14th Annual International Electromaterials Science Symposium

5 – 7 February 2020

Kambri Precinct, Australian National University
University of Wollongong
Deakin University
Monash University
University of Tasmania
Australian National University
University of Melbourne
Swinburne University of Technology
La Trobe University
Dublin City University
Friedrich Alexander University of Erlangen
Hanyang University
University of Warwick
Yokohama National University
Organising Committee

**Australian National University**
Michelle Coote (Chair), Lijuan Yu (Student Committee Leader)

**University of Wollongong**
Vanessa O’Brien, Lauren Hood, Sam Findlay, Delvene McKenzie, Jun Chen, Sam Rathbone (Student Committee Leader)

**Deakin University**
Jenny Pringle

**Monash University**
Alexandr Simonov

**La Trobe University**
Eliza Goddard
Thank you to our generous sponsors
Welcome to the 14th Annual International Electromaterials Science Symposium

On behalf of the Organising Committee, we welcome you to the 14th Annual International Electromaterials Science Symposium, in Canberra, Australia.

At ACES, we have been privileged to be in a position to carry out world-leading research for more than 10 years. Since 2005, ACES has been at the cutting edge of electromaterials science, discovering new materials and developing new approaches to fabrication. In this time, we have made significant contributions to the fields of energy, biomedical science, robotics and electrofluidics.

Our International Electromaterials Science Symposium provides a platform for us to showcase these advances and learn from researchers, clinicians and industry experts from across the world who share our passion and drive for utilising advanced materials to create new health and energy solutions that improve people’s lives.

We are in the midst of a revolution. Researchers are at the forefront of technological, clinical and industry breakthroughs. Where once we worked in silos, we are now working alongside end-users, industry, and regulatory experts to bring better outcomes to the communities we work for. We must recognise the need to work with individuals who can help navigate the regulatory pathway, commercial development activities and ethical issues that may arise from the breakthroughs achieved in research to allow us to successfully use this fundamental research and the knowledge accrued as the fuel to create commercial opportunity.

The 14th Annual International Electromaterials Science Symposium brings together experts in a diverse range of fields, from advanced fundamental research; to translational opportunities for sustainable applications in broader society; to refined skills in ethics, policy and public engagement.

Let’s use our time together to advance our own knowledge, consider our research in the broader social context, and strengthen our networks to build multidisciplinary connections. Together, we can confront the challenges ahead and deliver the best outputs possible.

Thank you for joining us at the 14th Annual International Electromaterials Science Symposium. We hope you enjoy hearing about the latest research in materials science and contributing to discussions on the exciting future our field has to offer.

Professor Gordon Wallace FAA
Director, ARC Centre of Excellence for Electromaterials Science
Director ANFF Materials Node

Professor Michelle Coote FRSC FAA
14th Annual International Electromaterials Science Symposium Chair
Symposium Program
<table>
<thead>
<tr>
<th>Time</th>
<th>Session 1 - Chair: Dr Hao Zhou</th>
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<tbody>
<tr>
<td>9:00am</td>
<td>Registrations Open – Lobby, Kambri Precinct Cultural Centre, Building 153, ANU</td>
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<tr>
<td>10:00am</td>
<td>Professor Michelle Coote, Australian National University: Welcome Remarks</td>
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<tr>
<td>10:05am</td>
<td>Professor Gordon Wallace, ACES Director: Opening Remarks</td>
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<tr>
<td>10:20am</td>
<td>Professor Jadranka Travas-Sejdic, University of Auckland, New Zealand</td>
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<td>Self-healing and Stretchable Polymer Electronics</td>
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<tr>
<td>11:00am</td>
<td>Professor Richard Kaner, University of California, Los Angeles, USA</td>
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<td>Graphene for Energy Storage</td>
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<tr>
<td>11:40am</td>
<td>Morning Tea</td>
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<thead>
<tr>
<th>Time</th>
<th>Session 2 - Chair: Dr Mark Howard</th>
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<tr>
<td>12:10pm</td>
<td>Associate Professor Zongyou Yin, Australian National University</td>
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<td>Nanomaterials for Energy Conversion: Reactivity and Stability</td>
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<tr>
<td>12:30pm</td>
<td>Professor Antonio Tricoli, Australian National University</td>
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<td>Scalable Structuring of Efficient Earth-Abundant Electrocatalysts for Water Splitting and CO₂ Reduction</td>
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<tr>
<td>12:50pm</td>
<td>Professor Mark Cook, The University of Melbourne</td>
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<td>Developing an Implantable Epilepsy Device</td>
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<tr>
<td>1:10pm</td>
<td>Lunch</td>
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<tr>
<th>Time</th>
<th>Session 3 - Chair: Dr Vipul Gupta</th>
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<tr>
<td>2:20pm</td>
<td>Professor Bong Sup Shim, Inha University, South Korea</td>
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<td>Multi-Functional Nanocomposites from Naturally Derived Materials: Conductive Melanin and Crystalline Celluloses</td>
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<tr>
<td>2:40pm</td>
<td>Associate Professor Ekaterina Pas, Monash University</td>
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<td></td>
<td>Towards All-Organic Radical Batteries</td>
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<tr>
<td>3:00pm</td>
<td>Associate Professor Ajay Pandey, Queensland University of Technology</td>
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<td>Smart Robotic Skin and Large Area Tactile Sensing Using Elastomers and Advanced Organic Optoelectronic Diodes</td>
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<tr>
<td>3:20pm</td>
<td>Professor Simon Moulton, Swinburne University: Poster Burster Session</td>
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<tr>
<td>4:10pm</td>
<td>Afternoon Tea</td>
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</table>
| 4:30pm| **Ethics Panel Session #1 – 3D Printed Medical Devices: Regulatory & Legal Challenges in Clinical Practice**  
*Chair: Susan Dodds*  
*Guest Panellists:*  
  - Associate Professor Jane Nielsen, Faculty of Law, University of Tasmania  
  - Professor Dianne Nicol, Faculty of Law, University of Tasmania  
  - Professor Cameron Stewart, Faculty of Law, University of Sydney  
  - Ms Jenny Kaldor, Faculty of Law, University of Tasmania |
| 5:30pm| **Posters After Five: BioLogic Canapé Reception** – Lobby, Kambri Precinct Cultural Centre |
| 8:00pm| **Day 1 Finish**                                                      |
### Day 2: Thursday 6th February 2020

#### Session 5 - Chair: Dr Alexandr Simonov

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>9:00am</td>
<td>Professor Justin Gooding, University of NSW</td>
<td>Nanoparticles that Mimic the Three-dimensional Architecture of Enzymes: The Role of Nanoconfinement in Enhancing Electrocatalytic Reactions</td>
</tr>
<tr>
<td>9:40am</td>
<td>Professor Mario Romero-Ortega, University of Houston, USA</td>
<td>Bioelectronic Applications of Graphene Fiber Electrodes</td>
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<tr>
<td>10:00am</td>
<td>Dr Nevena Todorova, RMIT University</td>
<td>Computational Modelling of Functional Nanomaterials in Biological Media</td>
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<td>10:20am</td>
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<td><strong>Morning Tea</strong></td>
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#### Session 6 - Chair: Dr Alex Harris

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>11:10am</td>
<td>Associate Professor Alister J. Page, The University of Newcastle</td>
<td>Growing Low-Dimensional Inorganic Nanostructures via CVD: Insights from Quantum Chemistry &amp; Molecular Simulations</td>
</tr>
<tr>
<td>11:30am</td>
<td>Professor Yun Liu, Australian National University</td>
<td>Defect Design for Dielectric Polarization</td>
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<tr>
<td>11:50am</td>
<td>Professor Brett Paull, University of Tasmania</td>
<td>Fibre-based Microfluidics and Diagnostics: Precise Concentration and Delivery of Targets using the Simplest of Substrates</td>
</tr>
<tr>
<td>12:10pm</td>
<td>Professor Anthony Burrell, National Renewable Energy Laboratory, USA</td>
<td>Behind the Meter Storage: Low TRL Work Guided by a System Level Approach</td>
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<tr>
<td>12:30pm</td>
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<td><strong>Lunch</strong> – including special Equity &amp; Diversity Panel Session</td>
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**Equity & Diversity Panel (held in the main conference room during lunch)**  
**Chair:** Linda Hancock  
**Guest Panellists:**  
- Louise Moes – Manager, Diversity and Inclusion, Australian Academy of Science  
- Professor Maria Forsyth – ACES Associate Director, Deakin University  
- Dr Justin Bourke – University of Melbourne

