increasing carbon emissions through translational research, industry linkages and engagement.
- Train the next generation of world-class researchers, leaders and innovators for Australia's skilled workforce to tackle ever-escalating socio-economic and industry challenges.

The Global Challenge

Greenhouse gas emissions substantially contribute to severe air pollution and climate extremes. The energy, transportation and chemical sectors are the largest contributors, primarily due to fossil fuel combustion. Achieving net-zero emissions necessitates a transition from fossil fuel-based energy to clean and renewable energy. However, the production of clean energy, while fuel-free, relies heavily on critical minerals as catalysts. This is an area where our Centre's research into innovative carbon catalysts offers a sustainable solution.

To reach net-zero emissions by 2050, the International Energy Agency predicts that demand for certain critical minerals could increase up to 75 times[1]. This issue is further complicated by the fact that critical minerals are predominantly found in just a few countries, which poses geopolitical risks, and the potential for sharp price increases, and supply shortages. As a result, clean energy reliant on these minerals is unsustainable.

Our Approach: We Use Carbon to Decarbonise the World

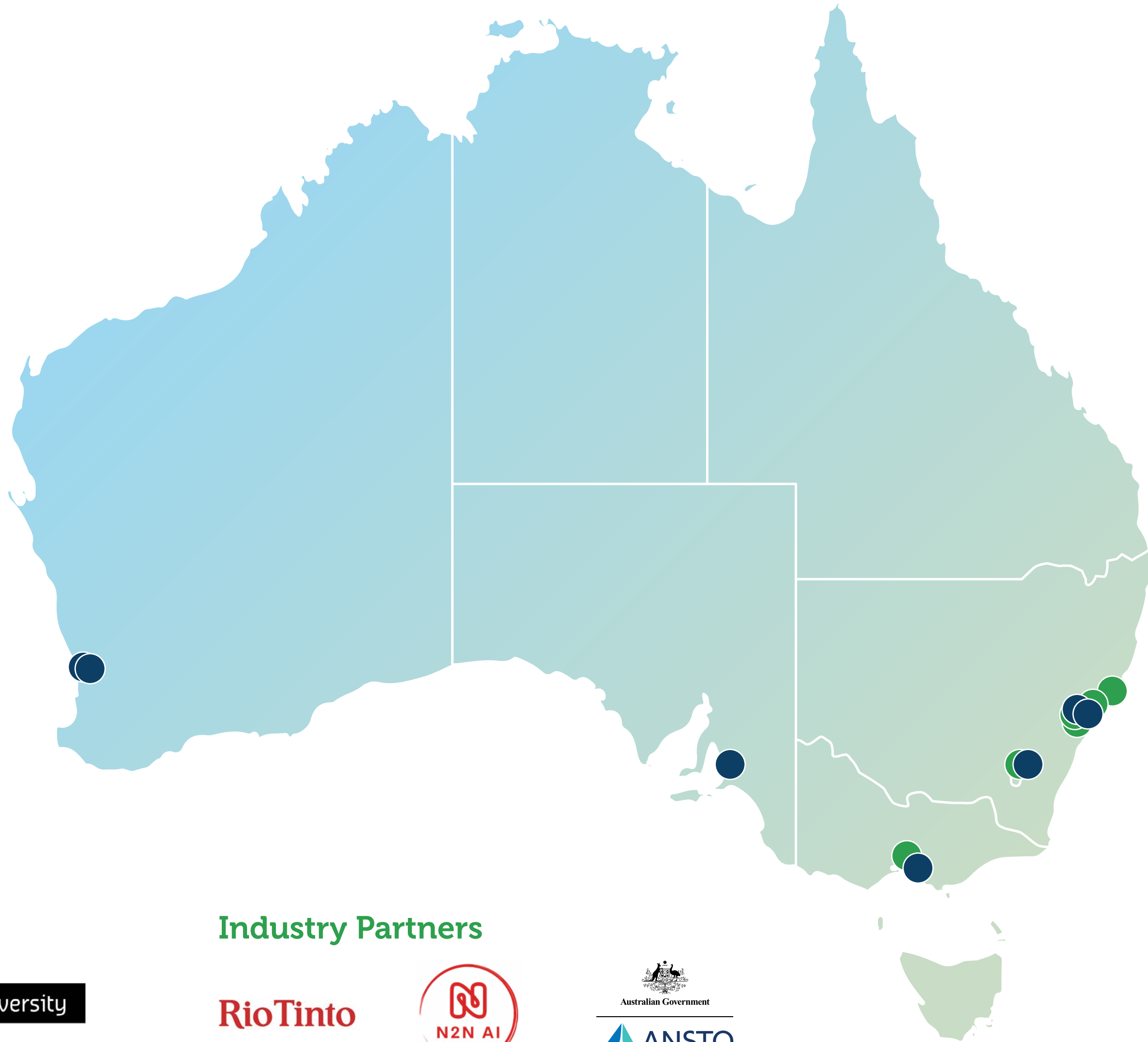
Catalysts are essential for the clean production of energy and chemicals to mitigate or eliminate carbon dioxide emissions. The most urgent global challenge we now face is to cost-effectively decarbonise the world without the limitations associated with critical minerals. Our Centre's team is pioneering the development of advanced metal-free carbon catalysts for clean energy technologies with zero emissions and for facilitating green chemistry that minimises carbon dioxide (CO_2) emissions.

Unlike critical minerals, carbon catalysts can be developed from carbon dioxide, biomass and other carbon-rich wastes, making them abundant and free from the risks and costs associated with critical minerals. Our work will provide the scientific foundations for transformative technologies that promote a green Earth by turning carbon waste into an asset. This approach will secure substantial environmental benefits and drive billions of dollars into our society through a circular carbon economy. The carbon problem thus becomes the solution.

1. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions

Our Partners

The Centre has established an extensive network of Australian and international organisations across government, industry, and world-class universities and national laboratories. Each partner has been selected for the expertise and valuable resources they bring to support the Centre's research goals and carbon science more broadly. These collaborations are essential for driving carbon science and innovation and for expanding our global impact.

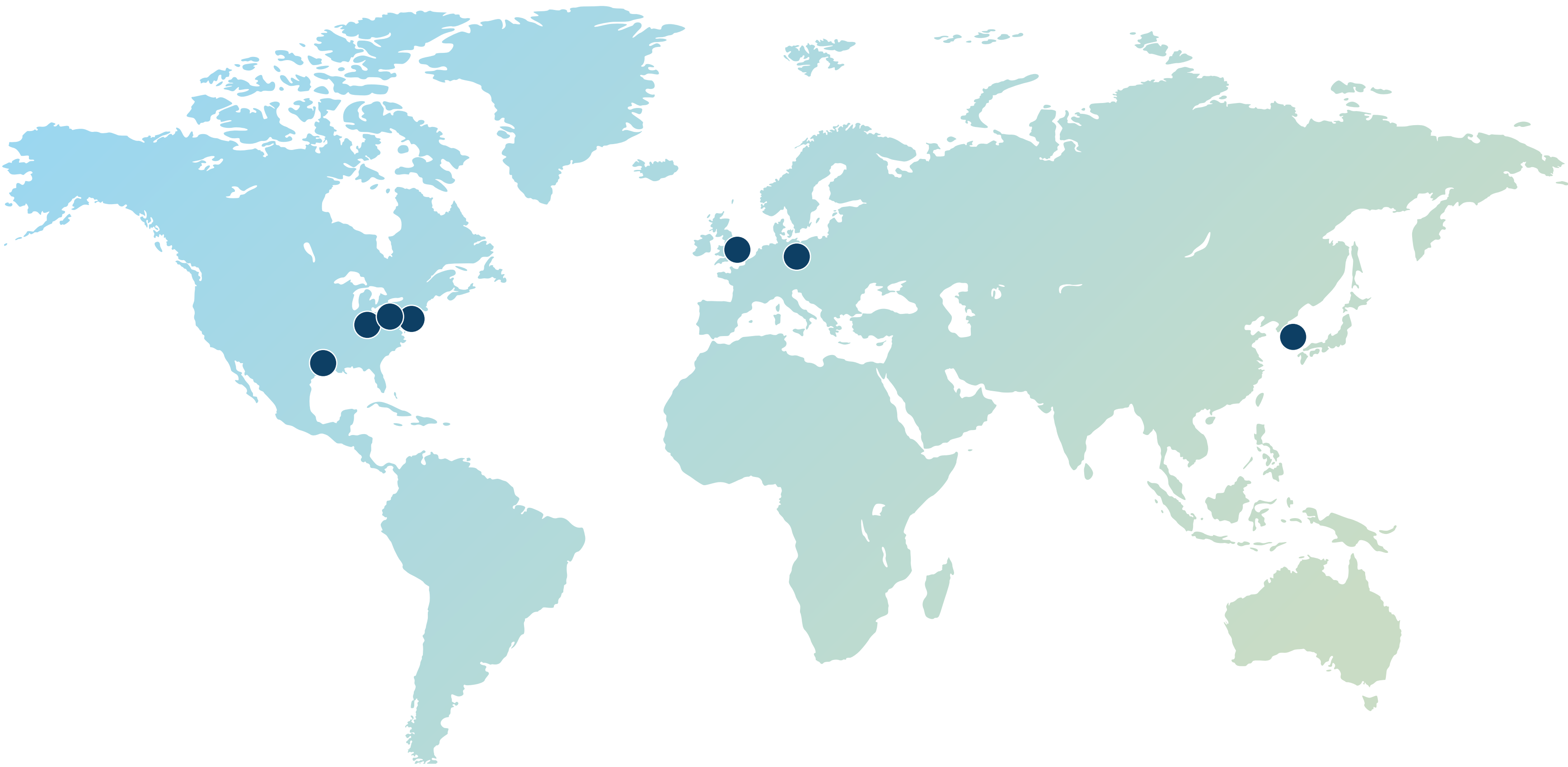


Participating Universities

- UNSW Sydney (Lead)
- The University of Adelaide
- Curtin University
- Monash University
- Australian National University
- The University of Sydney
- The University of Western Australia

Industry Partners

- Rio Tinto
- N2N AI
- Australian Government ANSTO
- CSIRO
- ATCO
- Hunternet



International Partner Organisations

UNIVERSITY OF CAMBRIDGE

AFRL AIR FORCE RESEARCH LABORATORY

Drexel UNIVERSITY

KENT STATE UNIVERSITY

MAX PLANCK INSTITUTE OF COLLOIDS AND INTERFACES

RICE UNIVERSITY

ULSAN NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY

Message from the Centre Advisory Board

It has been a pleasure to serve as Chair of the Advisory Board for the ARC Centre of Excellence for Carbon Science & Innovation during its first full year of operation. I would like to congratulate everyone across the Centre for an outstanding inaugural year since the official launch in November 2024. The achievements you have delivered in such a short time reflect not only scientific excellence but also a clear and deliberate commitment to long-term impact.

ARC Centres of Excellence are national investments in capability, collaboration and leadership. They create the conditions for world-class research and, importantly, for research that translates into real-world solutions. What distinguishes this Centre is how intentionally it has embedded pathways to innovation, translation and engagement from the outset. This focus on impact is what builds a legacy that extends well beyond the seven-year ARC funding horizon. It is also what makes the Centre more than the sum of its parts: a collaborative community united by a shared vision. Together, you can achieve what none of us could accomplish alone. Scientific excellence is the foundation for impact, and it is the quality of the research that the Centre is doing that makes impact possible.

At our inaugural Advisory Board meeting in November 2025, the Board was highly impressed by the scientific advances achieved in the Centre's first year, including strong publication performance and papers in leading journals such as Nature journals. A key theme in our discussions was the importance of balancing fundamental discovery with applied research to maximise both innovation and translational outcomes. The Board also had the opportunity to participate in the Centre's Annual Conference, where Board members engaged directly with Centre members. These conversations were a highlight, and I extend my sincere thanks to all Advisory Board members for their thoughtful advice, guidance and ongoing support to the Centre.

As we look ahead, this is a pivotal moment for Australia's research landscape. With the Australian Government undertaking a Strategic Examination of Research and Development, and the ARC reviewing the National Competitive Grants Program, it is crucial that the Centre continues to articulate its impact with clarity and confidence. Strengthening industry and end-user engagement will be essential, and the Centre is exceptionally well positioned to do so. Its strong governance, collaborative culture, and outstanding scientific and technical capabilities provide a powerful platform for national and global leadership in carbon science and innovation.

Thank you to all who have contributed to a remarkable first year. I look forward to seeing what this community will achieve as the Centre continues to grow, deepen its partnerships and translate its research into outcomes that benefit industry, the environment, and society.

Professor Bronwyn Fox AO
Chair, ARC Centre of Excellence for Carbon Science & Innovation Advisory Board
Deputy Vice-Chancellor (Research & Enterprise), UNSW Sydney

> What distinguishes this Centre is how intentionally it has embedded pathways to innovation, translation, and engagement from the outset.

Message from the Centre Executive Committee

2025 marked COE-CSI's first full year of activity following its official launch at UNSW in November 2024. In the past year, the Centre has focused on recruiting new students and researchers, progressing key research projects, strengthening connections among Centre members, empowering our community through training and mentoring opportunities, and expanding our outreach and engagement.

A Team of Excellent Achievers

COE-CSI now comprises 18 Chief Investigators, 26 postdoctoral researchers, 30 higher degree by research (HDR) students and four professional staff members.

We have continued to accelerate the production of high-quality research, publishing 80 papers in 2025, with 94% appearing in top-quartile (Q1) journals based on CiteScore in their respective fields.

Our researchers have been recognised for their outstanding achievements. In particular, Professor Shizhang Qiao was elected a Fellow of the Australian Academy of Technological Sciences & Engineering (ATSE), and Professor Yao Zheng received the 2025 Malcolm McIntosh Prize for Physical Scientist of the Year at the Prime Minister's Prizes for Science.

Fostering Collaboration and Engagement

Strengthening connections and promoting knowledge sharing across the Centre has been a major focus in 2025. The fortnightly Program Leadership Team (PLT) seminars, launched in January, provide a regular forum for Chief Investigators, postdoctoral researchers, HDRs, and associate and affiliated members from different organisations to share their recent research updates and exchange ideas. The Centre's annual conference brought together more than 80 attendees for two days of Centre updates, research progress, team building and networking.

Establishing and strengthening links with industry and government is central to COE-CSI's mission and long-term success. The Centre organised its first industry engagement workshop, bringing together government and industry partners and Centre researchers to explore gaps and opportunities in carbon materials, energy storage and low-carbon fuel production. Through presentations, Centre members heard about NSW Government decarbonisation initiatives and gained valuable industry perspectives on gaps and opportunities in carbon materials, energy storage and fuel production. Workshop speakers also shared great experience and advice with the Centre early career researchers (ECRs) and HDRs about critical tips to translate research into commercialisation.

Empowering the Next Generation

Empowering the next generation of researchers remains a core priority for COE-CSI. A series of diverse training programs were organised to support young researchers. These included leadership forums, an academic writing workshop, an advanced electron microscopy workshop, intellectual property training, a day with the Australian Nuclear Science and Technology Organisation (ANSTO) to explore their advanced capabilities of their Synchrotron and Neutron facilities, and training in communications and public engagement.

The Centre also further developed its outreach program with activities designed to inspire the next generation of scientists and engineers, and to encourage audiences to think critically about the meaning and value of our research. We conducted a wide range of events in 2025 for the public, school students, industry and government. Most activities targeted secondary school students and included the development and trialling of the Centre's first curriculum-aligned student workshop.

As recognised by the Centre Advisory Board, the Centre has achieved exceptional outcomes in the short period since it was established. Sincere thanks are extended to all of our Centre members, including our Chief Investigators, researchers, students and staff members, as well as our partners, board members and all Centre associates, for their contributions and commitment. We look forward to working further with all Centre members and collaborators as we continue to lead carbon science and innovation research and build a meaningful and impactful legacy as a committed and connected Centre.

ARC COE-CSI Executive Committee

2025 Highlights

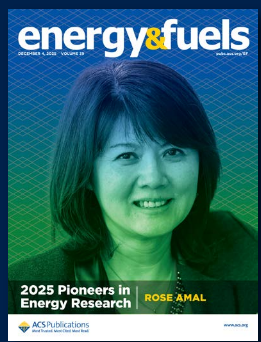
Held first Advisory Board meeting

Held first industry engagement workshop

167 Centre members and affiliates

7 Academic staff promotions

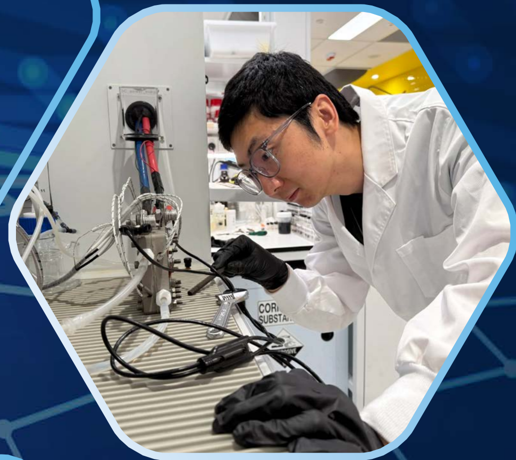
Published **80 research papers**



13 Centre members listed as 2025 Clarivate Highly Cited Researchers

Professor Shizhang Qiao elected a Fellow of the Australian Academy of Technological Sciences & Engineering (ATSE)

Dr Feiyue Gao awarded an ARC Discovery Early Career Researcher Award (DECRA)



Professor Yao Zheng awarded the Malcolm McIntosh Prize for Physical Scientist of the Year at the Prime Minister's Prizes for Science

Centre Annual Conference

COE-CSI's 2025 annual conference brought together the Centre's Chief Investigators, postdoctoral researchers, students and professional staff, as well as many Advisory Board members, in Sydney in November 2025. The conference provided opportunities to strengthen the Centre's research and culture. Chief Investigators and program leaders presented research updates, key milestones and future directions. Early career researchers and students also showcased their work through oral and poster presentations, giving them an opportunity to develop and strengthen their research communication skills in a supportive environment.

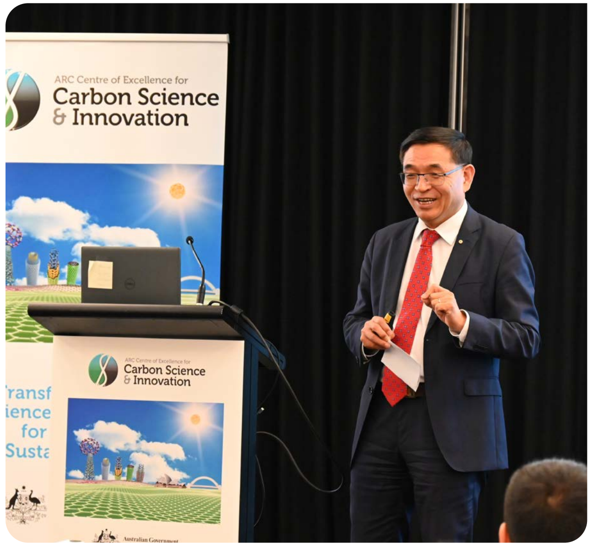
Advisory Board Chair Professor Bronwyn Fox AO (UNSW Sydney) delivered the opening address, emphasising the importance of a Centre that is greater than the sum of its parts. In plenary addresses, Advisory Board members Professor Max Lu AO (University of Wollongong), Professor Andrea Ferrari (University of Cambridge), and Professor Hui Yang (Chinese Academy of Sciences) presented their research and shared industry engagement expertise.

Dedicated sessions led by each Centre committee provided opportunities to reflect on progress and discuss new ideas across the Centre's research programs and governance activities.

Postdoctoral researchers and students were encouraged to submit abstracts to present their work through oral presentations and posters. The Centre's Research and Innovation Committee (RIC) assessed these presentations based on their content, clarity, relevance, communication and engagement to select the best of the 27 oral and poster presentations. Dr Xiaojun (Carlos) Ren, Dr Han Wu, Myat Thwe Naing and Putri Ramadhany received awards for their oral presentations, and Dr Yiran Jiao and Dr Jiaxin Li received awards for their poster presentations.

As many postdoctoral researchers and students were newly recruited across the year, it was a wonderful event to bring everyone together to reflect on our Centre's vision, strategy and research milestones.

Professor Max Lu AO and Professor Bronwyn Fox AO delivering their talks at the CSI annual conference.



LEFT: *Professor Liming Dai (left) and Putri Ramadhany (right).* BELOW: *From left to right: Associate Professor Rakesh Joshi, Dr Xiaojun Ren, Professor Yun Liu.*

RESEARCH AND COLLABORATION

Summary of 2025 Research Outputs

Collaboration statistics of the 80 published papers:

8 involved Partner Investigators **(10%)**

12 involved Partner organisations **(15%)**

29 involved multiple Chief Investigators **(36.3%)**

8 involved multiple Australian Partner Universities **(10%)**

9 involved Associate Investigators **(11.3%)**

49 outputs involved international collaboration **(61.3%)**

1,395 CITATIONS (as at 5 June 2026)

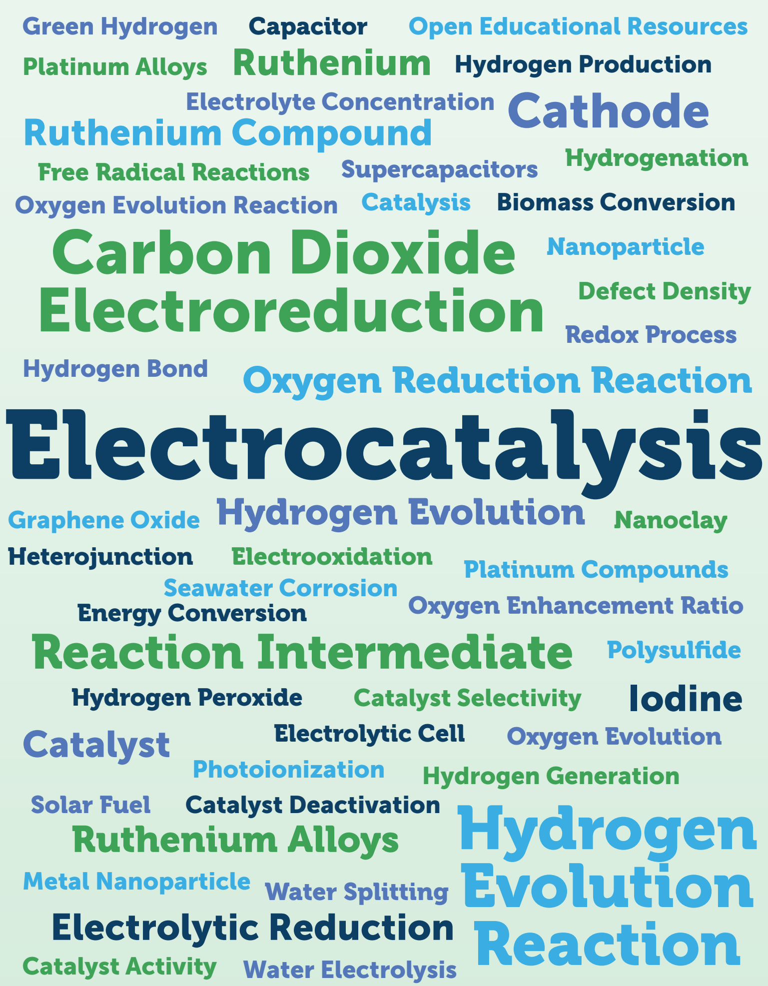
Journal articles in the top quartile (Q1) of CiteScore for relevant fields:

75 94%

Journal articles in the top 10% of journals by CiteScore:

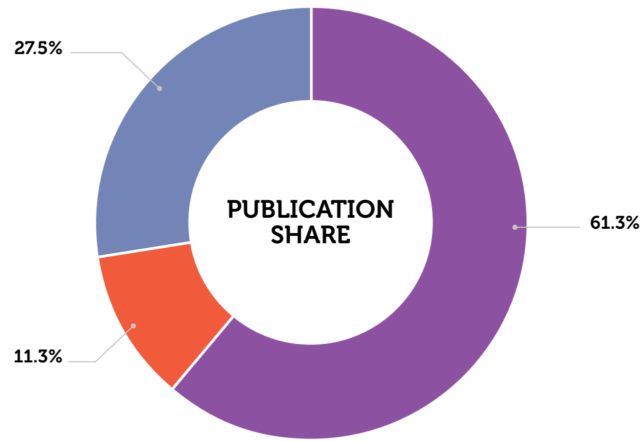
66 83%

Keyphrases



Geographical Collaboration

International, national, and institutional collaboration in 2025 publications.



METRIC	PUBLICATION SHARE	SCHOLARLY OUTPUT	CITATIONS
International collaboration	61.3%	49	506
Only national collaboration	11.3%	9	97
Only institutional collaboration	27.5%	22	337
Single authorship (no collaboration)	0.0%	0	0

Research Programs

COE-CSI has adopted a multidisciplinary approach towards achieving its objectives, embracing materials science, catalysis, energy, chemistry, AI-assisted design and synthesis, and technology translation.

Three research programs are being pursued to develop novel carbon-based materials and innovative technologies for renewable energy generation, clean chemical production, and environmental remediation.

RESEARCH PROGRAM 1
ADVANCED CARBON CATALYSTS

This program seeks to use precise nanofabrication of catalytically active centres to create novel carbon catalysts with specific and desired properties.

The key objective of Program 1 is to synergistically combine active sites with a coordinated support environment to create carbon catalysts that are substrate- and reaction-specific.

RESEARCH PROGRAM 2
CARBON CATALYSTS FOR CLEAN ENERGY

This program seeks to gain mechanistic insights into carbon-based catalytic reactions that are critical to clean energy conversion and storage devices and systems, including fuel cells, advanced batteries, and seawater electrolysis.

The key objective of Program 2 is to incorporate these new carbon catalysts into high-performance devices to deliver clean energy.

RESEARCH PROGRAM 3
CARBON CATALYSTS FOR GREEN CHEMISTRY

This program seeks to investigate the underlying catalytic mechanisms of multi-functional catalysts for green chemistry.

Insights gained from Program 3 will be applied to green and sustainable chemical processes, and environmental remediation.

Research Program 1

Advanced Carbon Catalysts

COE-CSI's Advanced Carbon Catalyst research program seeks to drive a paradigm shift in carbon science and innovation by creating novel carbon catalysts with desired catalytic properties through precise nanofabrication of catalytic active centres.

Program Leaders

Professor Yun Liu
The Australian National University

A/Professor Zhenhai Xia
UNSW Sydney

Our Game-changing Strategy: Using Carbon for Decarbonisation

Carbon, one of the Earth's most abundant elements, has several allotropic forms, including graphite (soft), diamond (hard), carbon nanotubes (strong), graphene (conductive), and fullerenes (highly symmetric). No other element has such a diversity of forms and such a wide range of properties for investigation and exploitation.

The COE-CSI team has developed technology to incorporate atoms other than carbon into pure carbon matrices. By heteroatom doping and by manipulating the dopant type, active domain size and substrate architectures, the team has transformed carbon into selective, high-performance catalysts. This fertile area of research is pivotal to the ongoing work of the Centre.

The COE-CSI team has also introduced an approach to its carbon science that combines precision synthesis with cutting-edge operando characterisation (measurements taken simultaneously with ongoing operations) and modelling techniques to gain an understanding of catalytic active centres (CACs) and mechanisms.

By strategically integrating active sites with custom-designed supports, this approach enables carbon catalysts to promote reactions with high catalytic activity and selectivity, unlocking novel carbon catalytic technologies for clean energy and green chemistry.

This research program integrates computation-guided precision synthesis, multiscale operando characterisation, and multiscale and multiphysics modelling to gain fundamental insights into CACs and their interactions with the environment. This objective-oriented design strategy is expected to facilitate breakthroughs in the development of advanced carbon catalysts that steer specific chemical reactions towards desired products for Research Programs 2 and 3, and beyond.

Carbon Catalysts for Renewable Energy

COE-CSI's second research program aims to gain mechanistic understandings of carbon catalytic reactions critical to clean energy conversion and storage devices and systems, including fuel cells, advanced batteries, and seawater splitting.

Program Leaders

Professor Yan Jiao
The University of Adelaide

Dr Rahman Daiyan
UNSW Sydney

COE-CSI is at the Forefront of Research into Next-generation Carbon Catalysts for Clean Energy

Clean energy technologies, including fuel cells, metal–gas batteries, and seawater splitting, are essential to net-zero carbon emissions.

Among these, Li–gas batteries stand out with their remarkable theoretical energy density, nearly six times that of conventional Li–ion batteries. Featuring metallic lithium anodes and gaseous cathodes, Li–gas batteries hold immense promise but are limited by their reliance on expensive noble metal catalysts. This program aims to overcome these barriers by introducing next-generation carbon catalysts.

The development of high-performance multi-functional carbon catalysts will enable self-sustaining solar-driven fuel cells that rival traditional technologies. COE-CSI is seeking to create such catalysts for energy conversion and storage by controlling catalytic active sites to promote desired reactions.

The Centre aims to apply its innovations to solar water splitting, exploiting Australia's abundant sunlight and seawater. With 58 million petajoules of annual solar radiation – 10,000 times the nation's energy needs – this research seeks to produce clean hydrogen (H_2) fuel directly from sunlight and seawater, unlocking a transformative pathway for clean energy.

This research aims to bridge the gap between catalytic properties and real-world applications, translating these innovations into high-performance, clean energy devices and demonstrating their scalability and viability for a sustainable future.

Research Program 3

Carbon Catalysts for Green Chemistry

COE-CSI's third program investigates the underlying catalytic mechanisms of multi-functional catalysts for green chemistry. Insights from this research program are used to guide green chemical processes for the clean production of chemicals.

Program Leaders

Professor Rose Amal
UNSW Sydney

Emeritus Professor Klaus Regenauer-Lieb
Curtin University

COE-CSI is Defining New Pathways for Green Chemistry

The chemical industry produces fuels, fertilisers, plastics, paints and medicines that are essential to everyday life. However, conventional fossil fuel-based chemical manufacturing methods are becoming increasingly unsustainable, consuming 10% of global energy and contributing 7% of greenhouse gas emissions. Industrial processes, such as ammonia production and hydrogen peroxide synthesis, rely on energy-intensive conditions, using high temperatures and pressures and releasing significant amounts of carbon dioxide.

Electrocatalysis offers an attractive alternative by employing electricity to drive chemical reactions at room temperature, dramatically reducing energy consumption and carbon dioxide emissions. The challenge, however, lies in the lack of high-performance, cost-effective catalysts capable of precisely controlling these reactions.

COE-CSI is developing next-generation multifunctional carbon catalysts for transformative applications, including carbon dioxide conversion to fuels and value-added chemicals, nitrogen gas reduction to ammonia, hydrogen peroxide generation from air/water with sunlight, e-refinery for photocatalytic wastewater treatment, and biomass conversion.

Research Highlight 1: Precisely Positioning Catalytic Atoms onto Supports

The ARC COE-CSI is pioneering a transformative approach to catalyst design – one where researchers precisely control the arrangement and placement of individual atoms to unlock unprecedented performance in sustainable chemical processes. Two breakthrough studies conducted in 2025 demonstrate how atomic-level engineering can be applied in green chemistry and in the production of clean energy.

Traditional Limitations in the Production of Catalysts

Conventionally produced catalysts have long suffered from a fundamental problem of randomness. When metal atoms are deposited onto support materials to form catalysts, they typically clump together in unpredictable ways, thereby producing active sites that offer limited accessibility to reactants and substrates. This random deposition has severely restricted catalytic efficiency and stability including in critical reactions for transitions towards green energy – from hydrogen production to ammonia synthesis.

COE-CSI researchers recognised that creating specifically designed atomic-scale architectures can prevent the random deposition of metals in the formation of catalysts, producing more available active sites per unit area of catalyst and thereby improving catalytic performance.

Breakthrough 1: Engineering Copper Sites for Ammonia Production

The Challenge

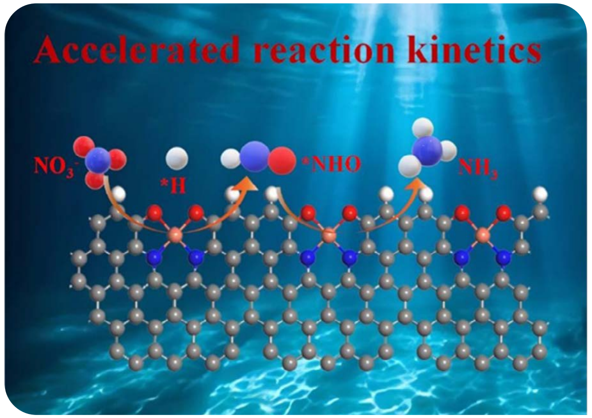
Nitrate contamination through agricultural and industrial activities has become a pressing environmental problem worldwide. Conversely, ammonia remains essential for fertilisers, energy storage and emerging low-carbon fuels. Converting nitrate waste into ammonia using renewable electricity offers an elegant solution to both challenges – but achieving this efficiently has been limited by slow proton transfer and complex reaction pathways.

The main bottleneck in the reduction of nitrate to ammonia is that the inefficient dissociation of water restricts the proton supply.

The Solution

Centre researchers – including Centre Director Professor Liming Dai, Deputy Director Professor Rose Amal AC, Chief Investigators Dr Emma Lovell, Dr Rahman Daiyan, Professor Richard Tilley and Professor Zhenhai Xia, postdoctoral researchers Dr Yan Li, Dr Jinyang Guo, Dr Yuwei Yang and Dr Bingliang Wang, and Associate Investigator Associate Professor Shery L. Y. Chang – fabricated isolated copper atoms embedded within a nitrogen and oxygen co-doped porous carbon framework. This created a unique CuN_2O_2 coordination environment that fundamentally changes how protons are sourced during nitrate electroreduction.

Careful manipulation of the electronic environment around each copper atom enables the catalyst to facilitate faster dissociation of water, providing a continuous and efficient source of protons. This breakthrough work enables **92.7% Faradaic efficiency** for ammonia production with a **high production rate and low operating voltage** (0.2V), which outperforms most previously reported metal-based nitrogen-carbon catalysts.



This depiction shows how isolated CuN_2O_2 sites attached to N,O-doped porous carbon to increase water dissociation and nitrate activation, increase the speed of proton delivery and support efficient electrochemical ammonia synthesis. (Reproduced from Advanced Functional Materials, copyright 2025; Creative Commons CC with permission.)

How It Works

Using *in situ* infrared spectroscopy, isotope labelling experiments and advanced theoretical calculations, the team discovered that oxygen atoms adjacent to copper play a crucial role. Density functional theory (DFT) calculation confirmed that these oxygen atoms redistribute charge, lower energy barriers for water dissociation and support necessary protonation steps. The unique CuN_2O_2 structure allows control of proton delivery to exactly where needed. This turns water from a limiting factor into an active participant in the reaction.

Breakthrough 2: Platinum Strings for Hydrogen Evolution

The Challenge

As the global transition to green hydrogen accelerates, improving the efficiency of the Hydrogen Evolution Reaction (HER) – producing hydrogen from water using renewable electricity – remains critical. While platinum is the premier catalyst, and performs better when paired with ruthenium, traditional synthetic methods produce random arrangements where platinum atoms clump together, burying the metal and limiting the proximity between ruthenium and platinum sites.

The Solution

Led by Chief Investigator Professor Richard Tilley, COE-CSI researchers developed a method to direct the growth of platinum atoms on ruthenium nanoparticles. Instead of random clustering, they achieved controlled formation of platinum into atomic strings across the ruthenium surface.

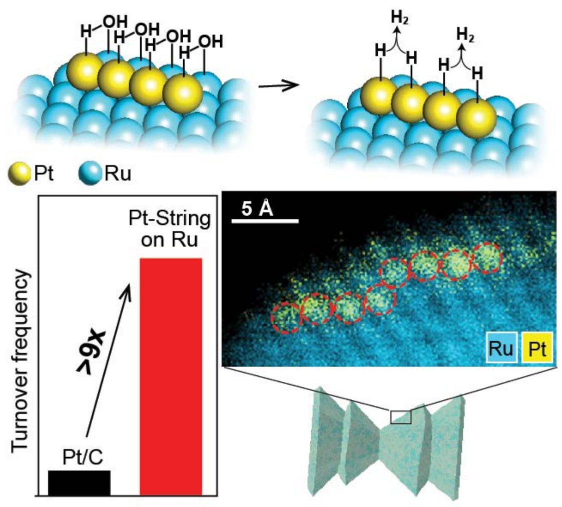
Using the newly developed, uniquely hourglass-shaped ruthenium nanoparticles as scaffolds, the researchers first nucleated small platinum islands on the nanoparticle edges. Through controlled heating, the platinum atoms rearranged into strings 3–10 atoms long. This architecture ensured that every platinum atom was surface-exposed, maximising efficiency.

The breakthrough work delivers the following impressive results:

- Nine times more active than commercial platinum standards
- Optimal atomic structure identified for hydrogen evolution
- Every platinum atom utilised effectively.

The Synergistic Mechanism

Advanced imaging revealed how these precision-engineered strings create a synergistic system. Ruthenium excels at breaking water molecules apart to form hydrogen atoms in the first step. The adjacent platinum strings are ideally configured to combine individual hydrogen atoms into H_2 gas—a perfect division of catalytic labour made possible only through atomic precision.



Top left and right: A diagram of the string arrangement of platinum atoms on a ruthenium nanoparticle and how this enables the water splitting step, and hydrogen recombination step, of the Hydrogen Evolution Reaction (HER). Bottom left: A nine-times improvement on activity. Bottom right: High-resolution elemental mapping from an electron microscope image.

Impact and Future Directions

These discoveries demonstrate how atomic-scale engineering can transform sustainable chemistry and clean energy:

Environmental Benefits:

- Converting nitrate pollution into valuable ammonia under mild conditions
- More efficient green hydrogen production for energy transition
- Reduced material usage through maximised atom efficiency.

Industrial Applications:

- Improved performance of industrial electrolysers
- More accessible green hydrogen technology
- Advanced design principles for numerous electrochemical transformations.

Looking Ahead

The Tilley group is exploring technology transfer to integrate these precision-engineered materials into large-scale energy systems, while the broader implications extend to developing single-atom catalysts for a wide range of sustainable chemical processes.

A New Paradigm

These studies represent more than incremental improvements; they establish a new paradigm in catalyst design. By demonstrating that subtle changes in atomic coordination can have major impacts on macroscopic catalytic performance, COE-CSI researchers are advancing understanding and providing practical solutions for cleaner, more efficient chemical technologies.

The message is clear: the future of catalysis lies not in random chance, but in intentional design at the atomic scale.

Professor Richard Tilley and his group (from left to right): Allegra Logan, Dr Xiaoran (Jeffrey) Zheng, Professor Tilley, Qinyu Li, Hafiza Komal Zafar and Kya Lamarra.

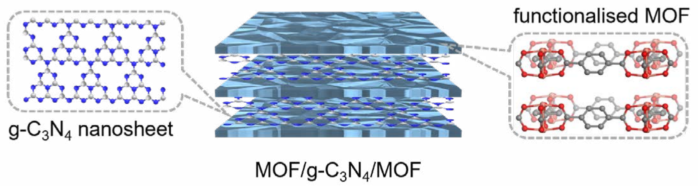
Key Publications

Li, Y.; Guo, J.; Yang, Y.; Wang, B.; Wen, H.; Bui, T. S.; Chang, S. L. Y.; Bedford, N. M.; Lovell, E.; Daiyan, R.; Amal, R.; Hou, Y.; Tilley, R.; Xia, Z.; Dai, L. Atomically Dispersed Copper Electrocatalysts with Proton-Feeding Centers for Efficient Ammonia Synthesis by Nitrate Electroreduction. *Advanced Functional Materials* **2026**, *36* (2), e08619. https://doi.org/10.1002/adfm.202508619.

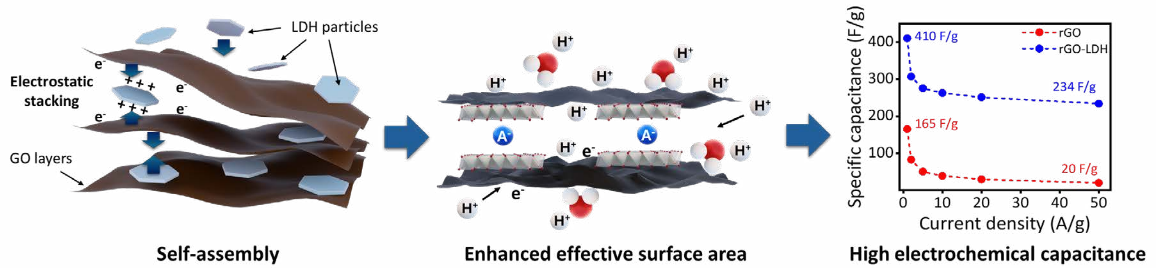
Li, Q.; Cheong, S.; Poerwoprajitno, A. R.; Xiang, S.; Frenkel, A. I.; Yang, Y.; Bedford, N. M.; Umer, S.; Lessio, M.; Ohnishi, I.; Ramadhan, Z. R.; Huber, D. L.; Dai, L.; Schuhmann, W.; Gooding, J. J.; Tilley, R. D. How the Arrangement of Platinum Atoms on Ruthenium Nanoparticles Improves Hydrogen Evolution Activity. *Advanced Materials* **2025**, *37* (41), e09610. https://doi.org/10.1002/adma.202509610.

Research Highlight 2: Tailoring Layered Carbon Architectures for Energy Storage and Catalysis

Emerging 2D carbon-based materials are strong candidates for next-generation energy storage and catalysis owing to their unique architectures, which have high conductivity, large surface areas and tuneable chemistry. Nevertheless, the irreversible restacking of adjacent layers can significantly reduce the number of effective molecular transport channels and surface-active sites, which may limit their performance. Addressing this challenge requires a materials-design approach to build stable, layered architectures.



Heteroatom-doped 3D carbon scaffolds.



Schematic illustration of the ion-transport mechanism in electrostatically assembled rGO–LDH nanosheets and the resulting enhancement in electrochemical energy storage performance.

Graphene oxide (GO) and reduced graphene oxide (rGO) are obvious candidates for this challenge. GO contains abundant oxygen functional groups that enable chemical modification and assembly, but its low conductivity limits its direct use in many electrochemical devices. rGO restores conductivity, but common reduction processes can trigger irreversible restacking, dramatically reducing the accessible surface area and limiting its performance in electrodes and catalyst supports.

Led by Chief Investigator Associate Professor Rakesh Joshi and in collaboration with Centre Director Professor Liming Dai, Chief Investigators Associate Professor Sophia Gu and CI Professor Richard Tilley, the COE-CSI team at UNSW Sydney has developed a simple and practical self-assembly route to fabricate spacer-engineered rGO laminates. Well-chosen spacers were inserted into the laminate to control interlayer spacing, prevent collapse and form continuous nanochannels for rapid ion transport. In this work, magnesium–aluminium layered double hydroxide (MgAl-LDH) nanosheets were used as 2D spacers to construct a layer-by-layer rGO/LDH hybrid structure. This design directly targeted the restacking problem by converting the laminate from a dense ‘closed’ stack into a 3D ordered architecture with stable, accessible pathways. The composite produced high-performance supercapacitors with a maximum 410 F/g capacitance, low internal resistance and a high-rate capability.

This published work offers a practical pathway for developing next-generation energy-storage materials and can be extended to other layered 2D systems for supercapacitors, batteries and related technologies.

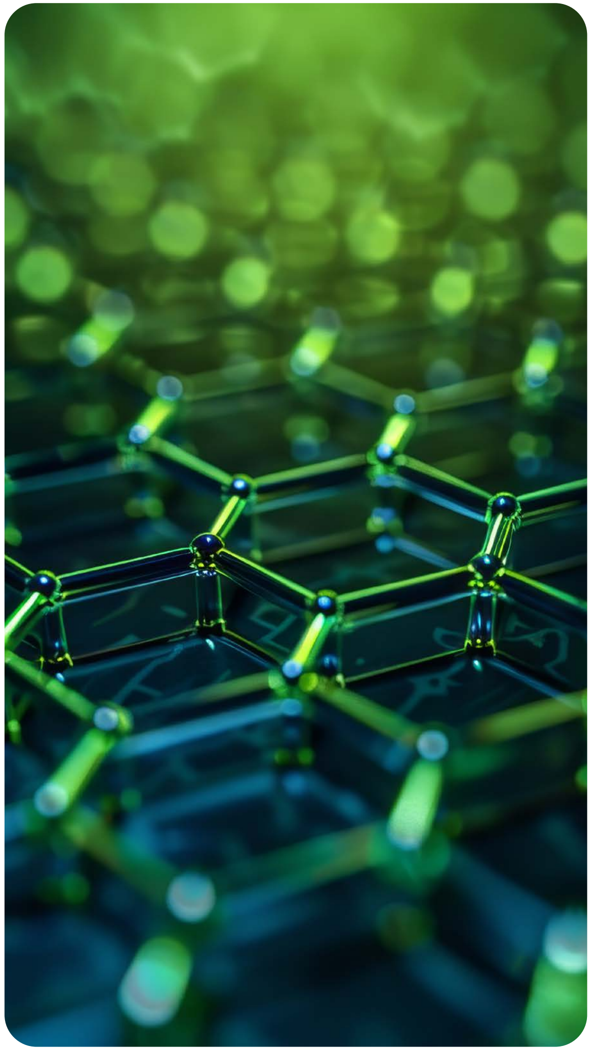
The construction of 3D carbon-based architecture is a critical approach towards making carbon materials more efficient and more functional with superior performance.

Based on the concept of designing laminated carbon architectures with unique properties of each building block, COE-CSI Chief Investigator Yun Liu and the team have broadened the research field to MOF/carbon nitride layer-by-layer assembly. That work addresses the low charge transport of g-C_3N_4 by constructing a highly ordered MOF/g-C_3N_4/MOF sandwich heterostructure for CO_2 electroreduction. Using layer-by-layer assembly, g-C_3N_4 nanosheets are embedded within MOF thin films to form a robust, electronically coupled heterojunction with well-controlled interfaces. The ordered architecture delivers higher photocurrent and charge-transfer efficiency than pristine components and conventional mixed composites, highlighting the importance of structural ordering. This strategy provides a reproducible route to precise MOF/2D hybrid design for high-performance photo-electrocatalysis.