#### Session 7 - Chair: Dr Klaudia Wagner

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<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1:50pm</td>
<td>Professor Maria Forsyth, Deakin University</td>
<td>Towards Practical High Energy Density Batteries Using Ionic Liquid Electrolytes and the Role of the Electrode Interphase</td>
</tr>
<tr>
<td>2:10pm</td>
<td>Dr Nagore Ortiz-Vitoriano, CIC EnergiGUNE, Spain</td>
<td>Engineering 3D Graphene Air Cathodes for Na-O2 Batteries</td>
</tr>
<tr>
<td>2:30pm</td>
<td>Professor Myung-Han Yoon, Gwangju Institute of Science and Technology, South Korea</td>
<td>Conducting Polymer Microfibers for Organic Electrochemical Transistor-based Bioelectronics</td>
</tr>
<tr>
<td>2:50pm</td>
<td>Dr Pu Xiao, Australian National University</td>
<td>Efficient Photoinitiating Systems for Fast 3D-Printing</td>
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<tr>
<td>3:10pm</td>
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<td><strong>Afternoon Tea</strong></td>
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| 3:30pm | **Ethics Panel Session #2** - Translating Renewable Technologies into Reality for Cleaner, More Just Climate Change and Energy Transitions  
**Chair:** Linda Hancock  
**Guest Panellists:**  
- Christopher Anderson - Director of Science Policy, Australian Academy of Science  
- Professor Doug MacFarlane – Monash University |
| 4:20pm | Professor Gordon Wallace, ACES Director/Professor Maria Forsyth, ACES Associate Director/Vince Stafrace, Director ProDigitek: Poster Awards |
| 4:30pm | **Day 2 Finish – Free Evening**                                      |
| 4:45pm to 6:15pm | **RSG/CI Meeting (By Invitation Only)  
Room 3.02, Marie Reay Teaching Centre  
Building 155, Kambri Precinct  
Australian National University** |
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>8:45am</td>
<td>Welcome and Introduction</td>
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<tr>
<td></td>
<td><strong>Professor Gordon Wallace, ACES Director</strong></td>
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<tr>
<td>9:00am</td>
<td>Electromaterials - Theme Leader: Professor David Officer</td>
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<tr>
<td></td>
<td>• Holly Warren - UOW (7 min): <em>Patterning of Hydrogels Using Ion-oprinting</em></td>
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<td></td>
<td>• Shaikh Faisal - UOW (7 min): <em>Next Generation Magnetic Plastics, Doughs, Gels and Liquid Droplets</em></td>
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<tr>
<td></td>
<td>• Fangfang Chen - Deakin University (7 min): <em>Molecular Insight into Designing Optimised Battery Electrolytes</em></td>
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<tr>
<td>9:30am</td>
<td>Electrofluidics and Diagnostics - Theme Leader: Professor Brett Paull</td>
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<td></td>
<td>• Vipul Gupta - University of Tasmania (7 min): <em>Three-dimensional Bifurcating Microfluidic Distributors to Realise a Brain-on-a-Bench System</em></td>
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<tr>
<td></td>
<td>• Liang Chen - University of Tasmania (7 min): <em>Electrofluidic Fibre-based Analytical Devices Coupled with Ambient Ionization Mass Spectrometry</em></td>
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<td></td>
<td>• Jawairia Khan - UOW (7 min): <em>3D Textile Structures as Electrophoresis Platforms for Selective Delivery and Separation of Complex Mixtures</em></td>
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<tr>
<td>10:00am</td>
<td>Soft Robotics – Theme Leader: Professor Gursel Alici</td>
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<td></td>
<td>• Hao Zhou - UOW (7 min): <em>A Soft Robotic Prosthetic Hand with Pattern Recognition Based Myoelectric Control</em></td>
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<td>• Gerardo Montoya Gurrola - UOW (7 min): <em>Adaptive Neural Interface to Control Prosthetic Devices: Design, Fabrication and Performance Evaluation</em></td>
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<td></td>
<td>• Hong Quan Le - UOW (7 min): <em>Improving Usability, Intuitiveness of Controlling Prosthetic Hand Via Non-invasive Approach</em></td>
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<tr>
<td>10:30am</td>
<td>Synthetic Energy Systems – Theme Leader: Professor Doug Macfarlane</td>
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<td></td>
<td>• Si-Xuan Guo - Monash University (7 min): <em>Strategies for Enhancing the Activity of Bismuth-based Catalysts for Electrochemical Reduction of Carbon Dioxide</em></td>
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<td></td>
<td>• Shuo Dong - Monash University (7 min): <em>Novel Electrolytes for Non-aqueous Redox Flow Batteries</em></td>
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<td>• Amrutha Vijayakumar - UOW (7 min): <em>Copper Nanowires with Tunable Selectivity for Electrochemical Reduction of CO₂</em></td>
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<td>11:00am</td>
<td>Morning Tea</td>
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<td>11:30am</td>
<td>Synthetic Bio Systems – Theme Leader: Professor Robert Kapsa</td>
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<td>• Eva Tomaskovic-Crook – UOW (7 min): Synthetic Biosystems to Model Brain Pathologies</td>
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<td>• Xifang Chen – UOW (7 min): Skin Bioprinting Using Sulfated Polysaccharide Ulvan</td>
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<td>• Bijan Shekibi – UOW (7 min): Electrical Stimulation of Neural Cells on Multielectrode Arrays</td>
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<tr>
<td>12:00pm</td>
<td>Ethics Policy Public Engagement - Theme Leader: Professor Susan Dodds</td>
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<td>• Mark Howard – Monash University (7 min): Wearables, Machine Learning and Efficiency in Health Care: How will I know that you’re thinking of me?</td>
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<td>• Linda Wollersheim – Deakin University (7 min): Analysing the Framing of Renewable Energy Actors in Australia and Germany</td>
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<td>• Mathew Cherian – Deakin University (7 min): Indian Energy Transitions: The Energy Divide</td>
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<tr>
<td>12:30pm</td>
<td>Professor Attila Mozer, UOW and Dr Tillmann Boehme, UOW: Certificate in Entrepreneurship and Innovation Presentations</td>
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<tr>
<td>1:30pm</td>
<td>Professor Michelle Coote, Australian National University: Closing Remarks</td>
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<tr>
<td>1:35pm</td>
<td>Dr Alexandr Simonov, Monash University: Feedback Session</td>
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<tr>
<td>1:40pm</td>
<td>Lunch and Day 3 Finish</td>
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<tr>
<td>1:40pm to 3:40pm</td>
<td>IAC Meeting (By Invitation Only)</td>
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<td>Room 3.02, Marie Reay Teaching Centre</td>
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<td>Building 155, Kambri Precinct</td>
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<td>Australian National University</td>
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Plenary & Invited Speakers
Biographies & Abstracts
Self-healing and Stretchable Polymer Electronics

Jadranka Travas-Sejdic

Polymer Biointerface Centre, The University of Auckland, Auckland, New Zealand
MacDiarmid Institute for Advanced Materials and Nanotechnology, New Zealand

Email: j.travas-sejdic@auckland.ac.nz

Electrically conducting polymers (CPs) display unique optoelectronic properties which makes them excellent alternatives to traditional conductors and semiconductors. Despite the many attractive properties of CPs, the poor solubility of CPs makes them difficult to process and has limited their use. These drawbacks can be overcome by functionalization of CPs with various moieties. An extension of that approach is grafting of CP backbone with polymeric sidechains; that enables modification of optoelectronic, chemophysical and mechanical properties of the CPs, as well as the possibility of further functionalisation.

We have previously demonstrated synthesis and characterization of variously functionalized conducting polymers with a range of grafted polymeric sidechains for biological applications; for example, grafting of poly(ethylene glycol methyl methacrylate), poly(acrylic acid) and poly(n-butyl acrylate), from either a conducting polymer film’s surface or the CP macroinitiators in solution. These materials have shown a promise as smart biointerfaces, responsive to various stimuli, such as electrochemical, pH, thermal and salt concentration. In this talk, we will discuss recent developments in development of that class of materials, where we extend the principle of grafting CPs to realize intrinsically stretchable and self-healing grafted conducting polymers. The physical, mechanical and electrochemical properties of these new materials will be presented and their potential uses in stretchable electronics will be discussed.
Professor Richard B. Kaner

Richard Kaner received a Ph.D. from the University of Pennsylvania in 1984 working with Prof. Alan MacDiarmid (Nobel Laureate 2000, deceased). After postdoctoral research at Berkeley, he joined the University of California, Los Angeles (UCLA) in 1987, earned tenure in 1991, became a full professor in 1993, a Distinguished Professor in 2012 and was appointed to the Dr. Myung Ki Hong Endowed Chair in Materials Innovation in 2017. He has published over 400 papers in top peer reviewed journals and holds 33 U.S. patents. According to the most recent Thomson-Reuters rankings, he is among the world’s most highly cited authors. Professor Kaner has received awards from the Dreyfus, Fulbright, Guggenheim, Packard and Sloan Foundations along with the Materials Research Society Medal, the Royal Society of Chemistry Centenary Prize, the Chemical Pioneer Award from the American Institute of Chemists and the American Chemical Society’s Buck-Whitney Research Award, Tolman Medal and Award in the Chemistry of Materials for his work on refractory materials including new synthetic routes to ceramics, intercalation compounds, superhard metals, graphene and conducting polymers. He has been elected a Fellow of the American Association for the Advancement of Science (AAAS), the American Chemical Society (ACS), the European Academy of Sciences, the Materials Research Society (MRS) and the Royal Society of Chemistry (FRSC).

Graphene for Energy Storage

Xueying Chang, Maher El-Kady, Ailun Huang, Mit Muni, Chenxiang Wang, Haosen Wang and Richard B. Kaner*

*Distinguished Professor of Chemistry
Distinguished Professor of Materials Science & Engineering
Dr. Myung Ki Hong Endowed Chair in Materials Innovation
University of California, Los Angeles

Email: kaner@chem.ucla.edu

Graphene is the ultimate two-dimensional material consisting of a single layer of sp² hybridized carbon. A facile, inexpensive, solid-state method for generating, patterning and electronic tuning of laser converted graphene will be discussed (Figure 1). Briefly, graphite can be converted into graphene oxide (GO) sheets, which readily disperse in water, and can then be reduced by various methods. Due to its unique ability to be solution processed and patterned, GO can be laser reduced to graphene directly onto various substrates without masks, templates, post processing, or transfer techniques. This work paves the way for the fabrication of inexpensive electrochemical energy storage devices that combine the energy density of batteries and the power density of capacitors.

Figure 1 (a) Schematic showing the fabrication process of a graphene micro-supercapacitor using a Light Scribe DVD drive. (b,c) This technique can produce more than 100 micro-devices on a single run and can be produced on virtually any substrate.
Dr Zongyou Yin obtained his B.S. and M.S. degrees at Jilin University in China, and completed his Ph.D. at Nanyang Technological University (NTU) in Singapore in 2008. Then, he started his postdoc careers at NTU/Singapore, followed by MIT and then Harvard University. Dr Yin started his own Research Group at Australian National University (ANU) from 2017. His group’s research is interdisciplinary, encompassing chemistry and physics of nano-to-atomic materials, fundamental relationship among materials-structures-devices, and synergistic integration of multi-functions towards systems for energy and wearable applications. He has filed 10 international patents and published over 110 articles in international journals. Based on Google Scholar, his total citations have reached over 19,840 with h-index of 56. He is the recipient of several awards, including the Awardee for the international <Make Our Planet Great Again> program from France, the ANU Futures Scheme, and World Highly Cited Researchers in 2015-to-2019 five years consecutively.

**Associate Professor Zongyou Yin**

**Nanomaterials for energy conversion: reactivity and stability**

Nasir Uddin\textsuperscript{a}, Yaping Du\textsuperscript{b}, Guohua Jia\textsuperscript{c}, Zongyou Yin\textsuperscript{a}

\textsuperscript{a}Research School of Chemistry, Australian National University, ACT 2601, Australia

\textsuperscript{b}School of Materials Science and Engineering, Center for Rare Earth and Inorganic Functional Materials, Nankai University, Tianjin 300350, China

\textsuperscript{c}Curtin Institute of Functional Molecules and Interfaces, School of Molecular and Life Sciences, Curtin University, Perth, WA, Australia

Email: zongyou.yin@anu.edu.au

With low-dimensional materials science advancement, low-dimensional catalysts and technology offer a vast and fascinating playground to explore the novel physiochemical properties of nano and sub-nano materials with the development for various applications including energy conversion and storage. Hydrogen (H\textsubscript{2}) as a clean fuel has always been attracting researchers’ intense interest in its generation and storage for the past decade. Most research up to date are more interested in the performance/reactivity and mechanism behind. However, in terms of practical application, people are recognising that the stability is equally important as reactivity. This talk will share some research on both reactivity and stability study from my research group. In this talk, the research on the development of redox reactions based H\textsubscript{2} generation will be presented and discussed. Our research outcomes indicated crystal phase, defect state, and surface chemistry can play the critical roles in designing and developing the novel workable catalysts for H\textsubscript{2} fuel production. The catalysis stability was evaluated by extending the working load, which indicate a robust and reversible behavior with well maintaining its reactivity. Low-dimensional materials with rich engineerable parameters provide a new avenue to enhance the functionality and their performance stability for new energy technologies. This talk highlights the synergistic materials science and engineering can provide the opportunities to customize materials for advanced modern energy technology development.
Antonio Tricoli is Professor of Materials Science at the Australian National University (ANU). He received his Bachelor and Master from ETH Zurich at the Department of Mechanical and Process Engineering. He continued his studies at ETH Zurich attaining his PhD in Nanotechnology in 2010. He joined the ANU in 2012 supported by a Future Engineering Research Leader fellowship, where he established the Nanotechnology Research Laboratory. His group research focuses on the multi-scale engineering of electromaterials for application in Energy and Medical Diagnostics. He is chair of the ANU Grand Challenge Our Health in Our Hands, a multidisciplinary strategic research program of the ANU. He is author of four book chapters and more than 100 scientific publications. His research contributions have been recognized with several awards including the 2010 HILTI Prize for the most innovative PhD thesis of ETH Zurich, an Australian Research Council Discover Early Career Award, and a WESTPAC Research Fellowship.