By combining complementary strengths in materials fabrication, interface chemistry, advanced characterisation and device evaluation, the COE-CSI researchers have the capability to build a larger and more consistent dataset linking processing, structure and function across different 2D systems. This shared platform will not only strengthen scientific outcomes and reproducibility, but could also expand the scope for new materials design, scalable assembly routes, and translation opportunities, delivering greater impact for COE-CSI in advanced energy storage, catalysis and related technologies.

Key Publication

Ren, X.; Lin, T.; Sun, B.; Ramadhan, Z. R.; Yin, H.; Hussain, F.; Dai, Q.; Tilley, R.; Dai, L.; Gu, Z.; Joshi, R. Electrostatically Induced Intercalation of Layered Double Hydroxide in Graphene Oxide for Enhanced Electrochemical Energy Storage. *Advanced Science* **2025**, *12* (48), e15923. https://doi.org/10.1002/advs.202515923.



Research Highlight 3: Enhanced Catalyst Performance Through Synergistic Strategies

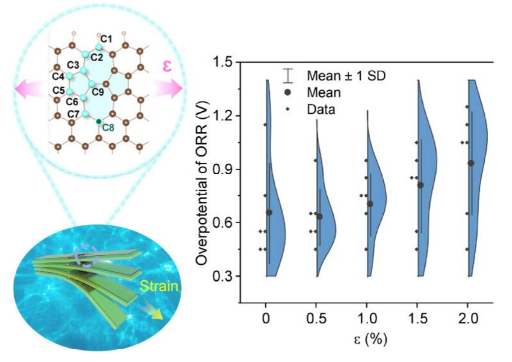
The ARC COE-CSI has developed approaches to increase catalyst performance for sustainable energy and chemical production. Recent breakthroughs demonstrate how mechanical strain, switchable ferroelectric polarisation, and metal-support interactions can each unlock new levels of catalytic activity – pointing towards integrated designs (going beyond catalysts-only design) that could revolutionise clean energy technologies.

Mechanical Activation: Strain-Driven Performance

Carbon materials possess exceptional tunability through their sp^2 hybridised conjugated structure, enabling property modification through heteroatoms, defects or strain – a versatility unmatched by any other material. Despite strain being a common operational factor, its impact on carbon-based metal-free catalysts had remained unexplored due to technical challenges in isolating mechanical effects from other structural variables.

Centre Director Professor Liming Dai – and collaborators led by Professor Bin Wang at China's National Center for Nanoscience and Technology – developed a novel experimental platform enabling continuous strain application while simultaneously collecting electrochemical signals. Using highly oriented pyrolytic graphite (HOPG), they revealed for the first time a direct correlation between surface strain and oxygen reduction reaction (ORR) activation.

The discovery is revolutionary: while pure unstrained HOPG shows no catalytic activity, controlled tensile strain produces strong, repeatable enhancement through strain-induced lattice variation and charge redistribution. Density functional theory simulations confirmed that strain on specific defects can increase reaction intermediate adsorption energies.

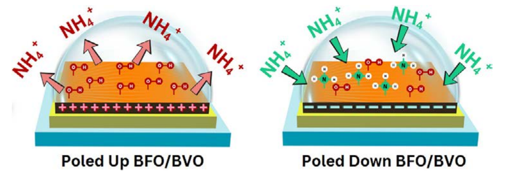


The mechanical effects on carbon-based metal-free catalysts (C-MFCs), showing that mechanical strain strongly influences catalytic activities. (Adapted from JACS, copyright American Chemical Society 2025.)

This establishes foundational principles for carbon-based mechano-electrocatalysis – where mechanical forces serve as powerful tuning parameters comparable to chemical composition. Technologically, catalytic devices could exploit operational stresses to enhance performance dynamically, creating self-optimising systems for fuel cells and electrolysers without expensive dopants.

Electrical Control: Ferroelectricity Enables Switchable Surfaces

As global demand for sustainable energy intensifies, photoelectrochemical (PEC) technologies offer promising pathways for using sunlight to produce fuels and chemicals. However, controlling reaction selectivity remains a critical challenge – multiple competing reactions in aqueous environments waste charges and produce unwanted products.



Schematic depicting the selective adsorption of OH and NH_3 species on poled up and poled down BFO/BVO. Polarisation induces changes to the BFO surface charge, promoting the attraction of oppositely charged, or repulsion of like-charged, species.

Deputy Director Professor Rose Amal AC and postdoctoral researcher Dr Michael Gunawan achieved a breakthrough by introducing ferroelectric materials into PEC systems. Ferroelectric materials possess switchable polarisation states that can be reversed by applying external electrical fields. Each polarisation state creates distinct surface charge arrangements that influence which molecules adsorb and participate in reactions – essentially providing an electrical 'switch' for surface chemistry.

The researchers added ferroelectric bismuth ferrite (BFO) to a bismuth vanadate (BVO) photoanode, creating a switchable system with unprecedented control over reaction selectivity. The ferroelectric polarisation acts as an active switch, enabling tuneable selectivity by favouring target molecule oxidation over water oxidation, which improves performance and increases chemical product formation. Crucial collaboration with Chief Investigator Professor Yun Liu and Associate Investigator Professor Nicholas Cox at ANU's Research School of Chemistry provided electron paramagnetic resonance spin-trapping evidence, allowing identification of key reaction intermediates and elucidation of the reaction mechanisms.

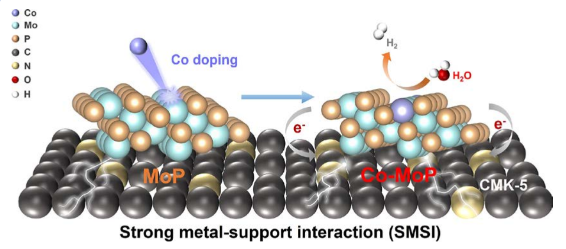
This innovative development enables dynamic, reversible control over surface chemistry through applied fields – fundamentally different from conventional photocatalysts. Single devices could produce different products on demand: oxygen when polarised in one direction, valuable oxidised chemicals in the other. The internal field formed also enables promoting charge carrier separation. While demonstrated on oxide photoanodes, the concept extends to carbon-based catalysts, potentially combining mechanical tunability with electrical switching for unprecedented multi-modal control in solar-driven chemical production.

Interface Engineering: Metal-Support Synergy

Chief Investigator Dr Wenxian Li's team tackled enhancement through strategic nanostructure design, pioneering the use of ordered mesoporous carbon (CMK-5) as a three-dimensional confinement matrix to amplify strong metal-support interactions (SMSI). This used 'confinement growth' where synthesising ultrafine nanoparticles (MoP, MoC, MoS_2) were made directly within CMK-5's precisely controlled channels.

Unlike conventional disordered carbon supports, CMK-5's ordered pore structure provides uniform confinement preventing aggregation while maximising interfacial contact. This creates intense electronic exchange between molybdenum species and carbon substrate – an SMSI effect that fundamentally alters the active site's electronic structure. X-ray photoelectron spectroscopy validated this coupling, revealing electron density modulation at Mo sites, which lowers energy barriers for hydrogen adsorption/desorption – critical rate-limiting steps in hydrogen evolution reaction (HER).

The results demonstrate that interface engineering transcends the performance limits of either component alone: MoP/CMK-5 achieves remarkably low overpotentials of 65 mV in alkaline conditions and 103 mV in seawater – approaching platinum performance with earth-abundant materials. This pH-universal performance is crucial for practical deployment where conditions vary widely. For large-scale hydrogen production, this provides a blueprint for viable, low-cost noble-metal alternatives, with implications extending to fuel cells, CO_2 reduction and nitrogen fixation.



Strong metal-carbon support interaction (SMSI) driven by d–d orbital hybridisation for enhanced green hydrogen evolution.

Convergence: Next-Generation Catalyst Design

These three advances address different fundamental aspects through complementary mechanisms. Mechanical strain modulates electronic structure through lattice deformation. Ferroelectric materials provide electrical control over surface chemistry. Metal-support interactions optimise electronic coupling at interfaces.

This convergent solution offers a way to highly efficient, flexible chemical manufacturing that can be modified to match many renewable energy inputs and meets the Centre's mission to develop clean alternatives to noble metals while reducing emissions.

Key Publications

Gunawan, M.; Bowdler, O.; Zhou, S.; Naing, M. T.; Leung, T. C.; Fang, X.; Cong, J.; Huang, J.; Zhang, Q.; Gunawan, D.; Hao, X.; Liu, Y.; Vongsvivut, J.; Cox, N.; Amal, R.; Valanoor, N.; Scott, J.; Hart, J. N.; Toe, C. Y. Ferroelectric Control of Photoelectrochemical Ammonia Oxidation Reaction. *Small* **2026**, *22* (6), e12887. https://doi.org/10.1002/smll.202512887.

Liu, B.; Xu, S.; Gao, Y.; Luo, X.; Xiong, J.; Li, H.; Yu, Z.; Zhang, L.; Zhang, Q.; Zhao, S.; Zhang, B.; Xia, Z.; Chen, L.; Feng, B.; Dai, L.; Wang, B. Intrinsic Mechanical Effects on the Activation of Carbon Catalysts. *J. Am. Chem. Soc.* **2025**, *147* (5), 4258–4267. https://doi.org/10.1021/jacs.4c14372.

Sha, S.; Zhu, Y.; Zhang, J.; Liu, Y.; Li, W.; Liu, B. Enhanced Mesoporous Metal-Support Interaction through d-d Orbitals Hybridization for Advanced Hydrogen Evolution Catalysis. *Journal of Colloid and Interface Science* **2026**, *703*, 139056. https://doi.org/10.1016/j.jcis.2025.139056.

Research Highlight 4: Bridging the Quantum Divide: How AI and Physics Unite to Revolutionise Green Catalyst Design

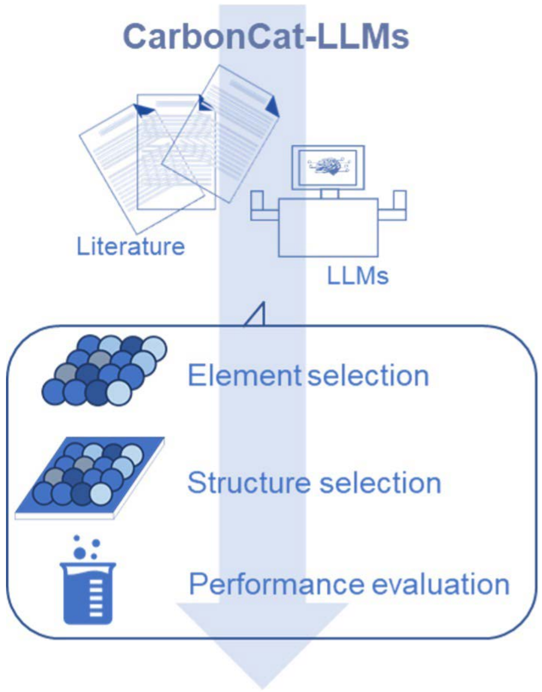
Why This Research Matters

The race to combat climate change depends to some extent upon our ability to convert carbon dioxide into useful fuels and to produce clean hydrogen efficiently. In that regard, scientists have faced a fundamental challenge: powerful computer simulations that predict how individual molecules behave often fail when scaled up to industrial reactors. This 'missing link' between the microscopic quantum world and real-world chemical plants has cost billions in failed experiments and slowed progress towards sustainable energy solutions.

At COE-CSI, this challenge was addressed by researchers from the University of Adelaide and Curtin University from opposite directions, and the resulting convergence represents a paradigm shift in the design of materials for a carbon-neutral future.

The Dual Innovation

Chief Investigator Professor Yan Jiao and her team at the University of Adelaide approached the problem through artificial intelligence, developing CarbonCat-LLMs, a sophisticated framework that harnesses large-language models to revolutionise catalyst design. Unlike traditional literature reviews that are time-consuming and prone to human bias, the CarbonCat-LLMs framework efficiently scans thousands of scientific papers, extracting critical information about catalyst compositions, structures and performance metrics. The framework then employs a novel cosine-similarity-based mapping approach to identify which elements work well together, uncovering not only known pairings but also combinations that researchers had overlooked or may not have predicted.

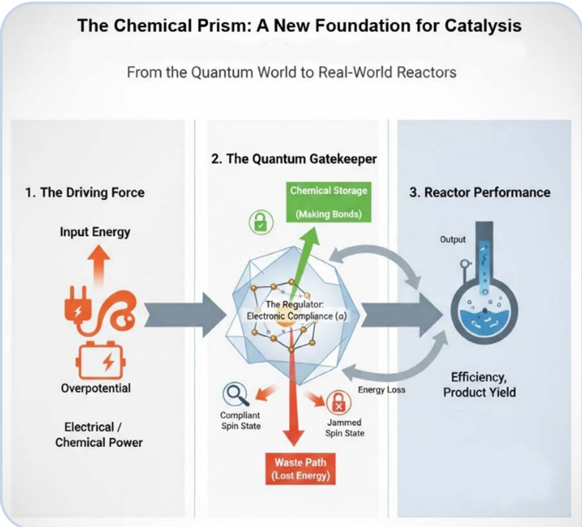


CarbonCat-LLMs framework developed by Professor Yan Jiao's team, and its potential applications.

The CarbonCat-LLMs framework successfully predicted compatible high-entropy alloy configurations years before experimentalists discovered them in the lab. The framework can design multi-element catalysts, identify optimal carbon substrates with specific dopants, like nitrogen or phosphorus, and even provide preliminary performance predictions – all before a single experiment is conducted.

Meanwhile, Chief Investigator Professor Klaus Regenauer-Lieb and his team at Curtin University attacked the scaling problem from a physics perspective. Inspired by how sand grains partition energy when they flow and jam together, this work led to the development of the 'Chemical Prism' framework. This breakthrough discovery centres on a quantum property named 'Electronic Compliance', a gatekeeper that determines whether energy supplied to a reaction creates useful chemical products or wastes away as heat.

This electronic gatekeeper explains why some catalysts with seemingly ideal properties fail in practice: their electronic structures exist in 'jammed' or spin-forbidden states that force energy down the waste path. By quantifying this compliance factor, the team created the first practical tool for predicting how quantum-scale electron behaviour translates to industrial-scale chemical flux.



The Energy Split: This diagram shows how the catalyst acts as a 'Regulator' (the Electronic Compliance α). Just like a prism splits light, the catalyst's electronic structure splits incoming energy (Driving Force) into two streams: useful chemical products (Storage θ_c) and wasted heat (Dissipation T_{eff}).

Collaboration That Bridges Disciplines

The transformative potential emerged when these two approaches converged on the Centre's shared research platform. The AI team's ability to rapidly identify promising catalyst candidates combined with the physics team's framework for predicting real-world performance created an unprecedented design pipeline. Complex quantum mathematics that once required specialised expertise can now guide practical engineering decisions.

The most useful aspect of this software is how it combines new approaches into a single 'Search-and-Filter' software package. By integrating Professor Regenauer-Lieb's fundamental physics into Professor Jiao's AI framework, the Centre has created a Physics-Informed Neural Network (PINN) architecture for catalyst design.

This unified approach works in two seamless stages:

1. Professor Jiao's CarbonCat-LLMs rapidly scan millions of possibilities to identify high-potential multi-element catalyst candidates.
2. These candidates are then processed through the PINN, which applies Professor Regenauer-Lieb's 'Electronic Compliance' equations to determine their properties. This ensures the AI only selects materials that are physically capable of efficient energy transfer, filtering out those that would fail in real-world industrial reactors.

This collaboration eliminates the traditional 'trial-and-error' gap between computational screening and industrial application. By embedding the 'Chemical Prism' physics directly into the AI's learning loops, the teams have built a blueprint for accelerating the transition to a carbon-neutral economy.

Impact and Future Directions

This integrated approach fundamentally changes the economics of green technology development. Instead of expensive trial-and-error laboratory work, researchers can now design, evaluate and optimise carbon-based catalysts computationally. The framework identifies materials that efficiently convert carbon dioxide into fuels or produce green hydrogen while minimising energy waste – crucial for making these technologies economically viable on industrial scales.

The research has immediate applications in battery technology, carbon capture systems and hydrogen production facilities. The team is now working towards technology transfer, with the CarbonCat-LLMs framework demonstrating strong potential for commercialisation in materials design industries.

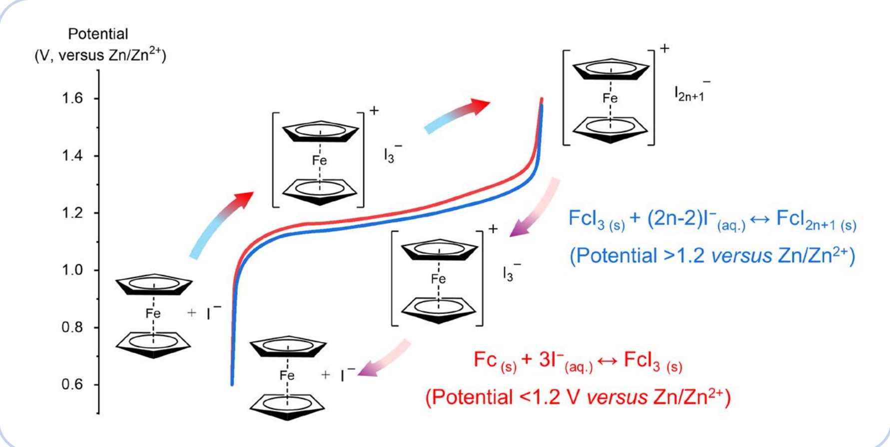
By applying artificial intelligence to fundamental physics, the researchers have identified more efficient catalysts and have provided software that can be used to create other sustainable technology developments. Centre research demonstrates that the most intractable scientific challenges often require not just brilliant individual insights, but the courage to bridge disciplines and unite diverse expertise towards a common goal.

Research Highlight 5: Ferrocene-Decorated Porous Carbon for Zinc-Iodine Batteries

Large-scale energy storage is essential for stabilising renewable power grids and supporting Australia's transition towards a low-carbon economy. Among emerging technologies, aqueous zinc–iodine batteries stand out because of their intrinsic safety, low cost and fast reaction kinetics.

Their practical deployment has been severely limited, however, by a long-standing technical bottleneck known as the 'iodine shuttle effect', in which soluble iodine intermediates migrate between electrodes. This process leads to rapid self-discharge, low energy efficiency and shortened battery lifetime. Addressing this fundamental challenge motivated the research team at COE-CSI, led by Centre Deputy Director Professor Shizhang Qiao, to rethink how iodine chemistry should be controlled inside working batteries.

Instead of relying on conventional passive host materials to physically trap iodine species, the team introduced a fundamentally new concept: **electroactive redox coupling**. By incorporating ferrocene into iodine cathodes, the researchers enabled a reversible ferrocene/ferrocenium redox process that actively binds iodine intermediates to form insoluble ferrocenium-polyiodide complexes. This innovation transforms the traditional liquid-phase, shuttle-prone reaction pathway into a stable solid-state conversion mechanism. As a result, iodine species are confined directly at the reaction sites, eliminating shuttle effects at their origin while simultaneously contributing additional electrochemical capacity.



Ferrocene-decorated porous carbon addresses the shuttle effect of zinc-iodine batteries on the promise of high energy density.

This new solution has many scientific and technological advantages. At the materials level, the cathode achieves a high active mass ratio and enhanced utilisation efficiency. At the device level, the team successfully translated this concept into practical pouch-cell prototypes. A 1.2 ampere-hour zinc-iodine pouch cell with industrially relevant electrode loading sustained long stable cycles while maintaining high energy efficiency and low self-discharge, highlighting its potential for application in industry.

Beyond its scientific impact, this work offers significant economic benefits. Ferrocene-based materials rely on earth-abundant elements and scalable processing methods, making the technology compatible with large-scale manufacturing. Techno-economic analysis suggests that the redox coupling strategy can simultaneously improve energy density and reduce overall battery cost, strengthening Australia's competitiveness in next-generation energy storage technologies.

Key Publication

Zhang, S.-J.; Hao, J.; Wu, H.; Hu, Y.; Chen, Q.; Johannessen, B.; Ma, Q.; Luo, D.; Qiao, S.-Z. Electroactive Ferrocene/Ferrocenium Redox Coupling for Shuttle-Free Aqueous Zinc–Iodine Pouch Cells. *Nat. Chem.* **2026**, *18* (2), 266–274. https://doi.org/10.1038/s41557-025-01986-7.

Research Highlight 6: Urine Electrooxidation to Produce Hydrogen in an Energy-Saving Manner

Urea is valuable as a fertiliser and its industrial production generates a high level of carbon emissions. Its cost renders it unviable as a starting material for hydrogen production. COE-CSI researchers, led by Chief Investigator Professor Yao Zheng at the University of Adelaide, have explored the direct use of the waste product urine as a cost-free and abundant alternative source of urea. A critical challenge was that chloride ions in urine would be oxidised to chlorine during the process, which would corrode the system's anode.

Using raw urine feedstock from natural human urine and wheatfield effluents, the system leveraged an interfacial microenvironment regulation on modified nickel (Ni)-based catalysts. By adding a strong Lewis acid (LA) protective layer (e.g. V_2O_5, MnO_2, etc.), the composite promotes a local alkaline reaction environment on the catalyst surface to repel Cl^- ions from Ni active sites (see image). This interfacial microenvironment engineering strategy in urine electrolysis can efficiently avoid chlorine-induced corrosion, contributing to the enhanced performance of this process.

The urine electrolysis system only requires an electricity consumption of 3.73 kWh Nm^{-3} for H_2 production under 300 mA cm^{-2}. This is an estimated 20% less electricity than water splitting systems.

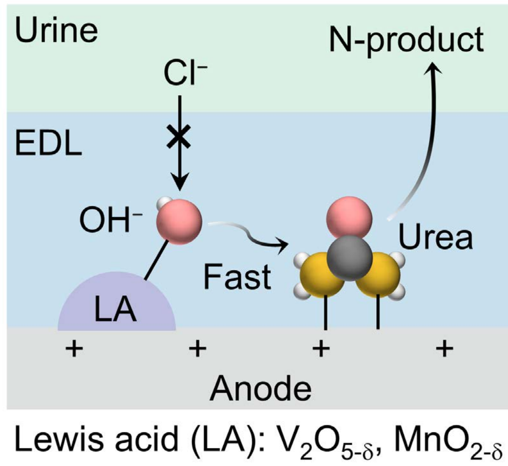
In a scaled commercial electrolyser, the system efficiently purifies 10 L of urine per cycle, with a high raw urine purification rate (97.41%), while producing H_2 at a rate of 115.84 L h^{-1}.

In a real wheatfield effluent scenario, the system demonstrates excellent cycling durability over 10 consecutive runs at a current density of 2,000 A m^{-2}, treating a total of 100 L of wheatfield effluent, yielding 48.27 L of H_2 with a wastewater purification rate of 90% per cycle, which contributes to green urea degradation.