Scalable Structuring of Efficient Earth-Abundant Electrocatalysts for Water Splitting and CO₂ Reduction

Antonio Tricoli

Nanotechnology Research Laboratory, College of Engineering and Computer Science, Australian National University

Email: antonio.tricoli@anu.edu.au

Electrochemical production of H₂ by water splitting is a promising carbon-free route for the large-scale production of renewable fuels and commodities. It provides a means to store renewable power such as electricity generated by photovoltaics and wind turbines, and facilitate its use for transportation and export. Development of commercial electrolysers for H₂ production at affordable cost and sufficiently large scales requires to replace current noble metal electrocatalysts by efficient earth-abundant alternatives. This is a challenging task as most earth-abundant materials struggle to provide simultaneously sufficient surface activity, stability, and electrical conductivity. Here, I will present the multi-scale engineering of efficient nanocomposite electrocatalysts, made of earth-abundant materials, for water splitting and CO₂ reduction by scalable routes such as flame synthesis. The self-assembly of fractal structures will be discussed as flexible tool for the large-scale design of composite material morphologies that can compensate for some of the above short-comings. Some of the most promising material structures will be presented including three-dimensional electrodes based on nanostructured Bismuth and Cobalt nanoparticles, providing a path toward their integration in full-sized devices.
Professor Mark Cook

Director of The Graeme Clark Institute, The Sir John Eccles Chair of Medicine and Director of Clinical Neurosciences at St. Vincent’s Hospital, Professor Cook specialises in the treatment of epilepsy. He is recognised internationally for his expertise in epilepsy management, particularly imaging and surgical planning. After completing specialist training in Melbourne, he undertook an MD thesis while working as Brain Research Fellow at Queen Square, London. He returned to St. Vincent’s Hospital, Melbourne to continue his interest in management of complex epilepsy. He has worked closely with engineers for most of his career, developing novel therapies for epilepsy. His interests have included experimental models of epilepsy and seizure prediction, and he has led the commercialisation of an implantable seizure detection device about to start clinical trials.

Developing an Implantable Epilepsy Device

Mark Cook
The University of Melbourne

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Remarkable insights into the patterns underlying seizure activity have been provided by data acquired in recent years from long-term intracranial monitoring devices. The recognition of marked disparities in the ability of patients to accurately identify seizures has very significant implications for management, assessment of new therapies, and safety. Intracranial recordings from subdural electrodes to predict seizures, demonstrating not only that this was possible but as well that striking patterns could be recognised that provided new approaches to the problem of seizure prediction. The short and long scales of seizure activity likely provide insights into the systems driving seizures, and potentially new perspectives on many problems that have defied explanation, such as drug-resistance. We have confirmed these cycles are not simply features of drug-resistant epilepsies, and found that the majority (80%) of patients with epilepsy showed circadian (24-hour) modulation of their seizure rates, as well as strong circaseptan (weekly) rhythms, with a clear 7-day period. Cycles longer than 3 weeks were also highly prevalent. The causes of multi-scale variation in seizure rates are yet to be comprehensively explored, but are likely to include a range of environmental and endogenous factors. Detecting multi-scale oscillations in seizure rate may provide new approaches to treatment decisions and the interpretation of drug trials. Knowledge of these cycles can be used to develop patient specific forecasting algorithms. Capturing accurate information about seizure frequency is clearly critical, but difficult to achieve in practice. Our earlier study involving a very invasive system was successful but not readily commercialised. We have subsequently developed a minimally invasive seizure detection system, currently being developed for a first in many study. The opportunities and challenges of such systems will be discussed.
Multi-Functional Nanocomposites from Naturally Derived Materials:
Conductive Melanin and Crystalline Celluloses

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Natural systems utilize multifunctional biocomposites by a bottom-up self-assembly of nanomaterials for creating multiscale, hierarchical, and multiphasic structures. While conventional man-made synthetic composites increase one functionality by sacrificing the others, the biocomposites often synergistically utilize their multi-functionalities. Here, by molecularly organized layer-by-layer assembly as well as thermodynamically driven orientation, we introduce multifunctional nanocomposites, recently developed from our laboratory, from natural biomaterials including high crystalline cellulose nanofibers and conductive melanin nanoparticles. High crystalline cellulose nanofibers, extracted from tunicates, have shown almost perfect crystallinity, straight fibrous shape, and liquid crystalline alignments. Thus, their nanocomposites showed uniquely oriented structures as well as excellent optical, mechanical, and barrier properties. On the other hand, naturally derived melanin nanoparticles are molecularly structured to possess finely tunable electrochemical conductivities, optical reflectivity, and casting shape stability with inherent biocompatibility. These composites can be used as key functional materials in the emerging applications such as biotic-abiotic smart interfaces, implantable electronics, and eco-electronics.
Associate Professor Ekaterina Pas

Ekaterina I. Pas (née Izgorodina) was educated at the Higher Chemistry College affiliated with the Russian Academy of Sciences and graduated with both a Bachelor of Science degree in Chemistry and Master of Science degree in Theoretical Chemistry. She obtained her Dr. Rer. Nat. degree in 2004 from the University of Münster under the supervision of Prof. Stefan Grimme. After a post-doctoral position with Prof. Michelle L. Coote at the Australian National University she joined the School of Chemistry at Monash University in 2006 as a Research Fellow in Prof. Douglas R. MacFarlane’s group. From 2008 until 2016 she has held two prestigious fellowships from the Australian Research Council, an Australian Post-Doctoral Fellowship and later a Future Fellowship, that allowed her to establish the Monash Computational Chemistry Group (https://mccg.erc.monash.edu/). In 2017 she was elected a Fellow of the Royal Australian Chemical Institute (RACI) and in 2019 she appeared on the list of top 100,000 researchers in the world. Her group specializes in development and applications of wavefunction- and electron density-based methods to studying large-scale systems – from condensed systems to large biomolecules with a view to develop radical organic batteries, design adhesive coatings and electrode materials based on neurotransmitters, utilise electric field and ionic solvents to catalyse chemical reactions, provide better control of free-radical polymerisation, design novel anti-cancer and antimicrobial drugs and predict polymorphism in crystals for enhanced pharmaceuticals. Her passion lies in the understanding of the role of intermolecular forces and structural arrangement on physicochemical properties of condensed systems and large biological systems. She is an Associate Professor in the School Chemistry at Monash University who strongly contributes to the teaching program through the curriculum development in computational and physical chemistry. Currently, she is also Associate Head International Affairs in the School.

Towards All-Organic Radical Batteries


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Ionic liquids (ILs) have been shown to successfully replace traditional electrolytes in a variety of electrochemical devices. Applications of organic-based electrodes based on polymers are relatively sparse due to their reduced electrochemical stability. Polymers synthesized from nitroxide or phenol radicals represent the most researched electrode materials to-date. Nitroxide-based polymers have been successfully applied as a cathode material, reaching the operating potential of > 3.5 eV when paired with a lithium anode. Due to the susceptibility of nitroxide radicals to undergo hydrogen transfer reactions, their reduced form has been particularly difficult to stabilize in traditional electrolytes, thus limiting the advancement of nitroxide polymers as both cathode and anode material.

Recently we have discovered that ILs provide an ideal medium for stabilizing organic radicals, including carbon-based and nitroxides. This stability is achieved due to a strong interaction existing between a nitroxide radical and the ionic liquid cation. We have further explored this concept of imparting stabilization on nitroxide radicals by improving both reduction and oxidation potentials in various ILs. Redox potentials of the TEMPO radical were predicted to reach up to 5.5 eV in pyrrolidinium ILs compared to that of 2.2 eV observed for TEMPO in aqueous electrolytes. More importantly, the reduced form of TEMPO – the aminoxy anion - was found to be very stable in the presence of ionic liquid ions. This unprecedented stability was further confirmed by experiment, showcasing a new strategy for the development of all-organic radical batteries.
Dr Ajay Pandey is a Senior Lecturer in Robotics and Autonomous Systems at the School of Electrical Engineering and Robotics, and a Domain Leader within Manufacturing with Advanced Materials, Institute of Future Environments. Prior to his current appointment, he held prestigious fellowships including QUT-Vice Chancellor’s Senior Research Fellowship and Australian Renewable Energy Agency (ARENA) Research Fellowship at the University of Queensland (UQ). Dr Pandey’s research interests have the interdisciplinary mix of Photonics, Chemical Physics, Molecular Electronics, Computer Science and Robotics. He has published widely across research areas connecting advanced materials to machine vision, energy, environment and robotics. He leads an interdisciplinary research group at QUT that specialises in technological implementation of advanced materials in Neuroengineering, Robotics, Energy Up-conversion and Machine Vision. He also serves as an Editorial Board Member of Scientific Reports- an open access from Springer Nature Group.

Smart Robotic Skin and Large Area Tactile Sensing Using Elastomers and Advanced Organic Optoelectronic Diodes

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One of the most critical senses that we rely on while interacting with the physical world is our sense of touch. Many modern robots have excellent vision and hearing systems that can mimic or even surpass human capabilities but capturing physical interactions via the sense of touch in robotics remains a major technological challenge. We have developed a new class of tactile sensors that utilize multi-functional operation of organic optoelectronic diodes in form of a highly integrated electronic skin [ACS Appl. Mater. Interfaces, 2019, 11, 24, 21775-21783]. Such sensors have shown remarkable spatial, temporal and angular resolution that closely mimic the force sensing ability of human fingertip. We have further exploited the photonic utility and directional property of light by making large area tactile sensors in planar form. Our robotic skin prototypes with active area of 10x10 cm² reveal that optical force sensing is an excellent candidate when it comes to tactile and proximity sensation over large areas.
Scientia Professor J. Justin Gooding

Scientia Professor Justin Gooding is currently an ARC Australian Laureate Fellow, the co-director of the Australian Centre for NanoMedicine and the co-director of the New South Wales Smart Sensing Network. He is a Fellow of the Australian Academy of Science and the Australian Academy of Technology and Engineering. He is the inaugural editor-in-chief of the journal ACS Sensors.

He leads a research team of over 40 researchers interested in surface modification and nanotechnology for biosensors for medical applications, electrocatalysis and 3D cell printing.

Nanoparticles that mimic the three-dimensional architecture of enzymes: The role of nanoconfinement in enhancing electrocatalytic reactions

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Nanoparticle electrocatalysts and enzymes present common features such as their size and the reactions they catalyze. One main difference between them is that while the active sites of nanoparticles are in direct contact with the electrolyte, enzymes have their catalytic sites spatially separated from the solution environment, providing high reaction kinetics and selectivity. In this work enzyme architecture is used as inspiration to make nanozyme; nanoparticles containing isolated channels and with the outside surface electrochemically passivated to enable the electrochemical reaction to happen exclusively inside those channels. This was first shown with PtNi nanoparticles for the oxygen reduction reaction (ORR) where it is shown that the excellent electrocatalytic performance is due to nanoconfinement effects. Subsequently we show how nanozymes can be developed for performing cascade reactions using the carbon dioxide reduction reaction as the model reaction where nanoparticles with a silver core and a copper shell are designed. Here we show how the nanoconfinement influences the product distribution.

Bioelectronic Applications of Graphene Fiber electrodes

University of Houston

Recording and stimulating from peripheral nerves that control internal organs critical for normal human physiology, is paving the way for effective neuromodulation of these nerves for clinical benefit. This electroceutical approach has been proposed as alternative treatment for drug-resistant conditions, including those in chronic inflammation and cardiovascular diseases. However, effective bioelectronic applications require miniature implantable electrodes capable of interfacing with small autonomic nerves with minimal to no effect on the nerve anatomy. Soft and flexible polymers and fiber based on highly porous reduced graphene oxide (rGO), are part of a new class of materials that have been developed specifically to interface small nerves, either standing alone or traveling in between blood vessels and fat tissue. These probes are mechanically robust and exhibited excellent electrical conductivity and charge storage capacity characteristics, while maintaining their strong flexible nature. This material have allow the fabrication of advanced neural interfaces. This new devices can be used to achieve sensitive recording and safe nerve stimulation. Examples of the use of this material for neural interfacing in Bioelectronic Medical applications will be presented.
Dr Nevena Todorova’s research passion is in using computational modelling techniques to better understand the behaviour, structure and properties of (nano) biomolecules and materials. Her research findings have been published in world-leading journals in the field, including *JACS*, *Nano Letters*, *Chemistry of Materials*, *Advanced Functional Materials* and *Small*. She has been awarded 2 international fellowships to visit the University of Cambridge, Imperial College London and University College Dublin, UK. Her work has been recognised by numerous travel grants and presentation awards from internationally and nationally renowned organisations such as the Materials Research Society, USA and the Royal Australian Chemical Institute. She is currently a Senior Lecturer and an Early Career Development Fellow in RMIT University’s School of Engineering.

**Computational modelling of functional nanomaterials in biological media**

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Nanoparticles exhibit a unique set of size-dependent physicochemical properties that can be easily tailored through functionalisation with biologically relevant chemistries. This has inspired the development of many innovative biomedical applications including colorimetric biosensors and drug-delivery agents. In order to rationally design and optimise these nanoparticles for incorporation and efficiency within biomedical devices and *in vivo*, there is a need to thoroughly understand the fundamental interactions at the bio-nano interface, and how these properties adjust in biological media. Computer simulations present a virtual microscope to assist in gaining such understanding through molecular insights into the structure and dynamics of these bioconjugated nanoparticle systems. Here, we present a selection of studies where we have employed multiscale computational techniques to provide molecular insights into the functional interface of bioconjugated nanoparticle systems used in drug-delivery, biosensing, and theranostic applications. These works demonstrate that simulations offer a powerful complementary approach to experiments to assists in the design of novel biomedical (functional) agents.

Growing Low-Dimensional Inorganic Nanostructures via CVD: Insights from Quantum Chemistry & Molecular Simulations

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Over the last few decades, catalytic chemical vapor deposition (CVD) has matured as a synthetic technique for producing many low-dimensional inorganic nanomaterials, such as carbon nanotubes (CNTs), graphene and boron nitrides. The general mechanism of graphene and CNT formation during CVD is now well established [1]. I will discuss recent results showing how CNTs and graphene nucleate and "grow" during CVD, and how this mechanism can be controlled by key chemical etchant species (e.g. H₂, H₂O, NH₃, acetonitrile etc.) [2-4]. However, in contrast to carbon nanomaterials, little is known regarding the catalytic pathways underpinning CVD synthesis of boron nitride nanomaterials [1]. I will present the first mechanism explaining the nucleation of boron nitride nanotubes (BNNTs) via CVD of boron oxide and ammonia borane, based on reactive molecular dynamics simulations [5,6]. Strikingly, BNNTs nucleate via a ‘network fusion’ mechanism, by which distinct BN fragments first form before ‘clicking’ together on the nanoparticle surface (Figure 1). We also reveal key roles played by H₂O and H₂ partial pressures and the presence of solid-phase catalytic nanoparticles on this mechanism.

Figure 1. Reactive non-equilibrium MD simulations reveal the mechanism of BNNTs on Ni nanoparticles via BN network fusion.

References
Professor Yun Liu

Yun Liu is Professor at the Australian National University leading a “Functional Materials Research Group” at the Research School of Chemistry. She is a materials chemist with a strong focus on local crystal chemistry, properties characterisation and the designed modification of solids to achieve new or improved properties for industry applications. Yun Liu received her PhD degree from the Xian Jiaotong University in 1997. She has since held the AIST Fellow and STA Fellow in Japan (1998-2001), and ARC QEII Fellow and Future Fellow (2006-2015) in Australia. She services the Asian ElectroCeramics Association and Asia-Oceania Neutron Scattering Associations an executive board member. She is vice president of the ANBUG. She is a Fellow of the Australian Institute of Physics, and a member of the SCANZ, MA, RACI and IEEE. She is the winner for the TechConnect Global Innovation Award in 2018 and Banksia Sustainability Award (Innovation) in 2013. She is and the finalist for “The Australian” -“Innovation Challenge” in 2013. Her research will cover one or more aspects as follows: (1) Material synthesis and design (2) Local structure and defect analysis (3) Functionality characterisation from nanometre to centimetre length scale, in particular related to dielectric, piezoelectric and ferroelectric properties, photocatlytic and photovoltaic effects as well as energy storage; And (4) Device fabrication. She has published over 221 peer-reviewed journal papers, including papers published in Nature Materials, Advanced Materials, Advanced Functional Materials and Chemistry of Materials. She held 27 patents.

Defect design for dielectric polarization

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Ionic doping and/or substitution in polar functional materials provide opportunities to tune the polarization for the peak performance or to create new polarization behaviors. In the past, the research in this field mainly focuses on the development of the relationship between the macroscopic structures (e.g. average structure determined by X-ray powder diffraction) and properties. It is found, however, that in many cases, such a relationship becomes very complicated and cannot be properly built. This is because that in a strongly correlated solid-state system, these ions can be structurally and/or chemically accommodated differently in local region but do not change the average structure. The trend that such ionic doping and/or substitution influence the properties is often not straightforward. In this talk, I will use several examples to demonstrate the local consequence of ionic doping and/or substitution and their impact on polarization property, and thus drawing your attention on the material design for high performance and new functions.
Fibre-based Microfluidics and Diagnostics: Precise Concentration and Delivery of Targets using the Simplest of Substrates.

Brett Paull, Liang Chen and Jean-Marc Cabot

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Alternative substrates to traditional polymer manifolds for microfluidics and diagnostic devices have attracted a great deal of interest over recent years. Disposable and low-cost materials, which are readily modified and so amenable to selective isolation and detection of target species have significant potential across a range of application areas. Paper based microfluidics present a typical example, whereby reasonably sophisticated analysis can be achieved with rather rudimentary materials and techniques. In this presentation we present an alternative low-cost class of substrate, namely fibres and threads, as the base to achieve reasonably advanced separations, isolation (trapping) and concentration of target species. Examples of electrodriven separation and concentration techniques (e.g. electrophoresis, isotachophoresis and isoelectrofocussing) will be shown for both small and large classes of molecules, with demonstration of how such simple approaches can be utilised for delivery of simple diagnostic assays, or for more advanced isolation and purification protocols. In addition, the issue of solute detection will be addressed, and some new approaches presented, including the use of on-fibre ambient mass spectrometry. Fibre modification, particularly spatially resolved modification, e.g. modified zones for potential selective solute trapping and enhanced detection, will also be discussed, and potential applications presented.
Anthony K. Burrell received a Ph.D. in chemistry in 1990 from the University of Auckland, New Zealand. He was a postdoctoral fellow at the University of Texas, Austin (1991-1992) before joining Los Alamos National Laboratory as a Directors Fellow in 1992. He then moved to the Chemistry Department at Massey University, New Zealand and 1994 and was awarded the Chair of Synthetic Chemistry in 1998. In 2001 he returned to LANL as a Scientist where he established new programs in materials chemistry. In 2011 he moved to Argonne National Laboratory where he was the Head of Department for the CSE Electrochemical Energy Storage Department and a PI in the Joint Center for Energy storage Research (JCESR). In 2016 he joined the National Renewable Energy Laboratory as Chief Technologist for Energy Storage. He has authored over 230 publications in refereed journals and has 42 issued US patents.

**Professor Anthony Burrell**

Behind the Meter Storage: Low TRL work guided by a system level approach

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This presentation will describe a new multidisciplinary research effort aimed at creating a cost effective, critical materials free, solution to Behind The Meter Storage (BTMS) by employing a whole systems approach. The focus of this initiative is to develop innovative battery energy storage technologies for high-power charging of electric vehicles (EVs). Solutions will need to eliminate potential grid impacts and provide ancillary services to the consumer. BTMS electrochemical solutions ranging from lead acid to lithium ion are being assessed for compliance with extremely long lifetime and high cycle life. The specific functional requirements for BTMS battery solutions that will provide novel battery systems with a lifetime of greater than 20 years and at least 10,000 cycles. The project ranges from a detailed analysis of the performance space that couples building needs, including thermal storage, deployed PV and high power. Integration of thermal and electrochemical storage is a unique challenge from choices of compatible chemistries through to control algorithms to optimize energy use and efficiency. Solutions will require a sound understanding of materials and cell properties and possible cost models as well as the balance of plant issues that will impact battery lifetimes and total system performance.
Professor Maria Forsyth “FAA” (Fellow Australian Academy of Sciences), is the Director of ARC Industrial Transformation Training Centre in Energy Storage Technologies, StorEnergy, past ARC Laureate fellow and currently an Alfred Deakin Professorial Fellow at Deakin University and an Ikerbasque Visiting Professorial Fellow at University of the Basque Country. She is the Associate Director in the ARC Centre of Excellence in Electromaterials Science (ACES) and Deputy Director of the Institute for Frontier Materials (IFM) at Deakin University in Australia, where she leads the research effort in energy storage and corrosion science.