While urine electrolysis shows a promising economic benefit compared to other electrolysis systems, several problems – such as long-term stability and the difficulties in urine collection – need to be solved.

Key Publication

Gao, X.; Hu, J.; Zhang, S.; Wang, P.; Wang, Z.; Chen, P.; Zheng, Y.; Qiao, S.-Z. Durable Natural Urine Electrolysis Enabled by Lewis Acid-Tailored Interfacial Microenvironment. *Advanced Materials* **2026**, *38* (9), e21945. https://doi.org/10.1002/adma.202521945.



A Lewis acid (LA)-tailored interfacial microenvironment strategy is proposed to engineer Ni-based catalysts, which selectively enriches interfacial OH^- while suppressing the adsorption of Cl^- impurities, thereby enabling durable natural urine oxidation reaction.

Research Highlight 7: COE-CSI Powering a Zero-Emissions Future

COE-CSI is delivering innovative and transformative solutions to turn waste into high-value materials and clean energy technologies, accelerating progress towards a sustainable, zero-emissions future.

These innovations represent more than laboratory achievements; they offer viable pathways towards Australia's net-zero economy. By harnessing the country's abundant solar energy, plastics, and agricultural wastes, these technologies could simultaneously reduce landfill accumulation, cut carbon emissions and create economic opportunities in green manufacturing.

Centre researchers are now working to scale up their processes and extend the concepts to other waste streams. They are actively seeking partnerships with industry and government to bring these technologies from lab bench to commercial reality.

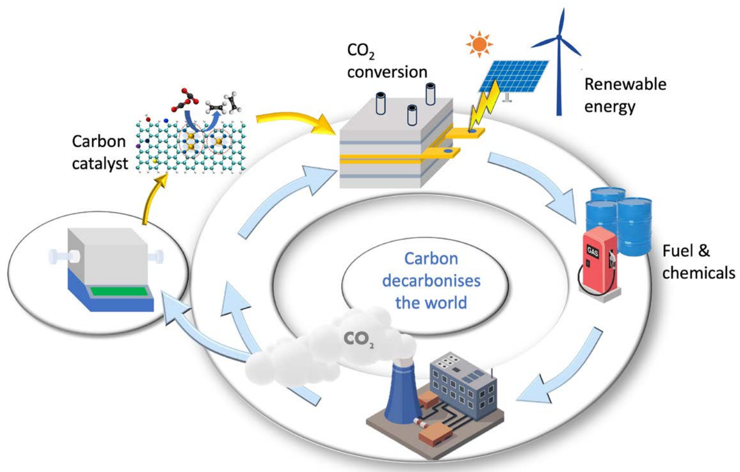
Four key projects are discussed here.

Case Study 1: Turning Carbon Dioxide Emissions into Solutions

As the world races to decarbonise, a team of researchers from COE-CSI has turned a critical challenge into an opportunity: transforming carbon dioxide (CO_2) into valuable carbon-based catalysts that could drive the production of sustainable fuels and chemicals. This innovative approach addresses climate goals while reducing dependence on expensive critical minerals.

The researchers want to find out if carbon itself, when used in important reactions, can help to reduce carbon dioxide gas output. The COE-CSI team – led by Chief Investigator Associate Professor Zhenhai Xia and Centre Director Professor Liming Dai, alongside six Chief Investigators and two HDR researchers – recognised that sequestering CO_2 alone would not reduce anthropogenic CO_2 levels sufficiently to prevent them from continuing to rise. To address this situation, the team first sought to convert CO_2 into high-performance catalysts that could transform carbon waste streams into fuels and chemicals. Achieving this would advance climate goals, drive materials innovation and contribute to a circular carbon economy.

The team's first achievement was to successfully make heteroatom-doped carbon catalysts, which are materials with nitrogen atoms that form highly active catalytic sites. These metal-free or metal-doped carbon catalysts offer cost-effective alternatives to expensive noble-metal catalysts.



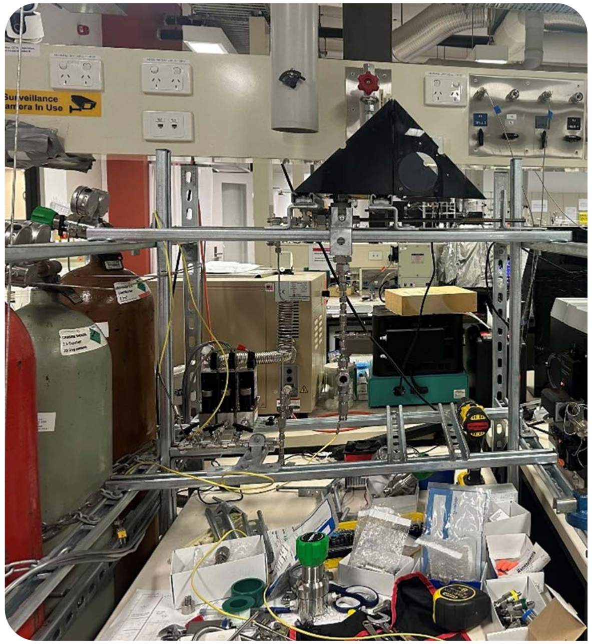
Emerging circular carbon economy: Transforming carbon emissions into carbon catalysts for sustainable energy and green chemistry – a novel strategy to use carbon in decarbonising the world. (Adapted with permission from AAAS.)

The researchers' next major challenge was to use such catalysts to convert carbon dioxide into larger organic molecules containing carbon–carbon bonds. Conventional processes require fossil-derived carbon monoxide and high energy inputs, making such processes unsustainable. One promising example employing a carbon catalyst is a nitrogen-doped graphene quantum dot catalyst that converts CO_2 into ethylene and ethanol – key building blocks for fuels and chemicals.

Through collaboration across catalyst design, reactor engineering and solar energy integration, the team is attempting to produce larger molecules by designing bifunctional catalysts that combine carburised metal active sites for CO_2 hydrogenation with acidic supports for hydrocarbon rearrangement. This would enable precise control over hydrocarbon chain length, targeting products such as sustainable aviation fuel (SAF).

To test these new catalysts, the researchers planned and made 'SAFire', a custom-built reactor with many new features. SAFire integrates advanced catalyst engineering with solar energy capture – both heat and visible light – under high-pressure conditions. Its sapphire-window reactor enables light-assisted reactions, while dynamic controls allow real-time optimisation. With comprehensive product analysis capabilities, SAFire rapidly evaluates gases, liquids and waxes produced during synthesis, accelerating the development process.

The significance extends beyond aviation fuel. By establishing a general framework for carbon–carbon and



A newly developed high pressure, high temperature photo-thermal carbon dioxide Fischer-Tropsch rig.

carbon–nitrogen coupling in CO_2 conversion, the team has paved the way for efficient production of diverse high-value chemicals. For example, catalysts have been synthesised to convert nitrogen-containing waste streams into ammonia and urea, essential for fertiliser and pharmaceutical production.

While scalability and cost challenges remain, CO_2-derived carbon materials offer distinct advantages, such as sustainable and renewable carbon sources that close the carbon loop while potentially reducing production costs through waste CO_2 utilisation. The team's journey, from discovering catalytic mechanisms to building specialised solar-powered reactors, demonstrates how collaborative research transforms scientific insights into real-world technologies.

The team is now pursuing patent protection and working to scale up the technology. Their goal is to establish partnerships for technology transfer, bring sustainable aviation fuel and carbon-neutral chemicals from the laboratory to commercial production, and thereby contribute meaningfully to global decarbonisation efforts.

Key Publication

Xia, Z.; Jin, H.; Zheng, Y.; Jiao, Y.; Qiao, S.; Gunawan, D.; Daiyan, R.; Amal, R.; Lawson, T.; Dai, L. Carbon Catalysts for CO2 Conversion: From Carbon Emissions to Zero-Carbon Solutions. *Science Advances* **2025**, *11* (47), eady9164. https://doi.org/10.1126/sciadv.ady9164.

Case Study 2: Transforming Peanut Shells into Graphene

Every year, around 55 million tonnes of peanuts are produced globally, leaving behind most of the waste from the shells. Most of these shells are either discarded or recycled into low-value applications that do not maximise their full potential. Researchers at COE-CSI, led by Chief Investigator Professor Guan Yeoh, are transforming these peanut shells into high quality graphene, often referred to as a 'wonder material'.

The development opens the door to cheaper, more sustainable electronics and energy storage devices, and could help transform agricultural waste into valuable products inside phones and computers that are used every day by billions of people around the world.

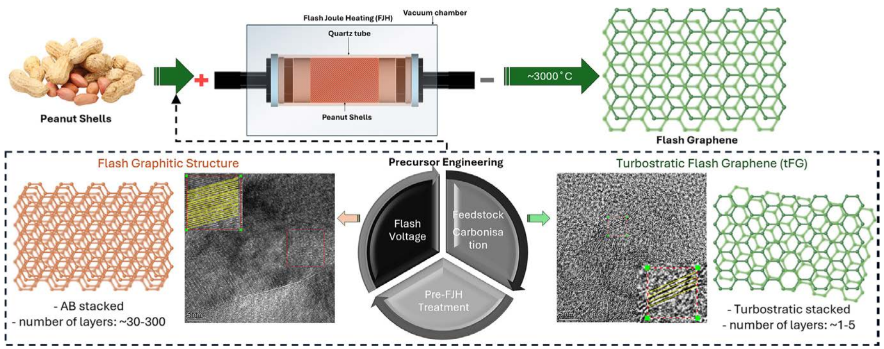
Traditionally, graphene production requires expensive equipment and prolonged high-temperature processing. Flash Joule Heating (FJH) is a process that heats materials to over 3000°C in mere milliseconds using electrical pulses. This changes the game by delivering extreme, instantaneous heat that reorganises carbon atoms into pristine graphene structures before they have time to clump together.

The breakthrough came from resolving a critical question: why did the process work brilliantly sometimes, but fail other times? COE-CSI postdoctoral researchers Dr Bo Lin and Dr Ivan Cordeiro discovered the answer lay in preparing the raw material appropriately before flashing. Through meticulous testing using advanced characterisation techniques available within COE-CSI – including Raman spectroscopy, electron microscopy and real-time electrical monitoring – they identified that rapid preheating created the ideal conductive state for successful conversion.

This optimised process transforms peanut shells into turbostratic graphene with exceptional quality: fewer defects, larger coherent domains and superior thermal stability than graphene produced by alternative methods. This high-performance graphene can reinforce composites in everything from car parts to construction materials and can serve as conductive fillers in next-generation batteries and electromagnetic shielding.

Key Publication

De Cachinho Cordeiro, I. M.; Lin, B.; Jia, M.; Wu, B. Z.; Yuen, A. C. Y.; Wang, C.; Yeoh, G. H. Precursor Engineering for Rapid Joule Heating Synthesis of Graphitic Carbon from Peanut Shells. *Chemical Engineering Journal Advances* **2026**, *26*, 101099. https://doi.org/10.1016/j.ceja.2026.101099.



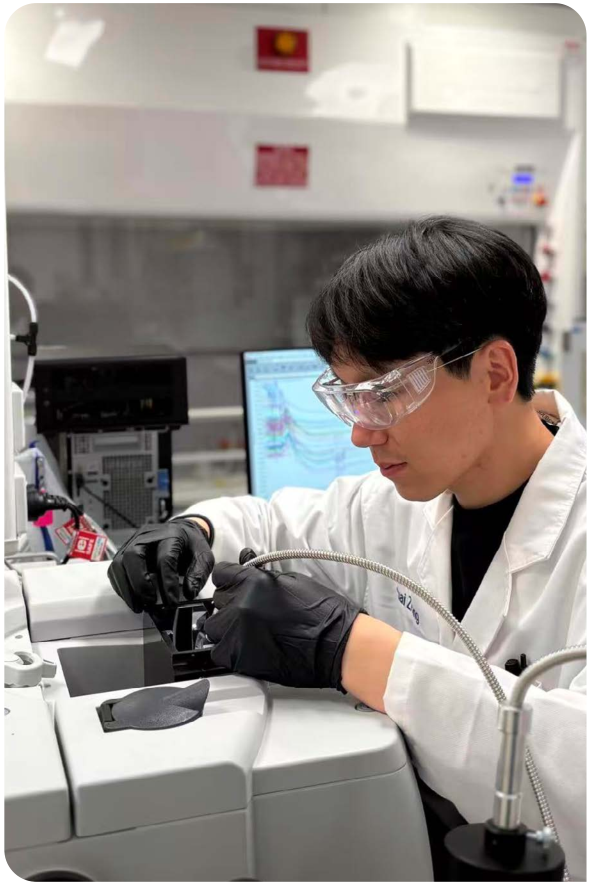
Conversion of peanut shells into flash graphene via the Flash Joule Heating process.

Case Study 3: Turning Plastic Bottles into Valuable Chemicals with Sunlight

Plastic waste remains one of the world's most pressing environmental challenges. In Australia alone, more than 84% of plastic waste ends up in landfill. Plastics are produced primarily from fossil feedstocks and contribute significantly to greenhouse gas emissions. Recycling plastic waste represents an important strategy for recovering waste carbon resources and mitigating environmental impacts.

At COE-CSI, Deputy Director Professor Shizhang Qiao and his team have developed a photocatalyst – essentially an artificial leaf – that uses sunlight to break down polyethylene terephthalate (PET) (the plastic in drink bottles and clothing) into two useful products: syngas (a building block for fuels and chemicals) and glycolaldehyde (a high-value intermediate for pharmaceuticals and biodegradable polymers).

The team engineered a sophisticated, 'all-in-one' catalyst featuring nickel boride and nickel borate arranged in a core-shell structure on cadmium sulphide. This design concentrates proton acceptors, electron acceptors and catalytic sites together, creating a molecular assembly line that efficiently channels electrons and protons to drive selective chemical transformations, preventing the formation of waste products like carbon dioxide while maximising valuable outputs. This work underscores the promise of solar photocatalysis for sustainable chemical production and solid waste recycling, while laying the foundation for future collaborations within the Centre.



COE-CSI postdoctoral researcher Dr Shuai Zhang in the lab at the University of Adelaide.

Key Publication

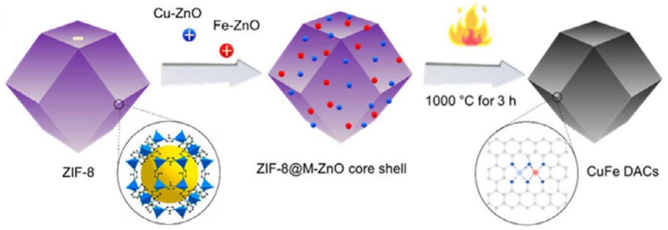
Zhang, S.; Gao, X.; Xia, B.; Slattery, A.; Ran, J.; Qiao, S.-Z. Artificial Photosynthesis of Glycolaldehyde and Syngas from Plastic Feedstocks via Boron-Functionalized Nickel Species on CdS. *Angewandte Chemie International Edition* **2025**, *64* (48), e202517025. https://doi.org/10.1002/anie.202517025.

Case Study 4: Turning Pollution into Products: The Power of Paired Atoms and a Pulsed Electrolyser

If farmers apply too much fertiliser, excess nitrogen that washes into rivers and groundwater can create pollutants and health risks. Additionally, production of the fertilisers themselves consumes enormous amounts of energy, primarily derived from fossil fuels. What if there were a way to solve both problems at once – converting the pollutant back into the product?

COE-CSI researchers, led by Deputy Director Professor Rose Amal AC and Chief Investigator Associate Professor Rahman Daiyan, have developed innovative catalysts that can transform nitrogen pollutants from wastewater into ammonia and urea fertilisers using only renewable electricity. It is a circular approach that tackles pollution while producing essential chemicals sustainably.

The secret lies in designing catalysts at the smallest possible scale. Traditional catalysts use single metal atoms scattered across a surface, which limits how precisely reactions can be controlled. The research team realised they could do better by pairing two different metal atoms right next to each other. Think of it like a relay: one metal atom grabs and activates the pollutant molecule, then hands it off to its partner atom to complete the conversion into useful products. This teamwork between atoms makes the whole process fast and efficient.



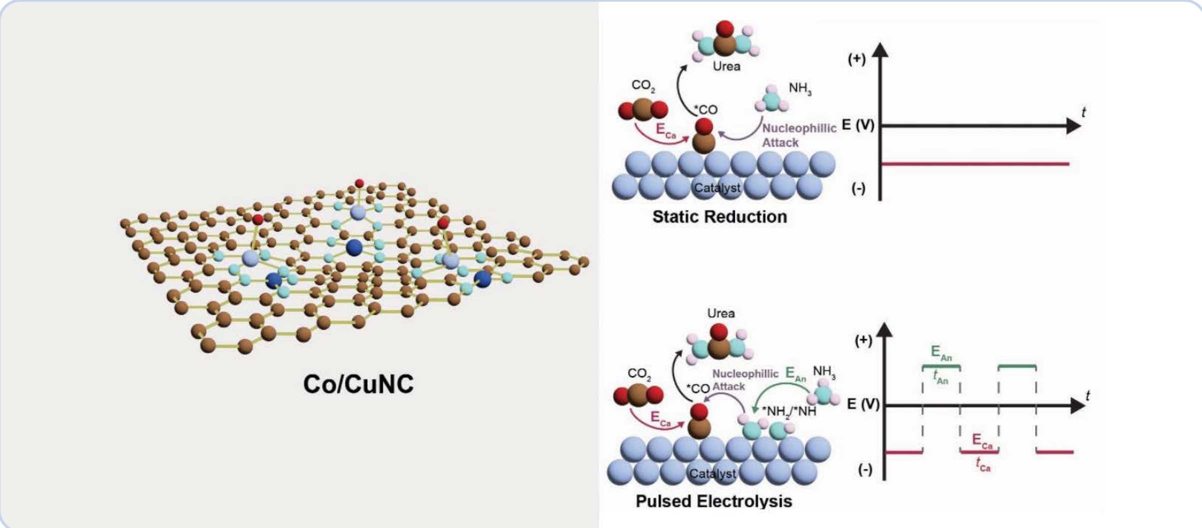
Rational design of dual-metal catalysts derived from metal-organic frameworks (MOFs) provides a pathway for developing dual-atom catalysts (DACs), which has the unique advantage of synergistic interactions between adjacent metal atoms that can precisely modulate the adsorption and activation of key intermediates, such as the N-intermediates during NO_3^-RR processes.

This approach was applied to address two major challenges. In the first, copper and iron atoms were paired to convert nitrate pollutants into ammonia. Using metal-organic frameworks as molecular scaffolding, the team created carbon structures that hold the two metals in perfect proximity. Advanced techniques that can monitor chemical reactions in real time revealed the division of labour: copper activates the nitrate ions, while iron helps convert them into ammonia. The results were impressive: 94% conversion efficiency with minimal wasted energy and almost no unwanted side reactions.

The second challenge was even tougher: combining carbon dioxide and nitrogen to make urea, the most commonly used fertiliser. Working with Centre Director Professor Liming Dai at UNSW and Chief Investigator Professor Yan Jiao from the University of Adelaide, the team discovered that traditional methods keep the catalyst in a single electrical state, which limits performance. The innovative solution was to pulse the electricity in carefully timed cycles. Using copper-cobalt atom pairs that can rapidly switch between different electronic states, they synchronised the formation of carbon and nitrogen building blocks that then couple together to form urea – achieving high yields of 295 mmol per hour per gram of catalyst.

The breakthrough was achieved through the realisation that the reaction steps had to be separated in time as well as space. Using sophisticated instruments available through the COE-CSI network, the team observed different molecular intermediates appear and disappear at different intervals during each electrical pulse. This dynamic approach enabled reactions that simply cannot happen under steady state conditions – a complete rethinking of how electrocatalysts could work.

Both catalysts can be manufactured using scalable methods, making them viable for industrial applications. The team is now exploring partnerships to test these technologies in wastewater treatment plants and decentralised fertiliser production facilities. By converting pollutants into products, and enabling chemical manufacturing powered by renewable electricity, this research shows how fundamental science can create tangible environmental and economic benefits.



Dual atom Cu–Co catalyst. The left panel illustrates the Co/CuNC catalyst structure, featuring atomically dispersed Cu and Co sites. The right panel compares C–N coupling mechanisms under conventional static electroreduction and dynamic pulsed electrolysis.

GOVERNANCE

Governance Structure

Our Centre's governance and leadership structure is designed to ensure the efficient operation of the Centre, maximise performance and support strategic planning, and support collaboration and engagement across all areas of the Centre.

Two external committees support the Centre's strategic development and provide external perspectives on the performance of its research programs.

Advisory Board

The Advisory Board plays a critical role in providing external feedback and advice to the Centre and its Director on strategies to extend linkages between academia, industry, government and other sectors at a national and international level, suggesting future visions for policy levers and industry trends, and fostering new connections.

The Advisory Board acts as an advocate for the Centre by helping to promote its work to key end-users, advising on the Centre's strategic plan, identifying risks and opportunities – including alerting the Centre to emerging funding streams or joint initiatives – providing guidance for the Centre's engagement in national and international initiatives, and offering advice for, and participating in, formal Centre reviews by the ARC, if required.

Advisory Board Members

Professor Bronwyn Fox AO
UNSW Sydney (Chair)

Professor Chennupati Jagadish AC
The Australian National University

Professor Max Lu AO
University of Wollongong

Dr Khalil Amine
Argonne National Laboratory

Professor Vicki Chen
The University of Queensland

Ms Helen Smith
Rio Tinto

Professor Andrea Ferrari
University of Cambridge

Advisory Board meeting with Centre Director and Deputy Directors

From left: Professor Shizhang Qiao, Professor Liming Dai, Dr Khalil Amine, Professor Vicki Chen, Professor Bronwyn Fox AO, Professor Chennupati Jagadish AC, Professor Andrea Ferrari, Professor Rose Amal AC, Professor Max Lu AO. Ms Helen Smith was unable to attend the meeting in person and joined online.

International Scientific Advisory Committee

Chaired by Nobel Laureate Professor Sir Konstantin Sergeevich Novoselov, the International Scientific Advisory Committee provides a global perspective on the Centre's scientific progress and research direction. The Committee also advises the Centre Director on important emerging directions and benchmarks the quality of the Centre's research against international standards.

International Scientific Advisory Committee Members

Professor Sir Konstantin Sergeevich Novoselov
National University of Singapore (Chair)

Professor Sir Richard Catlow
University College London

Associate Professor Daria Andreeva-Baeumler
National University of Singapore

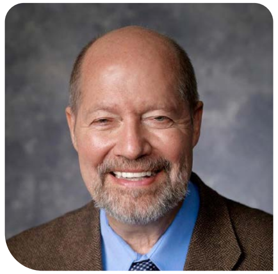
Professor Wei Huang
Nanjing Tech University

Professor Hui-Ming Cheng
Chinese Academy of Sciences

Professor Paolo Samorì
University of Strasbourg

Dr Esther Levy
Advanced Materials, Wiley

Vale Professor Ray Baughman



Professor Ray Baughman, an Associate Investigator and member of the COE-CSI International Scientific Advisory Committee, passed away in April 2025. He was the Robert A. Welch Distinguished Chair in Chemistry in the School of Natural Sciences and Mathematics and Director of the Alan G. MacDiarmid NanoTech Institute at the University of Texas at Dallas, USA.