Professor Forsyth leads collaborative projects in lithium and sodium battery technologies funded through recent Australian Research Council grants and with various industries. She is a co-author of over 550 journal and conference publications attracted more than 20000 citations. She has delivered more than 25 invited and plenary talks in the past 5 years. She was one of the team that delivered the ACOLA report “The Role of Energy Storage in Australia’s Future Energy Supply Mix” to the Chief Scientist in 2017. Professor Forsyth has served on several editorial boards and is currently senior editor for Journal of Physical Chemistry letters. She is the recipient of the Galileo Galilei award for her contributions to the Polymer Electrolyte and energy storage field, has received the Australian Corrosion Association Corrosion Medal and was awarded to The Victorian Prize for Science and Innovation (VESKI) in 2017.

**Towards practical high energy density batteries using Ionic Liquid electrolytes and the role of the electrode interphase**

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In recent years, superconcentrated electrolytes, in particular those based on Ionic Liquid solvents, have been the focus of our research due to their ability to support superior device and cycling performance of high energy density metal anodes. It is now well accepted that the electrode/electrolyte interface and the solid electrolyte interphase (SEI) layer that is ubiquitous on any given electrode in an operating battery is critical to the performance of a device. This interphase prevents unwanted electrolyte decomposition whilst presenting a low resistive pathway for the desired redox processes such as deposition and stripping of metal as in the case of a metal anode. The complex nature of the SEI is controlled by the electrolyte chemistry and composition chemistry in addition to the initial formation conditions. A thorough understanding of the electrified interface in any electrolyte/electrode system and the way for an optimization of the SEI remains a challenge, and yet it is essential for the development of future high performance batteries. We have focused on gaining an understanding of the fundamental aspects of bulk electrolyte transport and interfacial behaviour in these Ionic Liquid systems and their relationship to device performance, as will be discussed in this presentation.
Dr Nagore Ortiz-Vitoriano

Dr. Nagore Ortiz-Vitoriano is an Ikerbasque Research Fellow, who has been spearheading metal-air research at CIC energiGUNE (Spain) since 2016, of which she became research line manager in 2018.

She obtained her doctorate in 2011 for her work on solid oxide fuel cells (University of the Basque Country, UPV/EHU, Spain), during the course of which she undertook research stays at Risø DTU (Denmark) and Imperial College London (UK). She was awarded the doctoral special prize by the UPV/EHU for her significant contributions to experimental science. In 2013 she was awarded a Marie Curie International Outgoing Fellowship from the European Union, enabling her to join the Department of Mechanical Engineering at the Massachusetts Institute of Technology (MIT) in Cambridge (USA) where she worked with both lithium and sodium-air batteries. In 2015, she continued this fellowship at CIC energiGUNE, where she conducted research stays at Oak Ridge National Laboratory (USA) and Deakin University (Australia).

Dr. Ortiz-Vitoriano has focused on both rational design of electrode materials for energy storage (e.g. solid oxide fuel cells, Na-ion and metal-air batteries), as well as fundamental research focussed on elucidating key processes (by establishing relevant physiochemical models) in order to facilitate rapid future developments at both the material and system levels.

She has experience in managing national and international projects, mentoring (under)graduate students, and teaching experience in a wide range of international environments in three languages (English, Basque and Spanish). These skills, combined with her firm commitment to ensuring a productive and open work environment, has led to strong international links and a significant network of collaborators – including global leaders in their research areas.

Engineering 3D Graphene Air Cathodes for Na-O2 Batteries

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Rechargeable Na-O\textsubscript{2} batteries have received a great deal of attention as alternative to current lithium ion batteries, in particular due to their potential to provide higher energy densities. Besides the overall cell performance, this technology requires the utilization of suitable cathode materials, able to accommodate the maximum amount of discharge products without pore clogging and subsequent cell failure. Porous carbon materials have been largely used as electrodes and specifically, graphene has arisen as a very versatile and promising cathode due to its superior electrical conductivity and highly accessible 2D area.

First, we will discuss the effect of the pore size of self-standing, binder-free graphene electrodes on the electrochemical performance. Graphene materials with different pore sizes have been prepared by the thermal reduction of different graphene oxide structures, observing a compromise between pore size and performance to achieve high-performing batteries. This route, however, implies dangerous procedures and a subsequent reduction step to tune the sheets conductivity. We have, therefore, explored the electrochemical exfoliation route using a small, innocuous biomolecule in the dual role of exfoliating the electrolyte and the aqueous dispersant. This work demonstrates the advantages of the method and the result outperforms the graphene cathode studies reported in literature.
Professor Myung-Han Yoon

Myung-Han Yoon received his B.S. (1999) in Chemistry and M.S. (2001) in Physical Chemistry at Seoul National University, South Korea. He studied “Organic Semiconductors and Dielectrics Based Thin Films Transistors” for his Ph.D. (2006) in Materials Chemistry with the guidance of Prof. Tobin J Marks at Northwestern University in US. In 2006, he moved to Department of Chemistry and Chemical Biology at Harvard University (Prof. Hongkun Park group) as a postdoctoral fellow and focused on neuronal electronic/fluidic interfaces. He joined School of Materials Science and Engineering, Gwangju Institute of Science and Technology (GIST) as a junior faculty member in 2010, and became promoted to an associate professor in 2015 and a full professor in 2018. He has been an advisory professor at LG Electronics since 2016. His research interest is “Developing Solution-Processable Functional Materials Based on Conducting Polymers, Sol-Gel Metal Oxides, Fibrillar Hydrogel for Printable Flexible Electronics and Bio-Electronic Interfaces”.

Conducting polymer microfibers for organic electrochemical transistor-based bioelectronics

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Despite the great potential of polymer microfibers in human-friendly wearable electronics, most previous polymeric electronics have been limited to thin-film-based devices due to practical difficulties in fabricating microfibrillar devices, as well as defining the active channel dimensions in a reproducible manner. Herein, we report on conducting polymer microfiber-based organic electrochemical transistors (OECTs) and their application in single-strand fiber-type wearable ion concentration sensors. We developed a simple wet-spinning process to form very conductive poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) microfibers using aqueous sulfuric acid solutions and carefully examined their electrical/electrochemical properties. In conjunction with fabricating substrate-free PEDOT:PSS microfiber-based OECT devices, the proposed novel characterization method demonstrated that the current variation ratio can be a reliable method for evaluating the device performance for sensing ion concentrations, regardless of the actual channel dimensions. Finally, we developed single-strand fiber-type skin-mountable OECTs by introducing a source-gate hybrid electrode and demonstrated that the resultant microfiber sensors can perform real-time repetitive measurements of the ion concentration in human sweat.
Three-dimensional (3D) printing is an additive manufacturing technology that allows fabrication of objects by adding successive layers of materials (e.g. polymers) on top of each other through computer-aided design. Among different 3D printing approaches, the stereolithography technique based on the photopolymerisation process is extremely attractive due to environmental, economical and production benefits. Over the past decade, major advances have occurred in the development of new 3D printers; the engineering, electronic and optical technologies of 3D printing devices are already mature. However, only a limited number of photoinitiators or photoinitiating systems (e.g. phosphine oxide photoinitiators) are commercially available and suitable for 3D printing. But these traditional photoinitiating systems pose several challenges for biological applications. In particular, they require harmful high-energy UV light to operate and are not efficient for the recently emerged inexpensive 3D printers based on low-intensity visible light (i.e. lead to low printing speed). It is desirable to develop visible-light-sensitive photoinitiators with high photoinitiation efficiency which can significantly promote the 3D printing speed. In this presentation, an overview of photoinitiation ability of various newly developed photoinitiating systems will be given. Then, the relevant inherent photochemical mechanisms and the chemical structure/photoinitiation ability relationship will also be discussed. Finally, the application of high-performance photoinitiating systems for fast 3D-printing under visible light will be demonstrated.

References
ACES Showcase Speakers
Biographies & Abstracts
Holly Warren

Dr. Holly Warren is a research fellow at the University of Wollongong working within the Australian Research Council Centre of Excellence for Electromaterials Science. Her research focuses on hydrogel preparation and characterisation for various smart material applications along with the preparation and optimisation of various materials for bioprinting.

Patterning of Hydrogels Using Ionoprinting

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Hydrogel materials present innovative solutions for problems presented by hard components in fields such as soft robotics, bionics and electroactive materials science. The focus of this research is to develop actuating hydrogels which are strong, electrically conductive and can be fabricated using 3D printing techniques. A composite network of acrylamide, carbon nanofibres and alginate will be presented which includes both covalent and ionic cross-linking strategies. Novel ionoprinting methods are used to create consistency and cross-linking gradients through the bulk hydrogel. This can be used to control actuation and fine-tune the hydrogel motion.
Next Generation Magnetic Plastics, Doughs, Gels and Liquid droplets

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Magnetic materials are generally solid with fixed shape. The introduction of magnetic properties in flexible polymers, soft dough and gel or liquid form can open up a new era of wireless controllable materials for next generation composites, biomedical, drug delivery and energy related applications. The recent interest of forming liquid magnetic droplets using iron oxide nanoparticles with surfactant is an excellent example. [1] Here we have synthesized a highly dispersible iron oxide dispersed edge-functionalized graphene that is highly dispersible both in water and organic solvents. [2] This high dispersible properties lead us to fabricate magnetic polymer film by mixing with polymers, binder-free soft magnetic doughs, magnetic paste or gel. In parallel with the different three-dimensional configuration we have also prepared magnetic liquid oil droplets in water and water droplet in oil that can me moved by magnetic force as micro-robot. This interesting finding will help us to develop next generation micro or nano vehicles for drug delivery or carrier.

References
Molecular insight into designing optimized battery electrolytes

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Knowledge of the structure and ion transport of electrolyte materials is critical to understand their electrochemical performance and design the better suitable electrolyte materials for future batteries. Nowadays, Molecular modelling technique plays an increasingly important and indispensable role in material research. Here we present some case studies to demonstrate how we use molecular simulations to assist in designing the optimal electrolyte structure and composition, and understand the inherent ion transport mechanisms, interface structures, and link this information with the actual electrochemical performance in experiment.
I am an ARC DECRA research fellow at the UTAS node. My research is focused around 3D printing microfluidic platforms for electrofluidic and diagnostic applications. My research interests are based on my interdisciplinary background in material science, additive manufacturing, microfluidics, pharmaceutical sciences, analytical chemistry, and computational fluid dynamics.