Professor Baughman was a prolific inventor and scientist. His most recent research focused on developing new technologies for harvesting and storing waste energy, new types of artificial muscles, the fabrication, characterisation and application of carbon nanotube sheets and yarns, sensors, and new material synthesis.

COE-CSI members are profoundly grateful for Professor Ray Baughman's contribution to our Centre, especially his plenary speech during the ICACSI 2024 conference and his visit to our Centre in November 2024. His wisdom, generosity and unwavering encouragement influenced the scientific lives of many researchers.

Centre Executive Committee

The Centre Executive Committee, together with the Centre Director, has overall responsibility for the Centre's performance and for ensuring that its activities are conducted in accordance with the ARC Funding Agreement and the agreements with the Centre's collaborating organisations.

The Centre Executive Committee is composed of the Centre Director, who serves as the Committee Chair and carries overall responsibility for day-to-day leadership of COE-CSI and its research; the Deputy Directors; the sub-committee chairs; program leaders; an ECR/HDR representative; and the Chief Operating Officer.

Chair: Professor Liming Dai (UNSW)

Members:
Professor Rose Amal (UNSW)
Professor Shizhang Qiao (UoA)
Professor Yun Liu (ANU)
Professor Zhenhai Xia (UNSW)
Emeritus Professor Klaus Regenauer-Lieb (Curtin)
Professor Yan Jiao (UoA)
Professor Hui Tong Chua (UWA)
Dr Rahman Daiyan (UNSW)
Jane Su (UNSW)
ECR/HDR Representative: Dr Jingyi (Christine) Sun (UNSW)

Centre Sub-Committees

COE-CSI has three sub-committees and a Program Leadership Team (PLT), reflecting the Centre's areas of strategic focus that underpin the Centre's research and culture, support public outreach and facilitate research translation. Each committee also includes an ECR/HDR Representative, to reflect the voices of the Centre's junior researchers.

- Research & Innovation Committee (RIC)
- Equity, Education & Outreach Committee (EEO)
- Industry Engagement & Translation Committee (IET)
- Program Leadership Team (PLT)

Research & Innovation Committee (RIC)

Chair: Professor Shizhang Qiao (UoA)

Deputy Chair: Professor Yan Jiao (UoA)

Members: Professor Richard Tilley (UNSW), Emeritus Professor Klaus Regenauer-Lieb (Curtin) and Professor Liming Dai (UNSW)

ECR/HDR Representative: Dr Bo Lin (UNSW)

The RIC is at the forefront of driving innovation and research excellence within COE-CSI. Its primary role is to foster a culture of creativity, collaboration and impact.

Industry Engagement & Translation Committee (IET)

Chair: Professor Hui Tong Chua (UWA)

Members: Professor Guan Yeoh (UNSW), Associate Professor Zhenhai Xia (UNSW), Associate Professor Zi (Sophia) Gu (UNSW), Dr Wenxian Li (UNSW) and Dr Rahman Daiyan (UNSW)

ECR/HDR Representative: Dr Christopher Barnett (USYD)

The IET helps bridge the gap between research and industry, ensuring the real-world impact of the Centre's work.

Equity, Education & Outreach Committee (EEO)

Chair: Professor Rose Amal (UNSW)

Co-Chair: Associate Professor Simon Corrie (Monash)

Members: Professor Yao Zheng (UoA), Professor Yun Liu (ANU), Dr Emma Lovell (UNSW) and Dr Alexander Yuen (USYD)

ECR/HDR Representative: Dr Xiaochen Fu (Monash)

The EEO plays a crucial role in fostering a diverse, inclusive, and equitable environment within the Centre while also enabling effective outreach and education initiatives.

Program Leadership Team (PLT)

Leader: Professor Yun Liu (ANU)

Co-leader: Dr Rahman Daiyan (UNSW)

Members: The PLT comprises the co-leaders along with the two program leaders from each of the Centre's three research programs.

The PLT plays a key role in fostering collaboration across programs and within the Centre to boost scientific productivity.

PEOPLE

Centre Personnel: Key Figures

18 Chief Investigators

9 Partner Investigators

40 Associate Investigators

26 Postdoctoral Researchers

30 PhD Students

5 Masters by Coursework Students

2 Masters by Research Students

8 Honours Students

5 Professional Staff

Percentage of female postdoctoral researchers: **32%**

Percentage of female PhD students **39%**

Centre Personnel

Chief Investigators

ARC Laureate Fellow & Scientia Professor Liming Dai

Centre Director
UNSW Sydney

Scientia Professor Liming Dai joined UNSW in 2019 as an ARC Australian Laureate Fellow, Scientia Professor and SHARP Professor. Before joining UNSW, he spent two years in the Cavendish Laboratory (1990-1992) and 10 years with CSIRO (1992–2002). He was then an Associate Professor of Polymer Engineering at the University of Akron (2002–2004), the Wright Brothers Institute Endowed Chair Professor of Nanomaterials at the University of Dayton (2004–2009), and the Kent Hale Smith Professor in the Department of Macromolecular Science and Engineering at Case Western Reserve University (2009–2019). He is Director of the Australian Carbon Materials Centre (A-CMC), and Director of COE-CSI.

Professor Dai is recognised as an authority in the fields of carbon nanomaterials and carbon science. His expertise covers the synthesis, functionalisation, and device fabrication of conjugated polymers and carbon nanomaterials for energy conversion and storage, environmental remediation and biomedical applications. Professor Dai has published more than 700 refereed papers, with over 150,000 citations and an h-index of 196 (Google Scholar), and holds about 20 issued patents. He is a Clarivate Highly Cited Researcher in the categories of Materials Science and Chemistry. Among his many awards and recognitions, he received the IUMRS-Somiya Award from the International Union of Materials Research Societies (2019), the NASA Langley Henry J.E. Reid Award (2018) and an ARC Laureate Fellowship (2019). He serves as an Associate Editor of *Nano Energy*, the Special Chief Editor for Energy Materials of *Frontiers in Materials*, and was an Advisory Committee Member of the American Carbon Society. He is a Fellow of the Royal Society of Chemistry, Fellow of the National Academy of Inventors (USA), Fellow of the American Institute for Medical and Biological Engineering, Fellow of the Australian Academy of Technological Sciences and Engineering, Fellow of the Australian Academy of Science, Fellow of the European Academy of Sciences, and a Member of the Academia Europaea.

Scientia Professor Rose Amal AC

Deputy Director
UNSW Sydney

Professor Rose Amal AC is a UNSW Scientia Professor and was an ARC Laureate Fellow. A chemical engineer, and leader of the Particles and Catalysis Research Group, she is the Co-Director of the ARC Training Centre for the Global Hydrogen Economy (GlobH2E). She is the Powerfuels including Hydrogen Network (PFH2N) Lead for the NSW Decarbonisation Innovation Hub. Professor Amal is recognised as a pioneer and leading authority in the fields of fine particle technology, photocatalysis and functional nanomaterials, having made significant contributions to these related areas of research over the past 20 years. Her research contributions span fundamental chemistry to applied chemical engineering, from materials science and nano-research to specialised photochemistry. Her current research focuses on designing catalysts for solar and chemical energy conversion applications – including photocatalysis for water and air purification, water splitting, CO_2 reduction to make Syngas, and NO_x reduction to generate ammonia – and engineering systems for solar-induced processes that use the sun's energy as a clean fuel source. Professor Amal has received numerous prestigious awards including the 2023 Clean Energy Medal from the Institution of Chemical Engineers (IChemE), the James Cook Medal (2021) and the CHEMECA medal (2021). Professor Amal was named the 2019 NSW Scientist of the Year and was listed among Australia's Top 100 Most Influential Engineers (2012–2015).

ARC Laureate Professor Shizhang Qiao

Deputy Director
The University of Adelaide

Professor Shizhang Qiao is a Chair Professor at the School of Chemical Engineering and the founding Director of the Centre for Materials in Energy and Catalysis (CMEC) at the University of Adelaide (UoA). His research expertise lies in nanostructured materials for electrocatalysis, photocatalysis, batteries and other new energy technologies. He has co-authored 520 papers in refereed journals, with more than 160,000 citations, resulting in an h-index of 209. In recognition of his research achievements, Professor Qiao has been awarded several prestigious awards, including the inaugural ARC Industry Laureate Fellow (2023), the South Australian Scientist of the Year (2021), the inaugural Vice-Chancellor's Award for Excellence in Research at UoA (2019), ARC Australian Laureate Fellow (2017), ExxonMobil Award (2016) and ARC Discovery Outstanding Researcher Award (DORA, 2013). He is an elected Fellow of the Australian Academy of Science (FAA), a Fellow of the International Institute of Chemical Engineers (FIChemE), a Fellow of the Royal Chemical Society (FRSC), and a Fellow of the Royal Australian Chemical Institute (FRACI CChem). Professor Qiao is the Editor in Chief of *EES Catalysis* (RSC) and is recognised as a Clarivate Highly Cited Researcher (over 120 current ESI Top 1% highly cited papers) in three categories (Chemistry, Materials Science, and Environment and Ecology).

Professor Hui Tong Chua

The University of Western Australia

Professor Hui Tong Chua, PhD (NUS), M.Eng. (NUS), B.Eng (1st Class Hons, NUS), is Professor of Chemical Engineering and Head of Department of Chemical Engineering at UWA. His research interest covers Heat and Mass Transfer, Thermodynamics, Process Engineering, Waste Heat Utilisation, and Nanomaterial Syntheses. Six of his international peer-reviewed journal articles rank in the top 1% in the field of Engineering in terms of citations. One of his key research achievements is the successful spin-off of his catalytic methane cracking technology, now known as the Hazer Process, as Hazer Group Ltd, which raised $5 million in their Initial Public Offering on the Australian Stock Exchange (ASX: HZR) in November 2015. Professor Chua is one of the original inventors of the technology. He is the Chief Scientific Officer of Ablano Pty Ltd, which focuses on the commercialisation of few-layer graphene for electronic chip and consumer end product applications, and boron nitride nano-ions as a super lubricant for machinery and biomedical applications. He is also a Non-Executive Director of Good Water Energy Ltd, which is spearheading the development of baseload geothermal energy for steam, green hydrogen and ammonia applications.

Associate Professor Simon Corrie

Monash University

Associate Professor Simon Corrie completed his undergraduate degree in Chemical Engineering and PhD in Physical Chemistry at the University of Queensland, before undertaking postdoctoral studies at the HPV Research Laboratory at the University of Washington, Seattle.
After further postdoctoral studies in Australia developing microneedle arrays for wearable immunoassays, he joined the Chemical and Biological Engineering Department at Monash in 2016 to establish the Nanosensor Engineering Lab. He is a recipient of the Australian Research Council's DECRA Award and the 2018 Churchill Fellowship.
His research interests lie in developing engineered nanomaterials, coupling them with biological catalysts and binders, and using the resultant devices for applications in diagnostics and sustainable process engineering.

Dr Rahman Daiyan

UNSW Sydney

Dr Rahman Daiyan is a renewable energy and powerfuel specialist with a track-record in technology development, technoeconomic feasibility studies and technical design for government(s) and industry clients in Asia-Pacific and EU. He is a Senior Lecturer and Scientia Fellow at the School of Minerals and Energy Resources Engineering at University of New South Wales and an Australian Research Council (ARC) Discovery Early Career Researcher Award (DECRA) Fellow. He is the Deputy Lead for NSW Powerfuels including Hydrogen Network and is a Chief Investigator in the ARC Training Centre for Global Hydrogen Economy (GlobH2E), Australian Centre of Excellence for Carbon Science and Innovation, Australian Trailblazer Recycling and Clean Energy (TRaCE) Program, Australian research lead for Horizon Europe HyLuxValley, ARENA funded HyGate and OzAmmonia Project and lead for DCCEEW Green Iron Feasibility Study and Pacific Hydrogen Strategy. Dr Daiyan is co-founder of OzAmmonia, an ARENA backed spinout from UNSW.

Associate Professor Zi (Sophia) Gu

UNSW Sydney

Zi (Sophia) Gu is an Associate Professor and Head of NanoBiotechnology Research Laboratory at the School of Chemical Engineering of UNSW. After PhD training at the University of Queensland and Cornell University (USA), she was awarded an NHMRC Peter Doherty Biomedical Fellowship in 2014, prior to joining UNSW in 2016. Currently, she leads a NanoBiotechnology Research Group working on multidisciplinary research projects that combine knowledge and skills across material chemistry, biomedical engineering and nanotechnology. Her group has developed several nanoparticle platforms for disease diagnosis and treatment.

She has published over 70 research papers and filed a provisional patent. Most of these publications are in top-tier journals in the fields of Materials Science (*Advanced Materials, Advanced Functional Materials, Materials Horizons*), Nanotechnology (*Advanced Science, Small, Small Methods*), Chemistry (*Chemistry of Materials*), Biomaterials (*Biomaterials*), and Pharmaceutical Science (*Journal of Controlled Release, Pharmaceutics*). She has received several competitive grants and awards, and holds a number of academic leadership roles, including international conference chair and Associate Editor for the *Journal of Nanobiotechnology* (Springer Nature).

Professor Yan Jiao

The University of Adelaide

Professor Yan Jiao is Dean of the School of Chemical Engineering at Adelaide University and a leading researcher in computational electrochemistry and sustainable energy materials. She obtained her PhD in Chemical Engineering from The University of Queensland in 2012. She has been distinguished through numerous awards, including the Young Tall Poppy Science Award, Rising Star by *The Australian*, and finalist for the Malcolm McIntosh Prize for Physical Scientist of the Year in both 2022 and 2023.

Prof. Jiao's research focuses on designing catalyst materials and reaction environments for sustainable energy conversion through molecular modelling and computational chemistry. She has published more than 160 journal articles in leading journals, including *Nature Chemical Engineering*, *Nature Energy*, *Nature Communications*, *Journal of the American Chemical Society*, *Energy & Environmental Science*, and *Angewandte Chemie International Edition*. Her publications have attracted over 49,000 citations with an h-index of more than 80. Since 2019, Prof. Jiao has been listed annually as a Highly Cited Researcher in Chemistry by Clarivate Analytics.

Prof. Jiao has secured multiple nationally competitive grants as Lead Chief Investigator, including ARC Future Fellowship and Discovery Projects. She currently leads major national and international collaborations in computational catalysis and sustainable energy research.

Associate Professor Rakesh Joshi[2]

UNSW Sydney

Dr Rakesh Joshi is an Associate Professor in the School of Materials Science and Engineering at UNSW Sydney, where he leads the Graphene Research Group and serves as the Theme Leader for Energy and Environment. His research focuses on two-dimensional materials and advanced membranes for water purification, gas separation and clean energy applications. He holds a PhD in Semiconductor Physics from the Indian Institute Of Technology Delhi and was a Marie Curie International Fellow at the University of Manchester, where he worked with Nobel Laureate Sir Andre Geim.

Dr Joshi has published over 130 peer-reviewed articles, including more than 90 as lead or corresponding author, and holds five international patents. He has supervised more than 22 research students and secured major government and industry funding. He is a recipient of prestigious international fellowships, including the VAIBHAV Fellowship (India), Humboldt Fellowship (Germany), and JSPS Fellowship (Japan). He is a Fellow of the Royal Society of Chemistry and serves on the editorial boards of leading international journals.

2. Associate Professor Rakesh Joshi joined the Centre from 1 September 2025.

Dr Wenxian Li

UNSW Sydney

Dr Wenxian Li is a Senior Lecturer and an ARC Future Fellow in the School of Chemical Engineering at UNSW. He completed his undergraduate degree in Metallurgical Engineering at Northeastern University and his PhD in Materials Science and Engineering at the University of Wollongong (UOW). In 2011, he received the UOW Vice-Chancellor's Postdoctoral Research Fellowship, followed by an ARC Postdoctoral Fellowship (Industrial) in 2012. He then joined the University of Western Sydney as a Lecturer and was awarded an Australian Renewable Energy Agency (ARENA) Postdoctoral Fellowship. In 2015, he became a Professor of Special Appointment (Eastern Scholar) at Shanghai Institutions of Higher Learning, Shanghai University. Dr Li joined UNSW in 2022 and was awarded the ARC Future Fellowship in 2023. His research focuses on catalysts with low energy consumption and high mass exchange. He has published 10 book chapters and over 200 refereed papers on superconductors, solar energy and catalysts. He also serves on the Editorial Committee of the *Journal of Advanced Ceramics and Scientific Reports*.

Professor Yun Liu

The Australian National University

Professor Yun Liu is an internationally recognised applied materials chemist and ARC Georgina Sweet Laureate Fellow. She has a strong track record of influential work on the defect and crystal chemistry of functional materials, which revolutionises the design of novel materials for emerging technology and industrial applications. Professor Liu co-leads the Centre's Research Theme 1: Data-Driven Design, Precision Synthesis and Operando Characterisation of New Carbon Catalysts. She directs and drives a paradigm shift in carbon materials science by creating novel carbon catalysts with desired catalytic properties through precisely controlled catalytic active centres. Her research focuses on the development and utilisation of in situ characterisation techniques, improvement of the understanding of various carbon materials and catalytic mechanisms, and promotion of the application of emergent carbon-derived materials in energy and environment sectors. Professor Liu is also a dedicated podcaster who promotes women in STEM and inspires future generations of women in these disciplines.

Dr Emma Lovell

UNSW Sydney

Dr Emma Lovell is a lecturer in the School of Chemical Engineering at UNSW and a researcher in the Particles and Catalysis (PartCat) Research Group. Her research focuses on developing novel catalysts for a range of applications, with a particular focus on energy and environmental catalysis. Dr Lovell completed her PhD in 2016 at UNSW, developing catalysts for carbon dioxide conversion (with a research exchange at the University of Bremen). She was the recipient of the Women in Engineering Scholarship for the duration of her studies. Her PhD work focused on developing nickel-based catalysts for the carbon dioxide (dry) reforming of methane.

Currently, her research focuses on developing catalytic materials for a range of different energy inputs. This includes developing catalysts for the photo/plasmon-enhanced thermal catalytic carbon dioxide methanation and the plasma-catalytic carbon dioxide methanation and nitrogen fixation, as well as developing defective electrocatalysis for hydrogen evolution reaction as well as carbon dioxide reduction reactions.

Emeritus Professor Klaus Regenauer-Lieb[3]

Curtin University

Emeritus Professor Klaus Regenauer-Lieb is a highly distinguished Geophysicist and Applied Mathematician with more than 30 years of experience in Geothermal Energy and Reservoir Engineering, currently positioned at Curtin University (Emeritus Professor) and the University of New South Wales (Adjunct Professor). He is the Co-Lead for Program 2: Carbon Catalysts for Renewable Energy with Zero Emissions at COE-CSI. Professor Regenauer-Lieb is internationally recognised for pioneering multi-scale, multiphysics modelling of porous media based on fundamental physics, notably integrating Earth's heat, chemistry and mechanical behaviour. This expertise provides the essential numerical framework for understanding reactive transport and optimising the use of carbon materials in the Centre's quest for carbon-neutral energy solutions. His extensive academic career includes professor positions in Australia and Germany (UWA, UNSW, Curtin, Mainz) and postdoctoral research at the University of Minnesota, ETH Zurich and CSIRO.

3. Transitioned to Emeritus status in November 2025.

Professor Richard Tilley

UNSW Sydney

Professor Richard Tilley is Director of the Electron Microscope Unit at UNSW and a Professor in the School of Chemistry, having joined UNSW in 2015. The unit has 17 staff and over 20 electron microscopes including an aberration Transmission Electron Microscope (TEM) and cryo-TEM. His research involves the solution chemical synthesis and electron microscopy characterisation of nanoparticles. Applications of the nanoparticles range from electrocatalysis for fuel cells to magnetic nanoparticles for medical contrast agents. This research is becoming increasingly atomically defined, with ever-improving electron microscopes enabling the imaging of individual atoms, which in turn has led to the development of synthetic protocols to make atomically precise active sites for catalysis. He graduated with a Master of Chemistry from Oxford University and completed his PhD in the Department of Chemistry at the University of Cambridge, after which he was a Postdoctoral Fellow for two years at the Toshiba Basic R&D Center in Japan. From 2005, he spent 10 years in New Zealand as a Principal Investigator in the MacDiarmid Institute in the School of Chemical and Physical Sciences at Victoria University of Wellington, where he became Deputy Head of School and an Associate Professor.

Associate Professor Zhenhai Xia

UNSW Sydney

Associate Professor Zhenhai Xia is a Program leader at COE-CSI, and a Deputy Director of the Australian Carbon Materials Centre at UNSW. Before joining UNSW, he was a Full Professor jointly appointed to the Department of Materials Science and Engineering and the Department of Chemistry at the University of North Texas. His current research interests include multiscale and multi-physics modelling of clean energy conversion and storage, biological and bioinspired materials and surfaces, and mechanics of nanostructured materials/composites. He has authored one book, seven book chapters, and over 210 publications in peer-reviewed journals, including in *Science* and *Nature*. His work has been cited over 33,000 times and he has an h-index of 71 (2026 Google Scholar), with over 14 highly cited papers/hot papers selected by Web of Science. He was the recipient of 1997 Humboldt Scholarship award from the Alexander von Humboldt Foundation, Germany; the 2015 Nanoscience Research Leader Award from Science Letters, USA; the 2019 Somiya Award from the International Union of Materials Research Societies; and the 2020 Scientist Award from the International Association of Advanced Materials. He is also an Associate Editor of *Frontiers in Energy Materials*.

Professor Guan Yeoh

UNSW Sydney

Professor Guan Yeoh is a Chief Investigator at the Centre, and Director of two major centres in the Australian fire safety engineering landscape: the ARC Training Centre for Fire Retardant Materials and Safety Technologies, and the ARC Research Hub for Fire Resilience Infrastructure, Assets and Safety Advancements. Professor Yeoh received his Bachelor of Mechanical Engineering (Honours Class 1) and PhD in Mechanical Engineering (Computational Fluid Dynamics) from UNSW. He is a renowned expert in multiphase flows and has published a book titled *Computational Techniques for Multi-Phase Flows: Basics and Applications*, which has been widely read and cited extensively. He has also published other notable works including the highly cited book, *Computational Fluid Dynamics: A Practical Approach*. He manages significant industry-focused fire research projects including the development of carbon materials, green and durable polymer composites, next-generation fire suppression technologies, rapid-responsive sensors and early detection systems, and new flammability tests for compliance with fire safety regulatory standards. He has received four significant awards: Shaping Australia Awards (Winner, Problem Solver Category) in 2024; Australian Financial Review Higher Education Awards (Joint Winner, Research Commercialisation Category) in 2024; the Brennan Medal for the best book publication from the Institute of Chemical Engineers (IChemE) in 2009; and the NASA Award for novel research work in solidification in microgravity environment in 1992.