Three-dimensional Bifurcating Microfluidic Distributors to Realise a Brain-on-a-Bench System

Vipul Gupta and Brett Paull

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Microfluidic distributors that can uniformly distribute fluid from a single channel to multiple channels and into or across 3D spaces, and vice versa has always represented a challenge. Hence, herein, unique single-piece three-dimensional bifurcating microfluidic distributors have been designed and developed using 3D printing, which can distribute fluid from a single channel to multiple parallel channels and deliver fluid evenly into a receiving chamber/structure, and equally collect from this space in a similar manner to a single outlet. The distributors have resulted in low-dispersion divergence and convergence of flow to and from 64 parallel channels while operating at flow-rates ranging from 0.25 mLmin⁻¹ to 2 mLmin⁻¹, as characterised through computational fluid dynamic simulations and solid-phase extraction studies. The three-dimensional distributor has been used to develop a miniaturised perfusion chamber for three-dimensional cell culture growth and analysis and a high surface area multi-capillary column. The perfusion chamber has been designed to fit within a conventional electrochemical sensor to study cell’s electrical response to various stimuli in order to gain a better understanding of epilepsy. Moreover, multiple such chambers can be easily assembled together to develop an elaborate system, such as a Brain-on-a-Bench.
Liang Chen

PhD candidate (Utas)

Electrofluidic fibre-based analytical devices coupled with ambient ionization mass spectrometry

Liang Chen ¹, Stuart Thickett ², Brett Paull ¹*

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Fibres and fabrics have been frequently investigated as a group of inexpensive materials for the fabrication of low-cost, disposable microfluidic devices. The soft and flexible nature allows easy cutting, knotting or sewing of fibre onto various support materials to achieve suitable hydrophilic-hydrophobic balance. The porous structures between these inexpensive and commercially available materials are capable of transporting aqueous fluids through capillary action without the requirement of external pumping. However, fluid movement due to wicking varies significantly based on length, interfibre bonding and the types of gaps and voids in the structures of fibres, yarns, and fabrics. This project aims to develop fibre-based electrofluidic devices coupled with ‘on-fibre’ ambient ionisation mass spectrometry for direct and rapid characterisation of chemical and biochemical species, separated from complex mixtures and matrices. DESI is an ambient ionization technique for the detection of solid or liquid sample under ambient environment with little or without sample preparation. However, the lack of chromatographic separation makes it difficult to qualify and quantify analytes in complex samples. Therefore, it is meaningful for the combination of low-cost electrofluidic fibre-based analytical devices for sample preconcentration or separation from complex samples with ambient ionization mass spectrometry for rapid qualitative and quantitative detection.
Jawairia Umar Khan

Jawairia Khan is a PhD scholar in University of Wollongong. Her PhD work focusses on “Textile based Microfluidics” for separation and diagnostic science. Her background is textile engineering with masters in advanced materials. Her research interest includes surface functionalization of textiles materials to customize the separation properties of chemical and biological mixtures for multiplex assay.

3D textile structures as electrophoresis platforms for selective delivery and separation of complex mixtures

Jawairia U KhanAB, Sepidar SayyarAB, Brett PaullBC, Peter C InnisAB

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In recent decades, microfluidics has emerged as a game changer in the field of clinical diagnostics. These in-situ, on-site microfluidic portable devices have a great potential to substitute traditional analytical labs. However, the complex fabrication techniques and pumping system to drive fluids are a potential barrier towards practicality of microfluidic devices. In a simpler approach, the inherently built microchannels in textile substrates facilitate fluid movement without an external source provides a great potential for a far simpler approach than the microfluidic chip. In this work, textile-braided structures have been developed and investigated for the demonstration of on-fiber capillary electrophoresis and Isotachophoresis. These provide an open surface accessible separation platform, which contrast conventional closed glass capillaries or chips, where direct access to sample zone during separation is nearly impossible. These braided structures were further functionalized for modification of electroosmotic flow, selective delivery of different analytes and to enhance the overall efficiency of the process. This on-fiber surface accessible separation of different analytes demonstrated the advantages of simplicity, flexibility, speed and selectivity for the targeted separation and characterization of complex biomolecules (including blood, plasma, and urine). The developed technology will provide significant new inverted-microfluidic capabilities in bioanalysis, proteomics and rapid clinical diagnostics.

References

Hao Zhou received the B.S. degree in building environment and facility engineering from Tongji University, Shanghai, China, in 2004, the M.S. degree in mechanical engineering from the University of Queensland, Brisbane, QLD, Australia, in 2008, the second M.S. degree in engineering practice (mechanical) from the University of Wollongong, Wollongong, NSW, Australia, in 2009, the Ph.D. degree from the School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, Wollongong, Australia, in 2014. He is currently a Research Fellow with ARC Centre of Excellence for Electromaterials Science, University of Wollongong, mainly focusing on soft robotics for prosthetic devices. His research interests include mechanical design of prosthetic hands, soft actuators, soft sensors, human machine interface based on bio-signals (e.g., electromyogram), simulations and analysis of electromagnetics, simulations and analysis of the biomechanics of small intestine, mechanics of viscoelastic materials, and active locomotion of wireless capsule endoscopy.

A soft robotic prosthetic hand with pattern recognition based myoelectric control

Hao Zhou

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Conventional prosthetic hands require assembly of rigid parts (e.g., links and joints) and they usually lack mechanical compliance. By combing the techniques of soft robotics and additive manufacturing (3D printing), we have developed a novel soft robotic prosthetic hand, which has a monolithic structure and its fabrication is much more cost-effective compared to that of those conventional prosthetic hands. With programed intrinsic compliance of the soft body, this hand prosthesis has better performance in terms of adapting to unknown surfaces when grasping objects. Wireless surface electromyography (EMG) sensors together with pattern recognition algorithm are utilized to analyze the muscle activity from a user’s residual arm and predict the intention of hand movements. As a human-computer interface (HCI), this system can provide a user with more intuitive control of the robotic prosthetic hand than most commercial myoelectric hands on the current market, by which it can potentially reduce the rejection rate of myoelectric hands. Our soft robotic hand is demonstrated to be able to perform the commonly used hand patterns for activities of daily living (ADLs). The final outcome of the whole project is creating a cost-effective soft robotic hand prosthesis with an intuitive control system, programmable mechanical compliance, integrated sensors and a neural interface system.
Gerardo Alan Montoya Gurrola

Mexican mechatronics engineer from the Laguna Institute of Technology. With more than 6 years of experience working in the manufacturing industry, worked as full-time teacher at 2 of the main technological universities in southern Mexico. With he’s team, was awarded as National (Mexico) and World champion in 2013 of the Vex Robotics Competition which made him enter the STEM hall of fame of the REC Foundation. He has participated in altruistic projects as co-founder of RE: Purpose for good, an association responsible for making technological assistance accessible to people with disabilities, using recyclable materials for the fabrication of prostheses and wheelchairs. Currently a PhD student, under the tutelage of Professor, Gursel Alici at Wollongong University in the Soft Robotics area and an active member of the Centre of Excellence for Electro materials Science ACES

Adaptive Neural Interface to Control Prosthetic Devices: Design, Fabrication and Performance Evaluation

Gerardo Montoya

PhD Student in Soft Robotics

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Neural Interface is a direct communication method between a nerve system and an external piece of hardware, this hardware can be prosthesis, a transportation device or even a property [1]. Nowadays, there are interfaces that depend on certain physical capacities, which are not available to all persons with disabilities, having a direct impact on their independence and their adaptation to the environment in which they live. The development of this type of interface can help not only the manipulation of a prosthesis, but once developed the system can be extended and adapted to other technologies, such as Domotics, manufacturing and telemetry, in addition to helping us to understand a little more how the nervous system works in certain states and environments. This research proposes a new approach in the obtaining and recording of data through the Nervous System, more specifically the median and ulnar nerves. The proposed device seeks to solve the problems that have been presented during the last decades with respect to obtaining data of this nature. The research also aims to develop a technology that is usable in the day a day of patients, as well as facilitating the manipulation of upper limb prosthesis, helping haptic communication [2] with the environment that surrounds them.

References:
Improving usability, intuitiveness of controlling prosthetic hand via non-invasive approach

Hong Quan LE

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The human hand possesses a sophisticated structure. With more than 25 degrees of freedom, 18 tendons cross the wrist, 19 articulations and opposable thumbs it capable of carry out extremely fine and complex movement. Possessing that high level of dexterity, the human hand is a useful enable us to interact with environment for communicating with each other with ease. Losing the hand lead to detrimental consequence. Post-operation, artificial limbs are chosen by patient with the hope restoring function and look of their lost segment. Nevertheless, most prosthetic hand on the market fails to satisfy customer needs due to their lack of control intuitiveness. Rejection rate among prosthetic users is as high as 40%. My research project aims to improve robustness and intuitiveness of functional prosthetic hand via non-invasive method. Current non-invasive prosthetic control is affected by various factors: high input lag between intention and actuation, performance degradation across sessions and different limbs position. To control myoelectric prosthetic hand, Machine learning is applied for accurately decoding user intention in fix, seated pose from electromyography signal. For tackling performance degradation of varying limb position and across session, transfer learning is applied with the objective of achieving satisfactory performance with minimum calibration.
Si-Xuan Guo

Dr. Si-Xuan Guo obtained her PhD degree from the Department of Chemistry, National University of Singapore. She is currently a Research Fellow in the School of Chemistry and the ARC Centre of Excellence for Electromaterials Science, Monash University. Her research focuses on the synthesis of nanomaterials and their applications in energy conversion.

Strategies for Enhancing the Activity of Bismuth-based Catalysts for Electrochemical Reduction of Carbon Dioxide

Si-Xuan Guo, Ying Zhang, Xiaolong Zhang, Douglas R. MacFarlane, Alan M. Bond, and Jie Zhang*

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Electrochemical reduction of CO₂ is a promising method to convert CO₂ into useful chemicals or fuels especially when electricity generated from renewable sources is used. However, the application of this method is limited by the high overpotential needed and low product selectivity. In this talk, I will present the strategies that have been used in our group to enhance the activity of bismuth-based catalysts for electrochemical reduction of CO₂.
In July 2014, I finished the undergraduate program and received a Bachelor of Engineering Degree from School of Chemical Engineering, Tianjin University, China. In 2015, I went to University of Edinburgh to do my master degree and joined Prof. Neil Robertson’s group. The research project was the Synthesis of New Organic Dyes for Dye Sensitized Solar Cells. A Master of Science by Research Degree was admitted in November 2016. From October, 2017, I started my PhD program in School of Chemistry, Monash University and worked with Prof. Douglas Macfarlane. My research project is Advanced Redox Materials for Electrolytes in Non-aqueous Redox Flow Batteries.

**Novel Electrolytes for Non-aqueous Redox Flow Batteries**

**Shuo Dong, Diogo Moulin Cabral, Douglas R Macfarlane**

ARC Centre of Excellence for Electromaterials Science, School of Chemistry, Monash University, Clayton, Victoria 3800, Australia

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Redox flow batteries are recently considered as a promising technology for large scale energy storage systems. Although some types of the battery have been commercialized, their low working voltages caused by the aqueous electrolytes limit their further applications. Using organic solvents has previously been attempted and the idea of non-aqueous redox flow batteries is proposed. However, the low solubilities and poor electrochemical properties of the redox couples inside the organic electrolytes have become the main issue. In this work, to improve the solubility of [Fe(bpy)₃]²⁺, serval methods were tried and discussed, which includes the modification of the complex, the selection of counter ions and the work on the solvents.
Amruthalakshmi Vijayakumar

I am a final year ACES affiliate PhD student.

Copper Nanowires with tunable selectivity for Electrochemical Reduction of CO₂

Amruthalakshmi Vijayakumar¹, Kezhong Wang¹, Yong Zhao¹, Caiyun Wang*¹, and Gordon G. Wallace*¹

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Abstract: Electrochemical reduction of CO₂ (CO₂ ER) at room temperature can produce value-added chemical feedstocks and liquid fuels. It is considered as an attractive way for the CO₂ recycling. Selective and efficient catalysts are required for the practical implementation of CO₂ER. Copper is the mostly investigated catalyst for CO₂ER, as it can form different products including hydrocarbons and alcohols.

Herein, we demonstrate an efficient catalyst, copper nanowires (Cu NWs) on copper mesh that are prepared by the thermal oxidation in combination with the electrochemical reduction. This catalyst demonstrates a product selectivity dependence on the nanowire length with a product preference between formate and carbon monoxide. Cu NWs with a length of 2.32 µm are favourable for the generation of CO with a faradaic efficiency ratio of 2.52 between CO and HCOO⁻ at -0.8 V (vs. reversible hydrogen electrode); in contrast, this ratio became 0.71 for Cu NWs with a length of 2.73 µm which with formate as the dominant product.
Dr Eva Tomaskovic-Crook is a Research Fellow within the Synthetic Biosystems theme of ACES at the University of Wollongong. Eva’s research brings together front-line technologies human stem cells with cell instructive bio- and electro-materials for next generation tissue building. Her approach includes novel 3D-printing, stem-cell derived organoidogenesis, and electro-stimulation, particularly for neural tissue engineering and application – including drug/toxicity testing, medical device development, disease diagnostics, tissue replacement therapy, and regenerative medicine.

Eva completed her PhD at the Ludwig Institute of Cancer Research and University of Melbourne. Her PhD focused on developing antibody targeted drug loaded nanoparticles to treat colorectal cancer. As a Postdoctoral Fellow at A*STAR Institute of Molecular and Cell Biology in Singapore, and St Vincent’s Institute in Melbourne, her research in cancer cell biology continued, to identify therapeutic targets of breast cancer using applied bioinformatic approaches. Prior to her PhD, Eva worked as a Senior Research Assistant for over 7 years in the field of Schizophrenia neurobiology and drug discovery at the Mental Health Research Institute of Victoria in Melbourne, and the Clinical Brain Disorders Branch of the National Institute of Mental Health at the US National Institutes of Health in Bethesda, USA.

Eva’s work within ACES is enabling her to apply and further develop her experience and interests in human cell biology, neurobiology, biomaterials, and electro-/pharmaceuticals research. Recent highlights include the development of a novel method for generating human brain organoids and an innovative platform for creating human neural tissues by 3D electrical stimulation of stem cells. The research was recently awarded the inaugural Research Australia 2019 Health and Medical Research “Frontiers Research Award”. The Frontiers Research Award category recognises transformative research that extends existing knowledge and understandings within health and medical research that will enable Australia’s health system to position itself as a global leader.

**Synthetic Biosystems to Model Brain Pathologies**

**Eva Tomaskovic-Crook**

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Electricity is important in the physiology and development of human tissues such as embryonic and fetal development, and tissue regeneration for wound healing. Exogenous electrical fields can emulate endogenous bioelectric potentials important for normal cell development and function. Electrical stimulation is also increasingly used clinically to restore function to tissues damaged by injury or disease. Partly driven by the need to address the escalating burden of psychiatric illnesses such as depression and schizophrenia, new and better treatments in terms of safety and efficacy are urgently required. Thus, there is a pressing need to create better “synthetic biosystems” to fully understand neurodevelopment and more accurately model brain pathologies. The generation of brain organoids derived from human pluripotent stem cells (PSCs) is a significant step towards better in vitro modelling. Brain organoids are discerned by their cellular and structural complexity, with characteristics of developing embryonic brains. We have demonstrated gelatin methacrylate (GelMA) to be a 3D printable semisynthetic cell growth substrate for rapid and novel induction of brain organoids from human induced PSCs. Here we report on the status of our current research where we have shown the versatility of 3D and electroactive platforms for both research and translation, including modelling tissue development, function and dysfunction, electroceuticals, drug screening and regenerative medicine.
Extrusion-based 3D bioprinting has been increasingly employed in skin tissue engineering by virtue of its automatic process and space-controlling feature. However, this technique is hitting a bottleneck due to a paucity of suitable bioink formulation that is both biomimetic and printable. In this study, we developed bioinks based on ulvan, a sulphated seaweed polysaccharide from a controlled source of Australian ulvacean macroalge, for 3D bioprinting dermal compartments with embedded human dermal fibroblasts (HDFs). Full thickness skin were reconstructed by co-culturing the dermal compartments with the epidermal compartments of seeded HaCaT keratinocytes for up to 41 days. Our results demonstrated that the dermal compartments supported cell proliferation and extracellular matrix (ECM) deposition. Real-time quantitative polymerase chain reaction (qPCR) revealed that ulvan may downregulate the gene expression of collagen I (non-significantly) and collagen III (significantly) by HDFs. This could be potentially useful for preventing scar formation in wound healing. The full thickness skin constructs based on different formulations showed the development of two-layered structures with certain levels of stratification of the epithelial layer. Overall, the present work provides insights into the utilization of ulvan for skin tissue engineering and wound healing.
Bijan Shekibi

I completed my undergraduate studies in a double degree of materials engineering (honours) and biomedical science at Monash University in 2016. I enrolled to become a PhD student at the University of Wollongong in 2017, based at St Vincent’s Hospital in Fitzroy. My PhD project is on development of in vitro neuromuscular junctions towards a prosthetics interface. There are drafts for publications being written from work done during the PhD, however two articles have been published during summer internships while in undergraduate.

**Electrical Stimulation of Neural Cells on Multielectrode Arrays**

B. S. Shekibi\(^{1,2,3}\), A. Harris\(^{1,2,3}\), A. Quigley\(^{1,2,3}\), B. Rollo\(^4\), G. Wallace\(^1\), R. M. I. Kapsa\(^{1,2,3}\)

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Neural cells derived from primary fibroblasts using viral transfection and cultured on a multielectrode array. The neural culture exhibits spontaneous and synchronous action potential bursts. Multielectrode array systems were used to characterise the bursting pattern of the culture and electrically stimulate it extracellularly. A series of different stimulation protocols were applied to determine the effects of various voltages (500mV, 750mV, 1000mV), number of biphasic pulses (1-20) applied and the number of parallel stimulation events (1-20). The cells exhibited a dynamic refractory period post stimulation that depended on the intensity of the stimulation parameters. However, excessive stimulation of the neural cells lead to decreased spontaneous activity. The stimulation parameters developed using NGN2 neural cells will be applied towards stimulation of other neural cells.
Mark Howard

Mark is a Research Fellow with the Philosophy Program at Monash University, part of the Australian Research Council Centre of Excellence for Electromaterials Science (ACES) in the research field of Ethics, Policy and Public Engagement (EPPE). A key milestone he is working toward is identifying the range of potential effects of emerging medical diagnostic systems (esp. wearables) on social relations and ascertaining the implications for access to, and experience of, health care. Of primary interest are the effects of such transformative/disruptive technology on societal wellbeing. This includes considering the relevant sociotechnical systems and normative structures that impact on the design, deployment and use of hardware and software and how this contributes to social and political outcomes. Specialising in political philosophy and applied ethics, Mark’s research in the area of emerging technologies focuses on social justice and alternative forms of participation in social and political institutions.

Wearables, machine learning and efficiency in health care: How will I know that you're thinking of me?

Dr Mark Howard

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In the emerging digital health market place, accounts of the potential for wearable medical devices to dramatically impact global healthcare are overwhelmingly positive. Pursuing a technological innovation narrative, the benefits of wearables and their attendant big data platforms and machine learning applications are predicted to include personalised medicine, improved efficiency and quality of care, the empowering of under-resourced communities, and delivery of health services previously unavailable to the citizens of developing countries. Typically techno-optimist or solutionist in their description, key barriers to this impending inflection point in healthcare are identified as technical issues such as short battery life, unreliable connectivity, poor wearability and a lack of data protection. While these bottlenecks are of legitimate concern, I argue the dominant solutionist paradigm is consistent with problematic ethical, social and political assumptions that if accepted uncritically risk designing social inequality and injustice into our interventions in global healthcare.
In the contest for Australia’s – and the world’s – renewable energy (RE) future, the model that eventually prevails matters significantly as it will impact society in multiple ways. Low-carbon energy transitions are not purely technological transitions but are also social, economic and cultural in nature with lasting environmental consequences. RE technologies are transforming previously highly-centralised and one-directional energy systems into more decentralised, bidirectional, and potentially democratic ones, thereby altering socioeconomic conditions more broadly. Yet, accelerated RE deployment and technologies themselves are not neutral, nor do they emerge in a social or political vacuum. Social forces shape and underpin system transitions and technologies, determining their form, utility and power relations (see Curran 2019; Smith 2005). My analysis identifies three types of RE activity (individual, community, commercial), whilst noting that they are not mutually exclusive, and explores how current (sub-)national policies frame each category. Analysing the framing of RE actors is vital as it reveals critical underlying assumptions about the political roles and importance of stakeholders in future energy systems. The analysis focuses on the framing of RE actors in Australia and Germany in a comparative manner, revealing several key similarities and fewer yet important differences.
Mathew Cherian is a PhD scholar with ACES with Deakin University and Prof Linda Hancock as his guide. Mathew has considerable experience in disaster management, relief and rehabilitation as former director of OXFAM and currently CEO of HelpAge India based in New Delhi India. He is researching on disasters and the implications on renewable energy and policy.