Dr Alexander Yuen

University of Sydney

Dr Alexander Yuen is a Senior Lecturer at USYD. He began his career as a Synthetic Organic Chemist and keen homogeneous catalysis end-user and subsequently moved into the fields of inorganic nanomaterials and catalysis. From 2012–2016 he was project leader for a Science & Industry Endowment Fund (SIEF) grant, *Advanced Catalytic Processes for Renewable Chemicals Manufacture* in collaboration with the CSIRO (Clayton), and industrial partner, Licella Holdings Ltd. Over the last 15 years, Alex has made significant contributions in the areas of catalytic nanoparticle and materials synthesis and characterisation; ionic liquid applications; supercritical solvent-based catalytic conversion of biomass for biorefinery applications; end-of-life plastic conversions; and on-water catalysis. In addition to being a Chief Investigator within COE-CSI, he is also Chief Investigator within the Solving Plastic Waste CRC, and is currently involved in developing electrocatalytic and plasma-based processes for the synthesis of ammonia from air and water. As a Group Leader in the Laboratory of Advanced Catalysis for Sustainability at USYD, Dr Yuen works closely with Professors Thomas Maschmeyer and Antony Masters.

Professor Yao Zheng

University of Adelaide

Professor Yao Zheng received his PhD in Chemical Engineering in 2014 from the University of Queensland under the supervision of Professor Shizhang Qiao. He is currently a Professor in the School of Chemical Engineering at UoA. He has worked for the past 15 years in electrocatalysis, combining experimentation and theoretical computation to drive discoveries in catalysis principles and catalyst design. He has developed new electrocatalyst candidates for various electrocatalysis applications, including oxygen-and hydrogen-involving reactions, CO_2 reduction, and other electrocatalytic refinery processes. Professor Zheng has published more than 150 research papers, which have attracted over 62,000 citations, with an h-index of 104. He has been recognised as a Clarivate Highly Cited Researcher (Chemistry) since 2019.

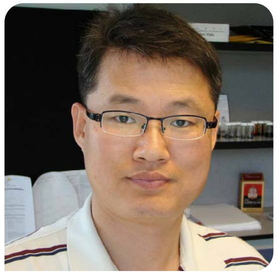
Group photo during the 2025 Centre Annual Conference.

Partner Investigators

Professor Markus Antonietti

Max Planck Institute of Colloids and Interfaces

Professor Markus Antonietti is an internationally recognised materials scientist. His research roots are in polymer science, and he developed his profile in modern materials chemistry, where sustainable processes and chemicals are a central theme. He has published around 650 papers and holds 90 patents, and has an h-index of 219. Professor Antonietti has been Director of the Max Planck Institute of Colloids and Interfaces, Germany, since 1993.



Professor Jong-Beom Baek

Ulsan National Institute of Science and Technology

Professor Jong-Beom Baek is a Distinguished Professor and Director of the Department of Energy and Chemical Engineering and the Center for Dimension-Controllable Organic Frameworks, Ulsan National Institute of Science and Technology, South Korea. His current research interests include the synthesis of two- and three-dimensional high-performance organic network structures and the chemical modification of carbon-based materials for multifunctional applications, including energy conversion and storage. He has authored or co-authored over 260 peer-reviewed publications in these areas. He has also registered and filed over 70 international and domestic patents, several of which have been transferred to industry for commercialisation. He also founded his own company, RuC2N.

Professor Manish Chhowalla

University of Cambridge

Professor Manish Chhowalla is the Research Area Lead for the Henry Royce Institute Atoms to Devices (A2D) Research Area. He is also Goldsmiths' Professor of Materials Science at the University of Cambridge and has research interests in the fundamental studies of atomically thin two-dimensional transition metal dichalcogenides (TMDs). In particular, his group studies the optical and electronic properties of different phases of 2D TMDs. He has demonstrated that it is possible to induce phase transformations in atomically thin materials and utilise phases with disparate properties for field effect transistors, catalysis and energy storage.

Dr Mei Gao
CSIRO

Dr Mei Gao is a Principal Research Scientist and Team Leader for the Printable Photovoltaics Team at CSIRO. Dr Gao's research interests cover several fields, including small molecule and polymer synthesis, surface modification, design and fabrication of high-sensitivity biosensors based on aligned carbon nanotube arrays and other nanomaterials. Her current focus is on the innovative design, fabrication and evaluation of organic solar cells and hybrid perovskite solar cells for large-scale roll-to-roll printing.

Professor Yury Gogotsi
Drexel University, Philadelphia

Professor Yury Gogotsi is a Ukrainian scientist in the field of Materials Chemistry and has been a professor at Drexel University, Philadelphia, since 2000 in the fields of Materials Science and Engineering, and Nanotechnology. Professor Gogotsi works on the synthesis and surface modification of inorganic nanomaterials, such as nanodiamond, carbide-derived carbons, nanotubes, and two-dimensional carbides and nitrides (MXenes). His group also explores energy-related and other applications of materials discovered and developed in the Gogotsi Lab. His work on carbon and carbide nanomaterials with tunable structure and porosity has had a major impact on the field of capacitive energy storage.

Professor Mietek Jaroniec
Kent State University

The research interests and activities of Professor Mietek Jaroniec and his group revolve primarily around the interdisciplinary topics of interfacial chemistry, and the chemistry of materials with ordered and disordered nanoporosity, with a special emphasis placed on physical adsorption at the gas/solid and liquid/solid interfaces, as well as synthesis, modification and characterisation of ordered and disordered nanoporous materials.

David Nguyen

N2N AI

David Nguyen works with world-class academic researchers, leading industry partners and tech startup founders worldwide to commercialise emerging Industrial Revolution 4.0 technologies – artificial Intelligence (AI), IoT, robotics and blockchain – and bringing them to life to change the world.

Dr Ajit Roy

United States Air Force Research Laboratory

Dr Ajit Roy has over 30 years' experience and research expertise in materials modelling and processing of structural, electronic and thermal properties of 3D porous nanostructures, 3D composites, carbon foam, and carbon–carbon composites. His current research encompasses experimentally validated nanomaterials design to tailor electrical, thermal, and mechanical properties with emphasis on atomic-scale hybrid materials design for tailored materials response. Prior to his time at AFRL, he was affiliated with the University of Dayton Research Institute (UDRI) for 10 years. His current research focus is in multifunctional materials, laser–materials interaction, strain-resilient electronics, energy transport in nanomaterials, behaviour and failure mechanisms in nanomaterials, and hybrid graphitic (carbon) foam.

Professor Boris Yakobson

Rice University

Professor Boris Yakobson's research interests are in the theory and modelling of structure, kinetics, and properties of materials derived from macroscopic and fundamental molecular interactions. He has conducted ground-breaking work on the physical properties of nanotubes, in particular their electro-mechanics, and more recently on graphene and graphane. Professor Yakobson is the Karl F. Hasselmann Chair in Engineering at Rice University. He holds a joint appointment with the Department of Materials Science and NanoEngineering and the Department of Chemistry. In 2008, he received a Nano 50 Award from the science magazine *Nanotech Briefs* for his innovation in nanotechnology, and in 2009, the Department of Energy R&D Award. He received his PhD in 1982 from the Russian Academy of Sciences. Professor Yakobson is an editorial board member of the *Journal of Nanoparticle Research* and is a member of the American Physical Society and the Electrochemical Society.

Postdoctoral Researchers

Dr Christopher Barnett
The University of Sydney

Dr Ling Chen
The University of Adelaide

Dr Quanbin Dai
UNSW Sydney

Dr Xiaochen Fu
Monash University

Dr Feiyue Gao
The University of Adelaide

Dr Xintong Gao
The University of Adelaide

Dr Denny Gunawan
UNSW Sydney

Dr Jinyang Guo
UNSW Sydney

Dr Lin Jiang
The University of Adelaide

Dr Yiran Jiao
The University of Adelaide

Dr Jiaxin Li
UNSW Sydney

Dr Yan Li
UNSW Sydney

Dr Bo Lin
UNSW Sydney

Dr Zhipeng Ma
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Dr Xiaojun (Carlos) Ren
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Dr Jingyi Sun
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Dr Bingliang Wang
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Dr Shuangyue Wang
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Dr Han Wu
The University of Adelaide

Dr Yuhan Xie
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Dr Cheng Yang
The Australian National University

Dr Yuwei Yang
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Dr Shaojian Zhang
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Dr Shuai Zhang
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Dr Zejun Zhang
The Australian National University

Dr Lingfei Zhao
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Dr Xiaoran Zheng
UNSW Sydney

Dr Shujie Zhou
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Curtin University

Adnan Ahmad
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Chaojie Chen
The University of Adelaide

Qianru Chen
The University of Adelaide

Ziyi Chen
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Adhy Prihatmiko Wibowo
UNSW Sydney

Singgih Wibowo
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Masters by Research Students

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Tayla Ray
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Hoang Phong Vo
The University of Adelaide

Julia Williams
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Administrative Officer
UNSW Sydney

Lucy Dinn
Communications and Media Officer
UNSW Sydney

Tammika Hutton
Node Administrator
The University of Adelaide

Dr Jason Major
Communications and Outreach Officer
Monash University

Jane Su
Chief Operating Officer
UNSW Sydney

From left: Gabriella Bate, Dr Jason Major, Jane Su and Tammika Hutton.

Associate Investigators

Professor Khalil Amine
Argonne National Laboratory

Dr Xiaowan Bai
The University of Adelaide

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University of Alabama at Birmingham

Dr Parama Banerjee
Monash University

Dr Stephen Byers
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Professor Victor Calo
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UNSW Sydney

Dr Timothy Bo Yuan Chen
City University of Hong Kong

Professor Yonghua Chen
Nanjing Tech University

Dr Chi (David) Cheng
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Dr Ka Yu Cheng
Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Dr Annie Colebatch
The Australian National University

Professor Nick Cox
The Australian National University

Dr Ulf Garbe
Australian Nuclear Science and Technology Organisation (ANSTO)

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Professor Chun-Hui Wang
UNSW Sydney

Dr Peter Whittaker
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Dr Anthony Chun Yin Yuen
Hong Kong Polytechnic University

Dr Qingfeng Zhai
UNSW Sydney

Capacity Building

Our Centre is dedicated to fostering capacity building by supporting research, professional development training, and mentoring, and providing diverse opportunities for all members. By empowering researchers at every stage of their careers, COE-CSI is building researcher capacity that will drive long-term impacts in carbon science and innovation.

Mentoring

Centre members are supported through a 'learning by doing' mentoring approach, where mentees gain hands-on experience by leading projects and initiatives, while learning from senior researchers. Some Centre Mid-Career Researchers (MCRs), mentored by the Centre's Deputy Directors, took leadership roles in sub-committees, building their leadership and networking skills under the guidance of senior leaders.

ECR and HDR committee representatives actively participated in Centre committee meetings, where they shared perspectives on researcher development, training needs, culture and engagement activities, ensuring the voices of emerging researchers were embedded in Centre planning and decision-making.

ECR and HDR representatives also played an important role in organising and delivering Centre events, including industry workshop and outreach activities. These experiences provided valuable organisational and engagement skills, while strengthening members' sense of belonging within the Centre community.

In 2025, COE-CSI joined the Mentorloop platform to support structured mentoring relationships across 16 ARC Centres of Excellence and Research Training Hubs nationwide. While uptake was slower than anticipated, the platform offers strong potential for facilitating connections with researchers and industry professionals. The Centre will review and reassess its engagement with Mentorloop in 2026.

Volunteer Impact: Building our Members' Confidence and Outreach Skills

In 2025, five volunteer Centre Early Career Researchers (ECRs) and Higher Degree by Research students (HDRs) supported Centre outreach events. Volunteers engaged the public and students at events such as *Science Alive!*, career expos and interactive student workshops.

We sought feedback from these volunteers to understand the impact of their experience conducting outreach. The following themes emerged from the data:

- **Understanding their audience:** Researchers began to learn how to distil complex science into messages that helped them to connect with their audience more effectively: 'I realised again how much simple, concrete language and small personal comments can make research feel more approachable and less distant.'
- **Understanding the value of dialogue:** Researchers realised that engagement is not a one-way delivery of information but rather, in the words of one volunteer, about 'connection and fostering understanding, which is a two-way engagement to bridge the gap of research and applications.'
- **Valuing communication skills:** Researchers gained skills which they saw as valuable and necessary to their future careers: 'This experience made me think of communication and engagement much more as a core part of my job rather than something optional. Being able to explain what we do and why it matters, in language that non-specialists can understand, is essential if we want our research to have real impact.'
- **Holistic perspective of their research:** This engagement experience, and learning to engage more effectively, facilitated their understanding of how the public perceive their research and how their research operates within society. They also came to appreciate why these things are important for effective engagement with, for instance, policy, industry and the community: 'One of the most insightful parts of the experience was hearing different perspectives, especially questions around the economic feasibility of our work. These conversations highlighted the importance of not only communicating what we do, but also why it matters and how it could be applied in the real world. Overall, the event reinforced the value of audience-specific communication and gave me a better understanding of how the public perceives and engages with scientific research.'

Training

COE-CSI provides a range of academic and professional training to equip members with essential skills and prepare them for future careers within and beyond academia.

Academic Publishing Panel Discussion

In February 2025, together with the ARC Training Centre for the Global Hydrogen Economy and Power Fuels Including Hydrogen Network, our Centre co-hosted a panel discussion on publishing in chemical engineering.

The panel brought together diverse voices from across the field to reflect on what truly matters in research dissemination today. While traditional metrics like journal impact factors are still part of the landscape, the panellists emphasised a more meaningful lens: the real-world impact of the work.

Panel members L–R: Professor Yijiao Jiang from Macquarie University, Editor, Carbon Capture Science and Technology; Scientia Professor Rose Amal AC from UNSW, Co-Editor-in-chief, Applied Catalysis B.; Associate Professor Carolina Belver, Executive Editor, Chemical Engineering Journal, Co-Editor in Chief, Applied Catalysis B.; Dr Emma Lovell from UNSW, Editor, Chemical Engineering Journal.; Dr Fengwang Li from University of Sydney, Editor, Materials Today Energy.; Panel moderator, Dr Priyank Kumar, UNSW.

Workshops with ANSTO

Early in 2025, Centre researchers benefitted from two valuable opportunities to engage with experts from our Centre Partner, the Australian Nuclear Science and Technology Organisation (ANSTO).

The first was a hybrid workshop held at UNSW and delivered by a team of ANSTO scientists, including Centre Associate Investigator Associate Professor Ulf Garbe. The workshop provided a comprehensive introduction to ANSTO's instruments and methodologies, along with practical guidance on proposal writing and funding processes. Participants also gained insights into neutron scattering techniques and the process of applying for beamtime at ANSTO's world-class facilities.

The second opportunity was a hybrid seminar delivered by Dr David Cortie at the Australian National University. The seminar attracted more than 30 students and staff, attending in person or online. Dr Cortie introduced the field of quantum beam science – spanning photons, matter waves, and spin-polarised particles such as muons, neutrons and X-rays – and outlined the relevant major infrastructure available to Australian researchers.

ANSTO workshop at UNSW campus.

Professor Richard Tilley leading a UNSW Analytical Centre tour for Centre members.

Infrastructure Facility Training

Several Centre researchers visited members at partner universities to access specialised facilities and expertise within the COE-CSI network, accelerating knowledge exchange and laying the foundation for future joint research and collaborative grant opportunities.

Centre Chief Investigator Professor Richard Tilley also delivered a training session on Advanced Electron Microscopy and led a UNSW Analytical Centre tour for Centre members.

ECR and HDR collaboration initiative

To support the development of future research leaders, the Centre launched an ECR and HDR Collaboration Initiative aimed at expanding networks and strengthening capability in joint project development.

ECR and HDR researchers formed four collaborative groups to share expertise and explore areas of common interest, with group leaders self-nominated. Each group was mentored by a Chief Investigator to support the development of ideas for potential collaborative grant proposals.

Chief Investigator Professor Yun Liu also delivered a proposal-writing workshop, introducing participants to research proposal development and the necessary steps involved in effective grant writing. Each group was further mentored by Centre Chief Investigators, who supported the proposal-development process.

The four resulting research proposals will be formally assessed for internal funding in 2026.

Panel members (from left to right): Advisory Board member Professor Vicki Chen, UNSW Dean of Engineering Professor Julien Epps, Centre Deputy Director Professor Rose Amal AC and moderator Dr Quanbin Dai.

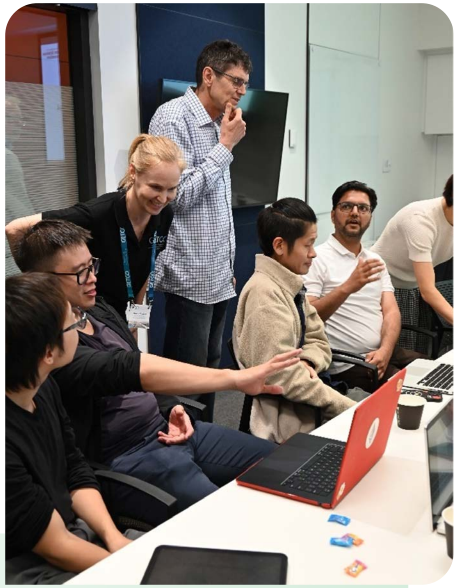
Leadership Training

COE-CSI held a panel discussion in November on 'Readiness to Be a Future Leader'.

At the COE-CSI Leadership Forum, our panel members Professor Rose Amal, Professor Vicki Chen and Professor Julien Epps shared powerful reflections on mentorship, leading with purpose, empowering others and building confidence into leadership.

Some key and valuable messages from the panel discussion were:

- Embrace both formal and informal mentors who can see your potential, inspire you, and help guide your journey.
- Leadership is not a title, a qualification or box you can tick. You can lead in many ways, big and small – by facilitating a group discussion, driving a project, supporting a colleague, or contributing to a solution.
- Know your values and why you lead: understanding your purpose shapes your direction and builds your confidence to lead.
- Trust what others see: sometimes others see strengths in you that you haven't yet recognised. Imposter syndrome is universal, but remembering your purpose and mission can help you build confidence. A good leader can also recognise their weaknesses and find a team that can support and complement them to become a stronger team.
- Transition from being the subject expert to being the translator and enabler: leaders don't need to be the smartest in the team but need to rely on and listen to the experts around them.
- Leadership is about uplifting others outside your discipline, and your immediate team. Good leaders advocate for the mission and empower their team to accomplish great goals together and make a greater impact.



Participants at the GETCO2 and COE-CSI joint communication training.

Communication Training

COE-CSI partnered with the ARC Centre of Excellence for Green Electrochemical Transformation of Carbon Dioxide (GETCO2) to deliver joint communication training to Centre ECRs and HDRs.

COE-CSI Communication and Outreach Officer Dr Jason Major highlighted the importance of science communication and provided practical strategies for translating complex research in a clear, accessible way.

GETCO2 Communications Advisor Anna Knudsen focused on building a strong professional presence on LinkedIn, guiding participants on how to optimise their profiles as researchers.

Equity, Diversity and Inclusion

COE-CSI is dedicated to fostering a workplace that embraces equity, diversity and inclusion, and has made great progress on these priorities in 2025.

Panellists L–R: Professor Cordelia Selomulya (Research and Commercialisation Director, Future Food Systems CRC; Associate Dean of Research), Associate Professor Zi Sophia Gu (COE-CSI Chief Investigator; Head of the NanoBiotechnology Research Laboratory), Dr Shujie Zhou (COE-CSI postdoctoral researcher), Erin Woods (Honours student in Chemical Engineering and Law), and moderator Dr Priyank Kumar (Scientia Senior Lecturer).

IWD 2025

To mark International Women's Day, COE-CSI co-hosted a morning tea and panel discussion about how to foster meaningful dialogue on gender equity in STEM and academia.

Panellists emphasised that success is deeply personal and can be difficult to define – it is qualitative and subjective. Progress towards individual goals, autonomy and fulfilment were each cited as key indicators. Discussions on being heard highlighted the importance of impact over volume, and the critical role leaders play in creating safe spaces where diverse voices are encouraged and respected.

Work-life balance emerged as a shared challenge, with panellists stressing the importance of defining personal priorities, setting boundaries and rejecting the pursuit of perfection. Balance, they noted, looks different for everyone. Looking to the future, panellists agreed that increasing women's participation in engineering requires early, effective outreach. Engaging girls from primary school onwards, reshaping perceptions of what engineering jobs look like, and showing how careers in engineering address societal problems were identified as essential.

Women of Colour in STEM

COE-CSI is dedicated to championing its members through awards and recognition. In 2025, the Centre nominated two female researchers for the Women of Colour in STEM Awards. Postdoctoral researcher Dr Shujie Zhou was selected as one of 10 finalists for the Rising Star Award at the 2025 Women of Colour in STEM Awards, presented by STEM Sisters. These awards celebrate the achievements, resilience and hard work of women of colour in the STEM field. Dr Zhou attended the awards gala dinner in October, and said, 'It was a wonderful night celebrating excellence, resilience and the inspiring journeys of so many incredible women.' Dr Zhou, who is a mentor and supervisor in her own right, expressed gratitude to her own mentor and supervisor, COE-CSI Chief Investigator Professor Rose Amal AC.

Dr Shujie Zhou at the 2025 Women of Colour in STEM Awards as a finalist for the Rising Star Award.

Carers Grants

COE-CSI offers funding to members with caring responsibilities and/or living with disability, to help ensure that they can participate equitably in Centre events and conferences, as well as attend external conferences and/or visit international partner institutions. The Centre recognises that primary caregivers and people living with disability can miss professional opportunities that would enhance the momentum of their research productivity and strengthen their research profile. This funding benefits both the individual and the Centre at large, as the increased ability of each Centre member to interact and collaborate with as many other members as possible serves to improve the research and development of all involved.

InSTEM conference

InSTEM is a national conference for members of ARC Centres of Excellence and is dedicated to advancing equity, diversity and inclusion (EDI) for marginalised and underrepresented people in STEM, while supporting those seeking to become stronger allies. COE-CSI representatives attended the 2025 conference in Melbourne.

The two-day program featured keynote addresses and panel discussions focused on inclusive leadership, allyship, wellbeing and practical strategies for creating equitable research environments.

The conference opened with a keynote by Professor Emma Lee OAM, a Trawlwulwuy woman from Tebrakunna country in Lutruwita/Tasmania. Drawing on over 25 years of work in Indigenous affairs, land and sea management, and governance, Professor Lee challenged traditional research approaches in her address on decolonising research. She emphasised the importance of respect, relationships, and empathy – approaches grounded in kinship rather than confrontation – to achieve lasting change.

Supporting culturally and linguistically diverse (CALD) researchers was a key theme of the conference. A panel of CALD women shared their experiences in STEM and highlighted the importance of recognising unconscious bias and embedding inclusive policies and structures. Organisations need to actively implement policies and structures to mitigate (un)conscious biases; as the panellist Dr Ruwangi Fernando said, 'Diversity is a fact, and inclusion is a choice'.

Other panels and talks explored the experiences of trans, gender-diverse and gender-fluid people in STEM fields (and particularly in ARC Centres of Excellence); the experiences of neurodivergent individuals; and mental wellbeing and burnout in academia. Speakers highlighted the importance of intersectional policies, support from the highest levels of leadership, and a culture which embraces diversity of people and experiences.

COE-CSI Communications and Outreach Officer Dr Jason Major (left) and Chief Operating Officer Jane Su (right) at the 2025 inSTEM conference in Melbourne.

2025 Annual Survey

In 2025, the Centre introduced its annual survey, which aims to help shape the Centre's future priorities and strengthen its culture, collaboration, engagement and operations. All members were invited to anonymously complete the short survey following the annual conference, with 25 responses received from all levels and roles across the Centre. The survey was kept short to maximise participation, and solicited feedback across all areas of the Centre, including the fortnightly seminars, the Centre culture, the respondent's own identity and involvement with Centre activities, and their suggestions for future offerings and directions. The insights gathered will help to guide the Centre's direction, with some feedback already used to refine the structure and plan for PLT seminars in 2026, as well as the design of forthcoming funding opportunities.

ENGAGEMENT

COE-CSI is proudly working together with government, industry, universities and the wider community for positive impact. This year, we conducted a wide range of events targeted at the public, school students, industry, and government, and held knowledge-sharing sessions with world leading experts in the carbon field.

Industry and Government Engagement

Dr Rahman Daiyan sharing insights at the Centre's Industry Engagement Workshop.

COE-CSI hosted its first Industry Engagement Workshop in October, bringing together Centre researchers with government and industry partners to explore shared challenges and opportunities in carbon materials, energy storage and low-carbon fuel production. The workshop marked an important step in strengthening two-way engagement and accelerating pathways to impact.

The Centre welcomed guest speakers including Thomas Gao (NSW Office of the Chief Scientist & Engineer), Peter Morrissey (HunterNet Co-operative), Gabriella Nunes (Trailblazer for Recycling and Clean Energy (TRaCE)), and Sam Evans (Cruxes Innovation). Through a series of presentations and roundtable discussions, Centre members gained valuable insights into NSW Government decarbonisation initiatives and industry perspectives on research gaps, commercial opportunities and emerging priorities.

A key focus of the workshop was research translation. Speakers shared practical advice on engaging effectively with industry, emphasising the value of early involvement of partners and end users, communicating impact in industry-relevant language, and balancing 'research creation' with 'research adoption'. Discussions highlighted the essential role of collaboration between research, industry and government in enabling advances across clean energy technologies.

The workshop fostered meaningful connections, showcased the breadth of Centre research and reinforced the importance of sustained, genuine engagement in driving Australia's transition to a low-carbon future.

Partner Investigator Professor Boris Yakobson visited CSI team in Perth.

Academic Engagement

COE-CSI researchers had a productive year, engaging with the academic community to share knowledge and build collaborations.

The Centre continued its Signature Seminar Series in 2025, where high-calibre international researchers presented their research findings to the wider academic community in carbon science and innovation. The seminars facilitated knowledge sharing and collaboration among researchers within and outside the Centre, as well as with industry partners.

Centre members also actively participated in national and international conferences, presenting their research through talks and posters, and contributing to discussions on emerging developments in carbon materials and clean energy technologies. Researchers were also invited to deliver seminars and guest lectures at leading universities and research institutions, strengthening the Centre's academic profile and fostering new collaborative opportunities.

ACS Nano Summit

In November, COE-CSI held a half-day session at ACS Nano Summit 2025 in Sydney. The event brought together more than 100 researchers, entrepreneurs, students and industry leaders to explore frontier developments in nanotechnology across critical sectors including genomics, medicine, renewable energy, decarbonisation, advanced semiconductors, AI and environmental engineering.

Centre Advisory Board members Professor Chennupati Jagadish AC, Dr Khalil Amine, and Professor Andrea Ferrari; Director Scientia Professor Liming Dai; Chief Investigators Associate Professor Rakesh Joshi and Associate Professor Zi Sophia Gu; postdoctoral researcher Dr Shuangyue Wang; and Associate Investigator Dr Qingfeng Zhai presented their research at the Summit, showcasing the impact and innovation of COE-CSI research.

Chief Investigator Associate Professor Rakesh Joshi at ACS Nano Summit 2025.

Centre Advisory Board member Professor Andrea Ferrari at ACS Nano Summit 2025.

Chemeca 2025

COE-CSI Chief Investigator Professor Yan Jiao was the Conference Co-Chair for Chemeca 2025. Chemeca is one of the largest annual chemical engineering conferences in Australasia for academia and industry. Centre postdoctoral researchers Dr Yiran Jiao and Dr Ling Chen both delivered oral presentations, while the Adelaide node of COE-CSI had an exhibitor's booth to engage with conference attendees.

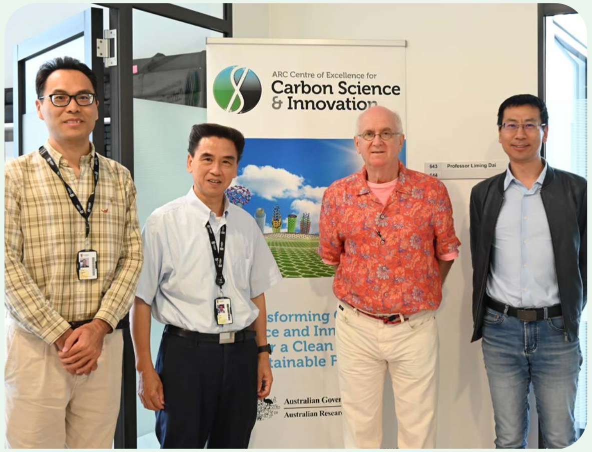
Chief Investigator Professor Yan Jiao speaking at Chemeca 2025 as the Conference Co-Chair.

Centre Signature Seminars

Centre Partner Investigator Professor Boris Yakobson from Rice University visited our Centre in December 2025.

Professor Boris Yakobson presented a seminar, 'Blending "Interesting" vs "important": theory insights on carbon, borophene, and... ceramics', during his visit to Sydney. Following his Signature Seminar, Professor Yakobson conducted a series of small group meetings and workshops in Sydney, Adelaide and Perth. These highly valued sessions provided Centre members with important opportunities for constructive dialogue with Professor Yakobson about research ideas and challenges.

Adnan Ahmad, a PhD candidate with COE-CSI at the Australian National University, attended Professor Boris Yakobson's seminar remotely. He reflected, 'the seminar provided a valuable theoretical perspective on how to link fundamental materials questions to technology-driven challenges. In particular, the discussion of chirality/helicity control in carbon nanotubes and the broader perspective on emerging materials like borophene were especially engaging. As I am currently working on carbon nitride–based materials, the seminar reinforced the broader role of theory and modelling in guiding materials design and processing strategies. I found the emphasis on concepts such as molecular interaction, kinetics and structure–property relationships helpful, and it encouraged me to think more critically about the fundamental structural understanding I am developing in my own work.'



From left to right: Centre Associate Investigator Dr Qingfeng Zhai, Director Professor Liming Dai, Professor Boris Yakobson, and Chief Investigator Dr Wenxian Li.

COE-CSI welcomed Distinguished Professor Ica Manas-Zloczower from Case Western Reserve University during her sabbatical leave.

Professor Ica Manas-Zloczower presented her seminar, 'Towards a Circular Carbon Economy: Recycling Thermoset Waste via Dynamic Chemistry', and met with many Centre members during her sabbatical leave at UNSW.

Dr Aditya Rawal, a Senior Lecturer and researcher at the Nuclear Magnetic Resonance Facility within the Mark Wainwright Analytical Centre at UNSW Sydney, attended Prof Manas-Zloczower's seminar. He said, 'I have a good background in polymer science, and am well acquainted with thermoplastics, thermosets and elastomers, in terms of their structure and properties. However, the talk that Ica presented was on a completely new class of recyclable polymers called vitrimers, which I had not heard of before. More fascinatingly, the talk presented a way to form these vitrimers by recycling thermosetting polymer, which, as a convention, are not recyclable! Interestingly, there is a significant gap in knowledge regarding the molecular structure of the vitrimers. Pursuant to the talk, Ica was very generous with her time, and we've launched what I hope will be a very fruitful collaborative project. I'm looking forward to receiving the first samples from her group in the coming week or so. I'm very excited to see what insights we can obtain.'

Professor Gary Wnek from Case Western Reserve University visited our Centre.

Professor Gary Wnek visited our Centre during his trip to Australia and later delivered a seminar, ‘Approaches for Valorization of Polyolefins and Blends: Some New Ideas Related to Metal Ore Processing’.

Dr Zhipeng Ma, a researcher in the School of Chemical Engineering at UNSW and a Research Fellow with COE-CSI, attended the virtual seminar and said: ‘Professor Wnek’s presentation was truly inspiring, particularly in the development of robust and sustainable plastic materials. The discussion between Professor Wnek and Professor Liming Dai also highlighted the potential of waste plastics as an alternative to conventional coal fuels. Beyond that, our Centre’s expertise offers pathways to convert waste plastics into value-added materials or chemicals. Australia has led global efforts in reducing the use of single-use plastic bags and related products in recent years. However, during my recent visit to the United States, I observed that plastic usage remains widespread. While we as chemical engineering researchers may not directly influence policy on plastic use, we can contribute by advancing technologies that transform plastic waste into valuable resources – promoting global sustainability through innovations in carbon science.’

Centre Postdoctoral Researcher Dr Shujie Zhou visited GETCO2 at the University of Queensland.

COE-CSI Visits to Other Carbon Centres

COE-CSI Centre Director Professor Liming Dai visited Wenzhou University and was the Co-Chair for the World Young Scientist Summit, which was held in China. This summit provided a platform for sharing cutting-edge research, fostering collaborations and discussing innovative solutions to global carbon and energy challenges.

Centre postdoctoral researcher Dr Shujie Zhou visited the ARC Centre of Excellence for Green Electrochemical Transformation of Carbon Dioxide (GETCO2) at the University of Queensland. Dr Zhou met with GETCO2 researchers, including Centre Director Professor Xiwang Zhang, and visited their laboratory facilities. Dr Zhou also delivered a seminar highlighting her research, introducing her research group, and outlining the goals and vision of COE-CSI.

Public Engagement

Our Centre's mission in public engagement is to go beyond just informing people about the science. Public engagement is our opportunity to facilitate a critical dialogue with our audiences, allowing them to think critically about our research and its implications.

With school outreach, our outreach objectives extend to affecting science literacy and developing an increased understanding of chemical engineering, both as a discipline and as a career opportunity. Our approach emphasises interactive and inclusive engagement, particularly with school students, where hands-on workshops – led by Centre Communications and Outreach Officer Dr Jason Major – create meaningful learning experiences.

COE-CSI is also committed to supporting equity and participation in STEM. We actively promote the involvement of women in science and engineering by ensuring strong representation of female researchers in outreach activities, providing visible role models for future generations.

PhD student Peiqi Qiu engaging children with an interactive demonstration at Science Alive! during National Science Week.

Science Alive!

Held in Adelaide, Science Alive! is a three-day public science festival held as part of National Science Week.

COE-CSI collaborated with the ARC Centre of Excellence for Green Electrochemical Transformation of Carbon Dioxide (GETCO2) to develop an interactive exhibit for the event that would engage participants' minds with our Centres' key challenge of using carbon to solve the carbon problem.

Day one of the event was dedicated to schools and teachers, with more than 5,000 students and teachers participating. The final two days were open to the public and attracted 17,000 visitors.

Our engagement elicited a definitive shift in visitor awareness and thinking about carbon, and about electrocatalysis and its potential as an energy-efficient way to convert carbon dioxide and other chemicals into useful products.

Among the approximately 400 visitors we directly engaged with over the three days, there was typically no prior understanding of electrocatalysis and catalysts. Via a constructive dialogue, visitors thought critically about the meaning and value of GETCO2 and COE-CSI research. They perceived this meaning and value through social, economic and technical lenses, with the following themes emerging from the evaluation data:

- **A sense of urgency:** People perceived an urgent need to solve the climate change and sustainability problem. This urgency saw a call to arms for change.
- **A need for dialogue:** People wanted more public dialogue about these issues, which included our Centres' research.
- **Opportunity:** People saw an economic and technical opportunity for our Centres' research to be translated into something of value.
- **Hope:** People expressed that our research can make a difference and help solve the above problems.

Centre postdoctoral researcher Jingyi Sun delivering a live demonstration for students at the #WithSTEMYouCan Careers Expo in NSW.

#WithSTEMYouCan Careers Expo

COE-CSI was among 115 STEM professional organisations to present interactive exhibits and workshops at the CSIRO and NSW Government's #WithSTEMYouCan Careers Expo in Penrith, NSW.

More than 730 Year 7–10 students from 18 schools participated in the event.

Our main objective in attending this event was to affect student understanding of chemical engineering as a discipline and as a career opportunity. Further, COE-CSI deliberately sought a female volunteer to enable female students to see a place for themselves in STEM, especially in the physical sciences and engineering.

School Outreach

In 2025, the Centre developed its first curriculum-aligned student workshop and teacher resources.

Using a combination of a hands-on experiment and critical thinking activities, we developed the 'Elephant's Toothpaste' workshop to engage Year 9 students with the concept of catalysis and its implications in the production of our fuels, food and medicine.

We worked with two schools to conduct pilot workshops to test and evaluate the different elements of the workshop. The first pilot was conducted with Keysborough College in Melbourne and the second with Roseville College in Sydney.

Data from the evaluations we conducted suggests the workshop positively affected student literacy about catalysis. Before the lesson, few students were unable to articulate in any depth the nature of a chemical reaction or catalysis. A small proportion of Roseville College students were the exception, with two students able to link catalysis with speeding up a chemical reaction, and one of those students understanding its link to activation energy.

Roseville College students had sufficient time to complete worksheets at the end of the workshop. Student responses on the worksheets suggested that all students understood that catalysts lower the activation energy. One student was able to make a connection between lower energy and greater sustainability, while all students understood the importance of surface area in catalytic design. Nearly all students understood that the concentration of reactants, temperature and pressure can affect the rate of reaction.

At both schools, the students engaged positively with the hands-on experiment and teachers noted that the workshop has definite value for this year level.

Centre postdoctoral researcher Bo Lin leading a hands-on catalysis workshop with students at Roseville College.

BrainSTEM and Monash University Laboratories Visit

COE-CSI Communications and Outreach Officer Dr Jason Major mentored six year 9 students participating in the 12-week BrainSTEM Innovation Challenge during Term 3, 2025.

As part of the Challenge, the six students and two teachers from Our Lady of Mercy College visited Monash University to meet Centre members and learn more about current scientific research and innovation. Centre Research Fellow Dr Xiaochen Fu, Centre Associate Investigator Dr Parama Banerjee, and Dr Jason Major conducted guided laboratory tours and led in-depth discussions about the breadth and implications of their research, as well as related research activities at Monash University.

During the visit, the students and teachers learned about research investigating ways to transform coffee grounds and biowaste into carbon materials capable of converting carbon dioxide into useful fuels, develop enzymatic biosensors, and apply interdisciplinary approaches that bring together expertise across medicine, engineering, chemistry, biology, and physics. The experience and discussions challenged the students' perceptions of scientists and the purpose of their research. It also collaborative scientific research can address global challenges including climate change, renewable energy, and cancer treatment.

Communications and Media

COE-CSI has devoted significant effort towards effective communication with its members, stakeholders and broader public audiences.

> A key aim of the Member Spotlight Initiative is to strengthen connections between internal and external audiences, support collaboration by highlighting research interests and achievements, and contribute to building a stronger sense of community among members.

Website, newsletters and social media

The Centre's website serves as its digital home: showcasing research, highlighting centre members and promoting engagement with stakeholders. In 2025, the website attracted approximately 9,700 active users worldwide. The largest proportion of active users came from Australia (36%), followed by China (19%) and the United States (16%).

The Centre's social media presence was primarily maintained through LinkedIn. Our Centre attained 478 new followers, reaching 1,600 followers in total by the end of 2025.

Centre newsletters are published monthly and alternate between an internal newsletter to just members and an external newsletter to both members and external subscribers, including partners. COE-CSI continued its Centre Member Spotlight initiative in the 2025 newsletters. Twelve members were featured, showcasing the diverse expertise within the Centre and exposing individual researchers to our members and wider audiences. A key aim of the Member Spotlight is to strengthen connections between internal and external audiences, support collaboration by highlighting research interests and achievements, and contribute to building a stronger sense of community among members.

Internal newsletters achieved a 75% open rate and external newsletters a 67% open rate. Based on our 2025 annual centre survey (N=24), 38% of respondents read every newsletter and 21% skim read each one, reading the stories of interest.

9,700
active website users worldwide

478
new followers

1,600
total followers

75%
internal e-news open rate

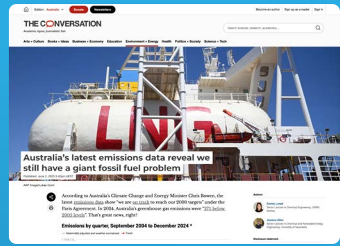
67%
external e-news open rate

5
news stories distributed

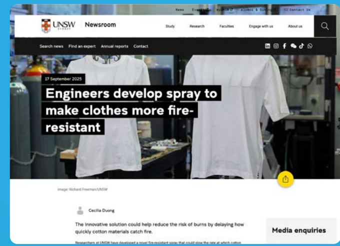
130
media outlets and journalists

Media

Our researchers were featured across several media outlets in 2025, including Channel 9 News and The Conversation. In addition, the Centre began translating major research publications into news stories for media audiences. Five stories were produced and distributed to targeted media outlets and journalists, resulting in their publication across 130 outlets and social media posts worldwide. All five stories were also published on Phys.org, where they attracted 17,000 views and were shared a further 316 times across various social media platforms, demonstrating the potential for our media content to reach audiences well beyond the 130 recorded pickups.

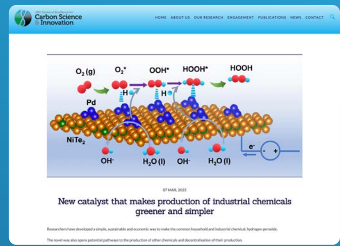


Australia's latest emissions data reveal we still have a giant fossil fuel problem
2 Jun 2025, The Conversation



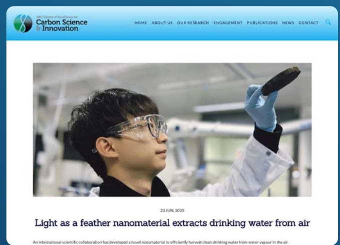
Engineers develop spray to make clothes more fire-resistant
17 Sept 2025, UNSW Newsroom

2025 Malcolm McIntosh Prize for Physical Scientist of the Year
Australian Government Department of Industry, Science and Resources

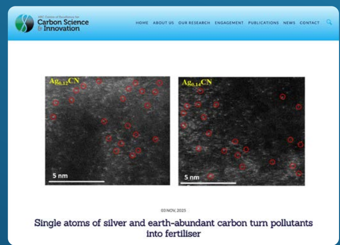


New catalyst that makes production of industrial chemicals greener and simpler
7 Mar 2025, COE-CSI

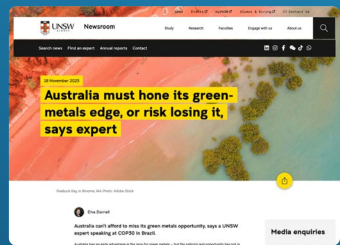
Urine, not water for efficient production of green hydrogen
5 May 2025, COE-CSI



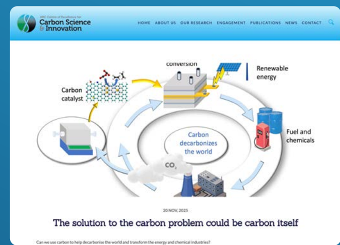
Light as a feather nanomaterial extracts drinking water from air
23 Jun 2025, COE-CSI



Single atoms of silver and earth-abundant carbon turn pollutants into fertiliser
3 Nov 2025, COE-CSI



Australia must hone its green-metals edge, or risk losing it, says expert
18 Nov 2025, UNSW Newsroom



The solution to the carbon problem could be carbon itself
20 Nov 2025, COE-CSI

PERFORMANCE

80
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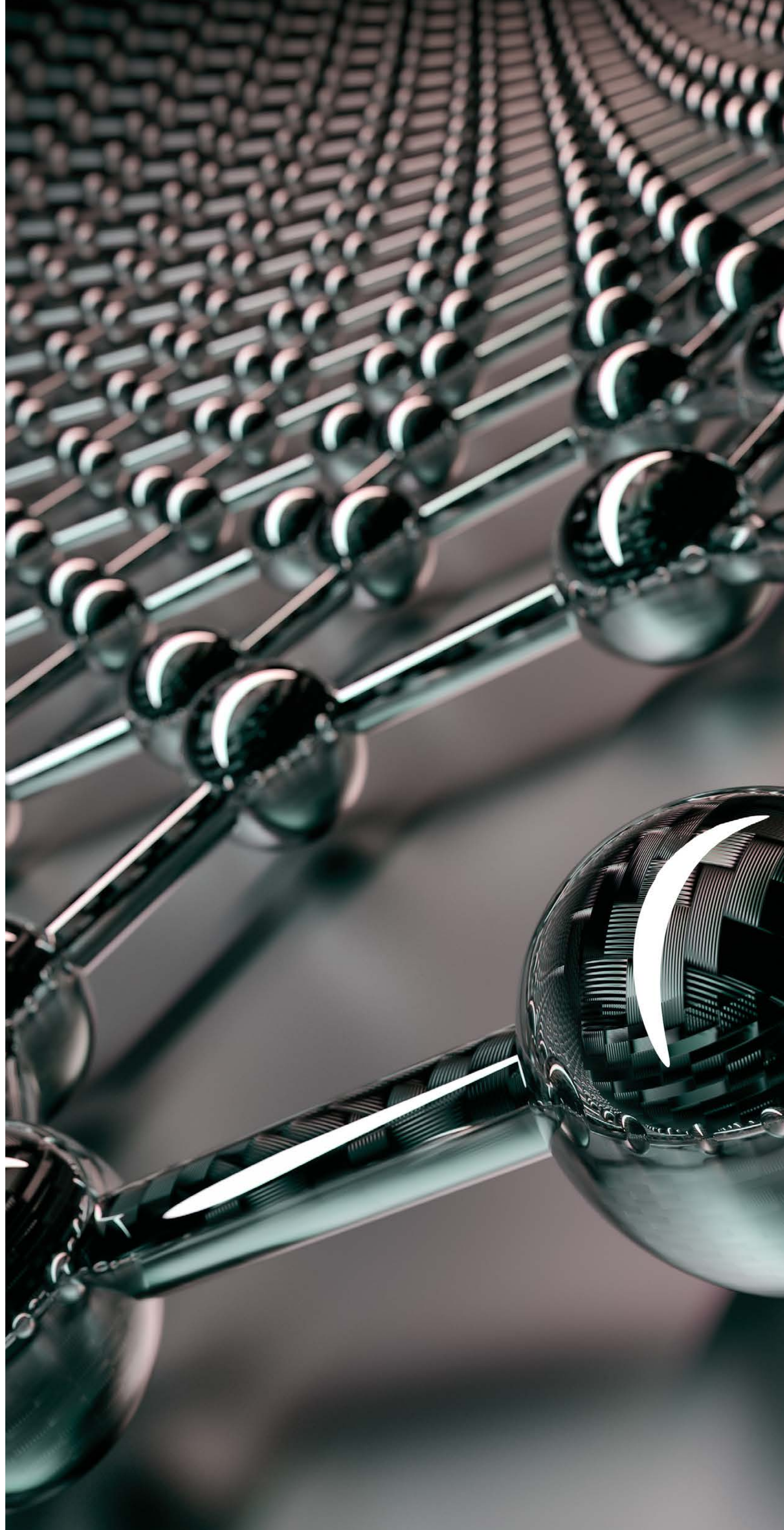
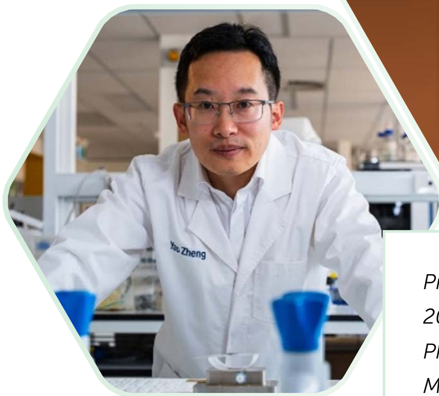


Awards and Recognition

Prizes and Awards

- **Dr Khalil Amine** elected to the National Academy of Engineering (USA)
- **Professor Rose Amal AC** named the 2025 Pioneer in Energy Research by *Energy & Fuels* journal, with a Special Issue published in tribute
- **Professor Yao Zheng** awarded the 2025 Malcolm McIntosh Prize for Physical Scientist of the Year at the Prime Minister's Prizes for Science 2025
- **Professor Shizhang Qiao** elected a Fellow of the Australian Academy of Technological Sciences & Engineering (ATSE)
- **Professor Hui Tong Chua** awarded the Chemical Engineer Achievement Award from Engineers Australia
- **Professor Hui Tong Chua** appointed to the Awards Committee for the 2025 Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) Awards Gala Dinner
- **Professor Hui Tong Chua** named President of the Asian Pacific Confederation of Chemical Engineering (APCChE)
- **Dr Emma Lovell** awarded the UNSW Engineering Excellence Award in HDR Supervision by the UNSW Faculty of Engineering
- **Dr Shujie Zhou** named as a finalist for the Rising Star Award at the Women of Colour in STEM Awards
- **Dr Feiyue Gao** awarded an ARC Discovery Early Career Researcher Award (DECRA) 2026

Professor Shizhang Qiao, Deputy Director of COE-CSI, was elected a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE).



Professor Yao Zheng, recipient of the 2025 Malcolm McIntosh Prize for Physical Scientist of the Year at the Prime Minister's Prizes for Science.

Professor Hui Tong Chua receiving the Chemical Engineer Achievement Award by Engineers Australia for his world-class engineering innovations and successful commercialisation efforts.

CLARIVATE

Several Centre members were listed as 2025 Clarivate Highly Cited Researchers. The Clarivate list identifies and celebrates individuals who have demonstrated significant and broad influence in their fields of research.

Our Chief Investigators:

- **Professor Shizhang Qiao** (Chemistry, Materials Science, and Environment & Ecology)
- **Professor Liming Dai** (Chemistry, Materials Science)
- **Professor Rose Amal AC** (Cross-Field)
- **Professor Yan Jiao** (Chemistry)

Our Partner Investigators:

- **Professor Yury Gogotsi** (Chemistry, Materials Science, Engineering)
- **Professor Mietek Jaroniec** (Chemistry, Materials Science)
- **Professor Dr Markus Antonietti** (Chemistry)
- **Professor Jong-Beom Baek** (Cross-Field)
- **Professor Manish Chhowalla** (Materials Science)

Our Associate Investigators:

- **Professor Jun Lu** (Chemistry, Materials Science, Engineering)
- **Dr Jinghua Guo** (Chemistry)

Our International Scientific Advisory Board:

- **Professor Sir Konstantin Novoselov** (Physics)
- **Professor Hui-Ming Cheng** (Chemistry, Materials Science, Environment & Ecology)

Plenary and Keynote Talks

Plenary talks

NAME	CONFERENCE	LOCATION	DATE
Professor Shizhang Qiao	2025 International Symposium on Electrocatalysis and Electrosynthesis	Hunan, China	28 March 2025
Professor Shizhang Qiao	3rd International Conference on Energy Chemistry (ICEC2025)	Shenzhen, China	26 June 2025
Professor Rose Amal AC	International Conference on Materials for Advanced Technologies (ICMAT) 2025	Singapore	30 June 2025
Professor Shizhang Qiao	IAS Frontiers Workshop on Renewable Energy for a Sustainable Future	Singapore	1 July 2025
Professor Rose Amal AC	IAS Frontiers Workshop on Renewable Energy for a Sustainable Future	Singapore	1 July 2025
Professor Liming Dai	3rd International Conference on Catalysis Science and Chemical Engineering (CatScience)	Budapest, Hungary	21 July 2025
Professor Shizhang Qiao	Frontier Development Symposium on Nanoporous Materials	Hohhot, China	10 August 2025
Professor Shizhang Qiao	The International Symposium on Electroanalytical Chemistry	Changchun, China	12 August 2025
Professor Liming Dai	Third Symposium on Bioinspired Interfacial Materials	Suzhou, China	27 August 2025
Professor Liming Dai	CHEMEET: 4th International Chemistry Conference	Athens, Greece	29 September 2025
Professor Liming Dai	International Symposium on Carbon Energy 2025	Wenzhou, China	12 October 2025
Professor Liming Dai	Beijing Graphene Forum 2025	Beijing, China	25 October 2025
Professor Shizhang Qiao	RSC Future Innovation Research Summit (RSC FIRST 2025): Energy Materials Frontiers	Wuhu, China	31 October 2025
Professor Liming Dai	12th International Conference on Advanced Fiber and Polymer Materials (ICAFPM2025)	Shanghai, China	2 November 2025
Professor Shizhang Qiao	2nd Australian Materials Chemistry Conference (AMCC25)	Gold Coast, Australia	17 November 2025
Professor Shizhang Qiao	Electrochemical, Materials and Analytical Chemistry Symposium (EMACS 2025)	Brisbane, Australia	21 November 2025
Professor Liming Dai	Applications of Chemistry in Nanosciences and Biomaterials Engineering (NanoBioMat 2025)	Online	26 November 2025
Professor Shizhang Qiao	International Forum on Future Energy and Chemical Engineering	Shanghai, China	28 November 2025
Professor Rose Amal AC	Clean Energy and Advanced Materials Symposium	Melbourne, Australia	29 November 2025
Professor Shizhang Qiao	International Conference on Next-Generation Chemistry, Chemical Engineering, and Materials Technology	Hong Kong	4 December 2025
Professor Yun Liu	The 19th Conference of the Asian Crystallographic Association (AsCA2025)	Taipei, Taiwan	4 December 2025
Professor Yan Jiao	Molecular Modelling Conference 2025	Melbourne, Australia	10 December 2025

Keynote talks

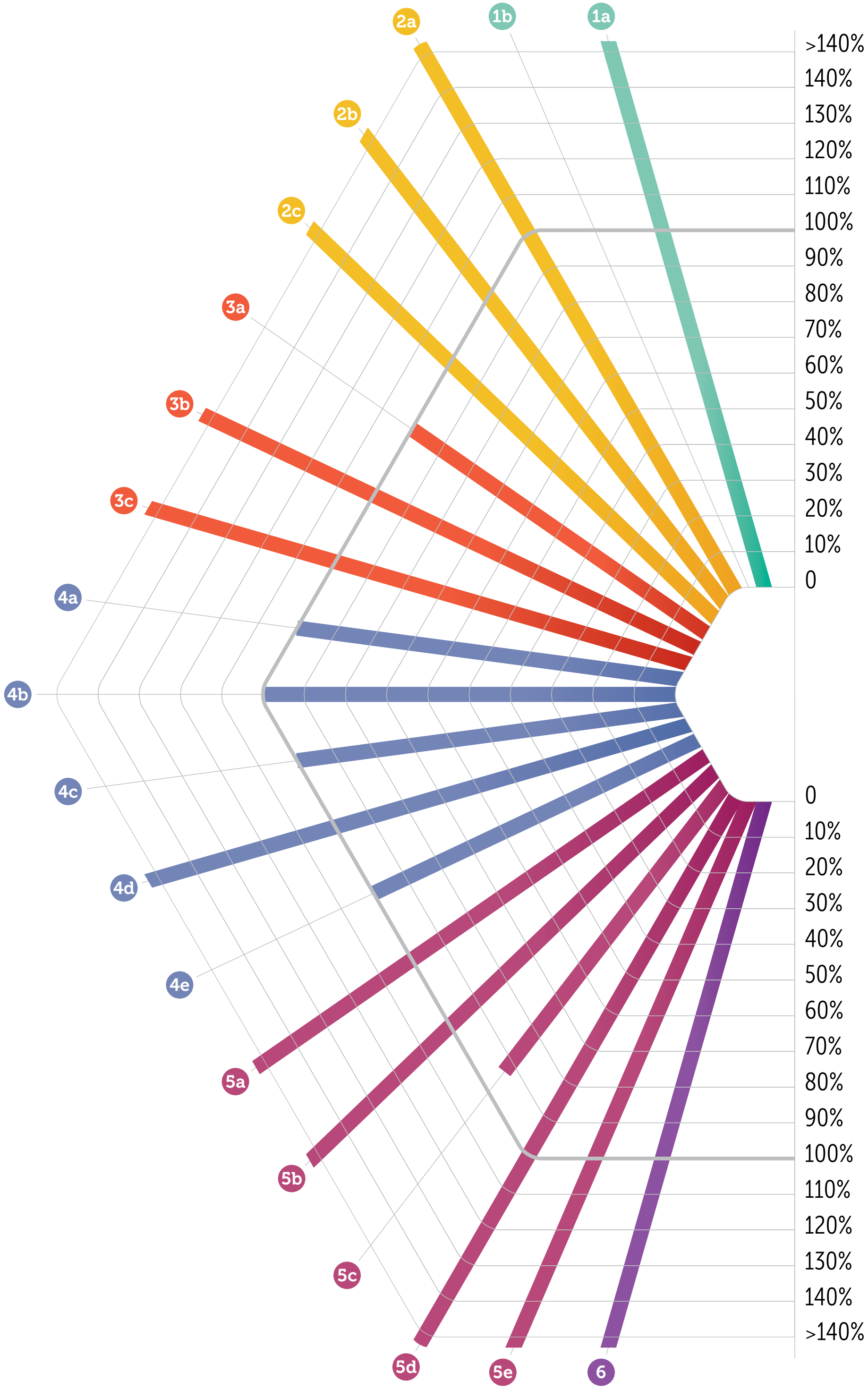
NAME	CONFERENCE	LOCATION	DATE
Professor Shizhang Qiao	International Conference on Nature-Inspired Materials and Chemistry	Hangzhou, China	19 January 2025
Professor Richard Tilley	11th International Conference on Advanced Materials and Nanotechnology (AMN11)	Christchurch, New Zealand	10 February 2025
Professor Yun Liu	Beilstein Nanotechnology Symposium 2025	Rüdesheim, Germany	13 May 2025
Professor Liming Dai	3rd International Responsive Materials Symposium	Nanjing, China	19 May 2025
Professor Yan Jiao	China Materials Conference 2025	Xiamen, China	6 July 2025
Professor Liming Dai	12th World Congress of Chemical Engineering (WCCE)	Beijing, China	15 July 2025
Professor Liming Dai	IUPAC General Assembly and World Chemistry Congress	Kuala Lumpur, Malaysia	17 July 2025
Professor Shizhang Qiao	10th Asia Pacific Congress on Catalysis (APCAT-10)	Singapore	4 August 2025
Professor Liming Dai	17th Annual Conference of the Global Chinese Chemical Engineering Scholars (GACCE-2025)	Queenstown, New Zealand	13 August 2025
Professor Liming Dai	Frontiers in Chemical Engineering: Global Chinese Chemical Engineers Symposium	Auckland, New Zealand	16 August 2025
Professor Liming Dai	10th International Conference on Nanoscience & Technology (ChinaNANO 2025)	Beijing, China	30 August 2025
Professor Shizhang Qiao	The 14th International Symposium on Nano & Supramolecular Chemistry (ISNSC 2025)	Santiago, Chile	31 August 2025
Professor Liming Dai	Advanced Materials Symposium	Wollongong, Australia	12 September 2025
Professor Yun Liu	The Japan Institute of Metals and Materials Autumn meeting	Hokkaido, Japan	17 September 2025
Professor Liming Dai	4th International Conference on Polymer Science and Engineering (Polymers-2025)	Online - Houston, USA	8 October 2025
Professor Liming Dai	China International College Student Innovation Conference	Zhengzhou, China	14 October 2025
Professor Shizhang Qiao	The 6th Tianjin Forum	Tianjin, China	18 October 2025
Professor Richard Tilley	2nd Australian Materials Chemistry Conference (AMCC25)	Gold Coast, Australia	17 November 2025
Professor Yan Jiao	2nd Australian Materials Chemistry Conference (AMCC25)	Gold Coast, Australia	17 November 2025
Professor Liming Dai	ACS Nano Summit 2025	Sydney, Australia	17 November 2025
Associate Professor Rakesh Joshi	ACS Nano Summit 2025	Sydney, Australia	18 November 2025
Dr Wenxian Li	Electrochemical, Materials and Analytical Chemistry Symposium (EMACS 2025)	Brisbane, Australia	20 November 2025
Dr Wenxian Li	The 1st International Symposium on the Sustainable Processing of Carbon Waste	Melbourne, Australia	4 December 2025

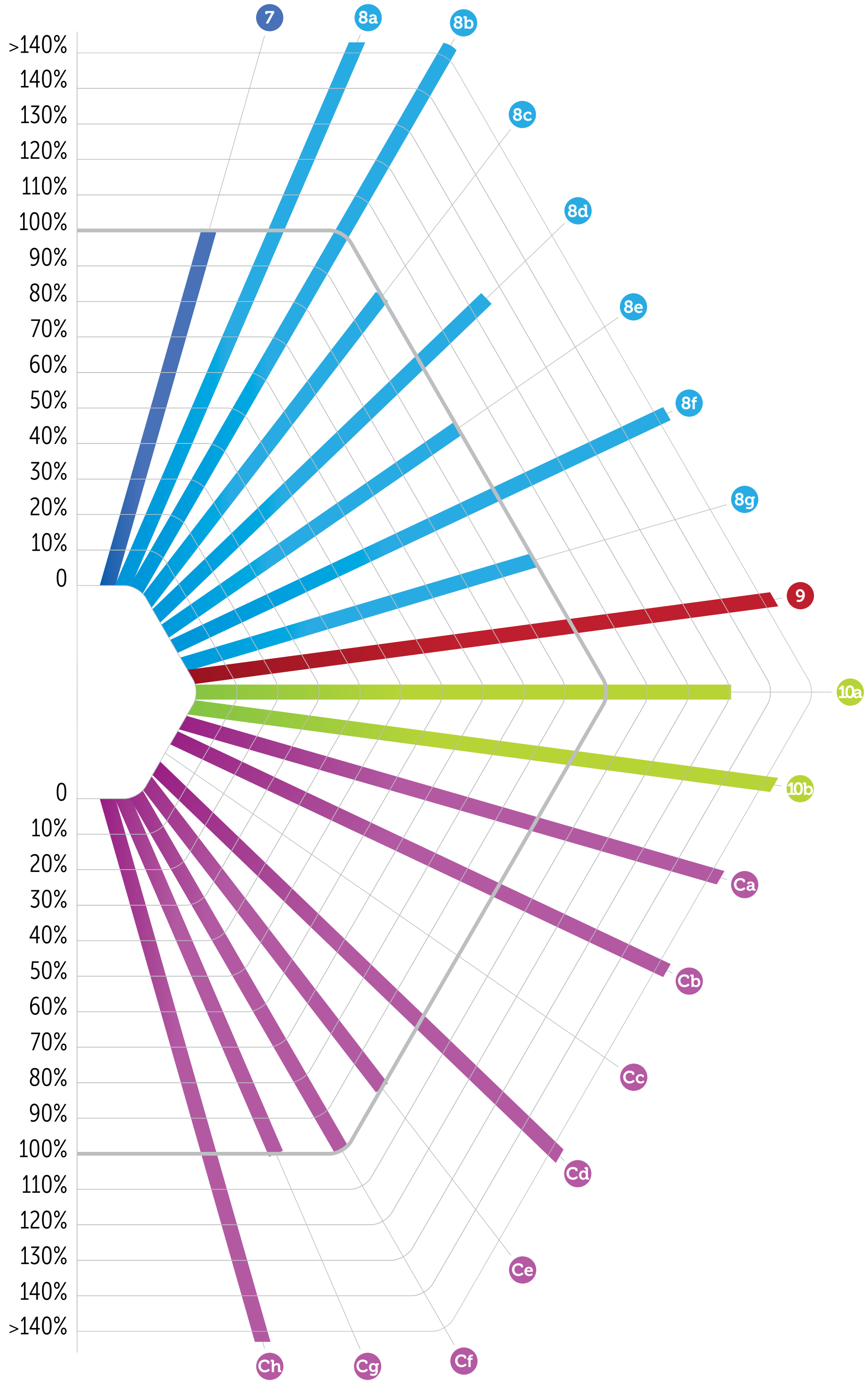
New Editorial Board Memberships

NAME	EDITORIAL ROLE	JOURNAL
Professor Liming Dai	Co-Editor-in-Chief	*Carbon Innovation*
Dr Shujie Zhou	Early Career Editorial Board	*Chemical Engineering Journal*
Dr Zhipeng Ma	Early Career Editorial Board	*Chemical Engineering Journal*
Professor Richard Tilley	Editorial Advisory Board	*Chemistry of Materials*
Professor Yao Zheng	Editorial Board	*Energy Z*
Professor Yao Zheng	Editorial Board	*eScience Energy*
Professor Yao Zheng	Editorial Board	*Inorganic Chemistry Frontiers*
Professor Yao Zheng	Editorial Board	*Interdisciplinary Materials*
Professor Yao Zheng	Editorial Board	*Ionic Materials and Devices*
Professor Yao Zheng	Editorial Board	*Materials Matter*
Professor Yao Zheng	Editorial Board	*Micro Nano Science*
Professor Yao Zheng	Editorial Board	*Molecular Chemistry*
Professor Yan Jiao	Associate Editor	*Transactions of Tianjin University (TTU)*

Key Performance Indicators

PERFORMANCE MEASURE	Target	Actual
1 Number of research outputs		
a. Journal articles	40	80
b. Patents including provisional	1	0
2 Quality of research outputs		
a. Journal articles in the top quartile (Q1) of CiteScore for relevant fields	20	76
b. Joint publications by different groups	10	26
c. Publications in Nature/Science family journals	1	5
3 Number of workshops/conferences held/offered by the Centre		
a. Annual centre conference	1	1
b. National/International conferences	1	2
c. Topical/Research program workshops/seminars	3	23
4 Number of training courses held/offered by the Centre		
a. Leadership development workshops	1	1
b. Induction and training of IP management	1	1
c. Professional engagement trainings	1	1
d. Communications/writing workshops	1	2
e. Training in gender equity and diversity	1	1
5 Number of additional researchers working on Centre research		
a. Postdoctoral researchers – at any one time	10	28
b. Honours students and Masters by coursework students – at any one time	3	13
c. PhD Students – at any one time	30	28
d. Masters by research students	1	2
e. Associate Investigators – at any one time	10	40
6 Number of postgraduate completions	**0**	**4**





PERFORMANCE MEASURE	Target	Actual
7 Number of mentoring programs offered by the Centre	2	2
8 Number of presentations/briefings		
a. To the public	6	15
b. To government or industry/business/end-users	4	8
c. To professional organisations and bodies	2	2
d. Other – School education programs	8	10
e. Other – Diversity in STEM outreach	1	1
f. Other – Social media posts	40	91
g. Other – Special events, e.g. Science week	2	2
9 Number of new organisations collaborating with, or involved in, the Centre	1	3
10 Number of female research personnel		
a. Equity and diversity initiatives – percentage of enrolled female graduate students	30%	39%
b. Equity and diversity initiatives – percentage of recruited female research fellows	20%	32%
Centre-specific KPIs		
a. Keynote and plenary talks at national and international conferences by COE-CSI researchers	7	45
b. Engagement with broad scientific communities e.g. Journal editorial memberships/special issues	1	16
c. Engagement with First Nations Communities	1	0
d. Establishing connections with existing carbon centres in Australia and overseas	1	6
e. Number of researchers exchanges including visits to PI Labs and vice versa	5	5
f. Centre Open Day	1	1
g. Industry engagement workshop	1	1
h. Industry newsletters	2	5

Financial Statement

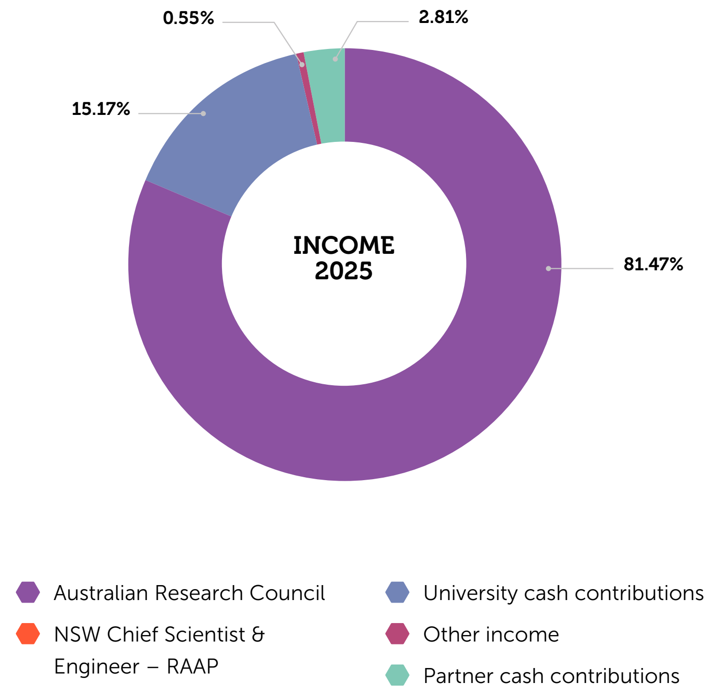
Carry forward	**11,689,169**

INCOME	**2025**
Australian Research Council	5,807,379
NSW Chief Scientist & Engineer – RAAP *(Note 1)*	
University cash contributions	1,081,199
Other income	39,969
Partner cash contributions	200,000
Total Income	**7,128,547**

EXPENDITURE	**2025**
Personnel	2,412,367
Equipment	-
Maintenance	275,133
Travel	161,394
Field Research	-
Teaching Relief	-
Other	161,123
Total Expenditure	**3,010,017**

Annual Surplus/Deficit	**4,118,529**

Closing balance as at year end	**15,807,698**



Note:

1. A total of $1,000,000 was received in advance in 2023 to support the Centre's operations over its full duration.

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