Indian Energy Transitions: The Energy Divide

Mathew Cherian
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India has come a long way in just a few years to rank fifth globally in renewable energy capacity. The Indian Prime Minister has doubled the renewables target to 450 gigawatts at the UN Climate Summit in September, signalling that the country’s focus on renewable energy is one for the long-term. As per the estimates of power planning body, Central Electricity Authority, India’s capacity mix will look predominantly green in 10 years with coal-fired projects constituting merely a third of total installations. However Natural disasters have made coastal areas extremely vulnerable and solar installation and wind energy becomes very vulnerable to disasters. No contemporary conversation on energy security can take place without speaking of energy storage. India needs a storage policy in place as it implements its renewable energy targets swiftly. In addition, there is a need to tap into multiple storage technologies, including pumped hydro, instead of depending on any one technology in the interest of domestic energy security. There is an increasing reliance on storage with lead acid batteries. Recycling of these batteries is almost impossible in remote areas and they pose a danger in disasters such as floods. The future of the energy divide in India will be poor battery storage technology for rural areas and coal-based energy through the grid for high consumption urban areas.
Poster Presenters
Biographies & Abstracts
Poster Presenter Summary

1. Alex Harris, University of Wollongong  
   *Sutrode: conductive sutures for next generation bionics*

2. Alex Nagle, University of Wollongong

3. Alexandre Xavier Mendes, Swinburne University of Technology  
   *Electroactive Hydrogels for Active Drug Delivery and Cellular Stimulation*

4. Amruthalakshmi Vijayakumar, University of Wollongong  
   *Copper Nanowires with tunable selectivity for Electrochemical Reduction of CO₂*

5. Andres Ruland, University of Wollongong

6. Rebecca Hodgetts, Monash University  
   *Optimisation of the solvent|electrolyte system for efficient electrocatalytic dinitrogen reduction to ammonia under ambient conditions*

7. Bijan Shekibi, University of Wollongong  
   *Electrical Stimulation of Neural Cells on Multielectrode Arrays*

8. Buddhika Gayani, University of Wollongong  
   *Single Cell Analysis of Cell-Material Interactions for Discovery of Phenotypic Disease Biomarkers*

9. Caiyun Wang, University of Wollongong  
   *Surface Engineering of Nanostructured Metals for Efficient Carbon Dioxide Reduction*

10. Catherine Simpson, Australian National University  
    *Activation of a Non-Redox Isomerisation Using Static Electricity*

11. Chong-Yong Lee, University of Wollongong  
    *In-situ electrochemical reduction and storage of CO₂ in calcium containing electrolytes*

12. Chunyan Qin, University of Wollongong  
    *Bipolar ElectroStimulation - A Wireless Platform for Cell Stimulation enabled by Conducting Polymers*

13. Cuong Nguyen, Monash University  
    *Nitrogen Photocatalytic Fixation on mesoporous Titanium Dioxide*

14. Dan Yang, University of Wollongong

15. Danielle Warren, University of Wollongong  
    *Electro stimulation of 3D Bioprinted Neural Tissues in Disease Model*

16. Gerardo Montoya, University of Wollongong  
    *Adaptive Neural Interface to Control Prosthetic Devices: Design, Fabrication and Performance Evaluation*
<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>Hao Zhou, University of Wollongong&lt;br&gt;A soft robotic prosthetic hand with pattern recognition based myoelectric control</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>19.</td>
<td>Hong Quan Le, University of Wollongong&lt;br&gt;Improving usability, intuitiveness of controlling prosthetic hand via non-invasive approach</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>20.</td>
<td>Inseong Cho, University of Wollongong&lt;br&gt;The significant effect of small substitutions of redox mediators on electron transfer kinetics between surface-bound porphyrins and Co^{2+/3+} polypyridyl complexes</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>21.</td>
<td>Jawairia Khan, University of Wollongong&lt;br&gt;3D textile structures as electrophoresis platforms for selective delivery and separation of complex mixtures</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>22.</td>
<td>Jeremy Dinoro, University of Wollongong&lt;br&gt;3D Printed Porous Structures Based on StarPore™</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>23.</td>
<td>Justin Bourke, University of Melbourne&lt;br&gt;Electrophysiological Systems for Tissue Engineering Applications within ACES</td>
<td>University of Melbourne</td>
</tr>
<tr>
<td>24.</td>
<td>Kale Amol Marotrao, Sunchon National University&lt;br&gt;One Step Synthesis Of Vanadium Metal Organic Framework For Supercapacitor Application</td>
<td>Sunchon National University</td>
</tr>
<tr>
<td>25.</td>
<td>Kezhong Wang, University of Wollongong&lt;br&gt;Neural stimulation and recording with flexible freestanding graphene fiber based microelectrodes</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>26.</td>
<td>Klaudia Wagner, University of Wollongong&lt;br&gt;Carbon dioxide reduction on Gortex based gas diffusion electrodes</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>27.</td>
<td>Kyuman Kim, University of Wollongong&lt;br&gt;Synthesis of Cuprous Oxide using Electrodeposition Method as a Photo-electrochemical Catalyst</td>
<td>University of Wollongong</td>
</tr>
<tr>
<td>28.</td>
<td>Liang Chen, University of Tasmania&lt;br&gt;Electrofluidic fibre-based analytical devices coupled with ambient ionization mass spectrometry</td>
<td>University of Tasmania</td>
</tr>
<tr>
<td>29.</td>
<td>Lijuan Yu, Australian National University&lt;br&gt;Re-Examination of Proline-Catalyzed Intermolecular Aldol Reaction: A Theoretical Study of the Mechanism and Stereoselectivity</td>
<td>Australian National University</td>
</tr>
<tr>
<td>30.</td>
<td>Linbo Li, Monash University&lt;br&gt;Facets-etching Tuning Strategy on Copper Oxides for Electrochemical CO2-to-Ethanol Conversion</td>
<td>Monash University</td>
</tr>
<tr>
<td>31.</td>
<td>Linda Hancock, Deakin University</td>
<td>Deakin University</td>
</tr>
<tr>
<td>32.</td>
<td>Linda Wollersheim, Deakin University&lt;br&gt;Analysing the framing of renewable energy actors in Australia and Germany</td>
<td>Deakin University</td>
</tr>
<tr>
<td>33.</td>
<td>Luciana Daikuara, University of Wollongong&lt;br&gt;Human Platelet Lysate-based platforms for Wound Healing Application</td>
<td>University of Wollongong</td>
</tr>
</tbody>
</table>
34. Mathew Cherian, Deakin University  
   Indian Energy Transitions: The Energy Divide

35. Michael Higgins, University of Wollongong

36. Mitchell Blyth, Australian National University  
   Oriented Internal Electrostatic Fields Cooperatively Promote Ground & Excited State Reactivity: A Case Study in Photochemical CO₂ Capture

37. Munavvar Fairoos Mele Kavungathodi, University of Wollongong  
   Effect of Comprehensive Passivation on the Charge Recombination at the Sensitized Surface

38. Natalie Ralph, Deakin University

39. Nicholas Hill, Australian National University

40. Nuwan Dhanushka, University of Wollongong

41. Pierre-Alexandre Martin, Chalmers University of Technology  
   Study of structure and interaction in localized highly concentrated electrolyte for new generation calcium-batteries

42. Saimon Silva, Swinburne University of Technology  
   Lubricin and GelMa: a hybrid biomaterial resistant to biofouling

43. Samuel Rathbone, University of Wollongong  
   Ultrasound Mediated Piezoelectric Stimulation of Human Neural Stem Cells

44. Sangwon Park, Sunchon National University  
   Ion exchanged P2-K₀.63Na₀.08[Cr₀.85Sb₀.15]O₂ with higher electrochemical performance than as-synthesized P2-K₀.70[Cr₀.85Sb₀.15]O₂ as potassium-ion batteries cathode

45. Shaikh Nayeem Faisal, University of Wollongong  
   Next Generation Magnetic Plastics, Doughs, Gels and Liquid droplets

46. Shuai Zhang, University of Wollongong  
   Wearable Thermo-electrochemical Cells: Using Redox-Gel Integrated Flexible Electrodes to Covert Body Heat into Electricity

47. Shuo Dong, Monash University  
   Fe(II) Mixed Ligand Complexes for High Energy Density Non-aqueous Redox Flow Batteries

48. Si-Xuan Guo, Monash University  
   Electrohydrogenation of Carbon Dioxide using a Ternary Pd/Cu₂O-Cu Catalyst

49. Sujani Abeywardena, University of Wollongong  
   Charged species on GelMA coated core-shell 3D textile structures in electrofluidics
50. Sung Min Kim, Hanyang University

51. Thomas Blesch, Monash University
   Iron-based non-aqueous Redox Flow Battery

52. Vincent Doan, Australian National University
   Computational Design of Highly Activating Ligands for Atom Transfer Radical Polymerisation

53. Vipul Gupta, University of Tasmania
   Three-dimensional Bifurcating Microfluidic Distributors to Realise a Brain-on-a-Bench System

54. Xifang Chen, University of Wollongong
   3D bioprinting dermal-like structure and full thickness skin using sulfated polysaccharide ulvan

55. Yongwoo Jang, Hanyang University
   Self-powerd gastric sensor for stomach motility

56. Zhi Chen, University of Wollongong
   Building biomimetic human cornea using electro-compacted collagen

57. Zhilian Yue, University of Wollongong

58. Tran Phu Thanh, Australian National University
   Nanostructured 8-Bi$_2$O$_3$ Fractals on Carbon Fibers for Highly Selective CO$_2$ Electroreduction to Formate

59. Isabella Russell, Australian National University
   Investigating a Novel ATRP Inspired Carbon-Based Radical Mediator
Alex Harris received his PhD from Monash University in electrochemistry under the supervision of Prof Alan Bond. Subsequently he was a team leader at Oxford Biosensors developing point-of-care blood sensors. He was then awarded an Office of the Chief Executive postdoctoral position at CSIRO, followed by a postdoctoral position in the synthetic biosystems group of ACES. He is a project leader in the HEARing CRC investigating the electrode-tissue interface of cochlear implants and other bionic devices. He leads a UoW Global Challenges team “combatting neurodegenerative disease” which is modelling emergent properties in the brain. His research aims to understand and improve the electrode-tissue interface, resulting in more effective clinical outcomes for patients and reducing the number of animals used in preclinical testing.

**Sutrode: conductive sutures for next generation bionics**

Alex Harris, Anita Quigley, Kezhong Wang, Robert Kapsa, Mario Romero-Ortega, Gordon Wallace

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Neurological disorders include epilepsy, deafness, Parkinson’s and Alzheimer’s diseases, and chronic pain which affect more than 20% of the global community. Existing drug treatments are often inadequate and result in significant life-disrupting side-effects. Treatment of neurological diseases has thus evolved towards electrical stimulation of nervous tissue with bionics devices to treat neurological disorders, within an emerging clinical field of “electroceutical” therapies. Key to the performance of such bionic devices is the quality and resolution of sensing and stimulatory electrodes’ interfacing with the neural tissue. Current electrodes are large and stiff, only allowing interrogation of large nerve fibres or neural networks, limiting the ability to monitor and control small specific neural populations. In addition, progressive corrosion or encapsulation by scar tissue impacts electrode sensitivity and functionality. The Sutrode is a microscale and highly flexible electrode that can be tied suture-like around small nerve fibres, allowing much more specific access to organs and tissues than existing electrodes. This presentation will detail recent results on Sutrode performance from different models.
Alexandre Xavier Mendes
PhD candidate in Biomedical Engineering at Swinburne University of Technology.
Double bachelor’s degree in Science and Technology and in Chemical Engineering obtained from Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brazil.
Experience studies in Biotechnology Forensics and DNA techniques at Fleming College, Canada.
Work experience in the pharmaceutical field on development and investigation of new drugs and optimization of process to minimize cost and maximize efficiency.
Research experience in development of electrocatalysts semiconductor fluid diffusers based on cobalt and nickel for application in filter-press reactors for degradation of emerging pollutants (drugs) in water.

Electroactive Hydrogels for Active Drug Delivery and Cellular Stimulation

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The development of new technologies based on electroactive materials has become an attractive approach due to its potential for application in different areas including drug delivery systems (DDS), biosensors, and tissue engineering.\textsuperscript{1} These materials have some interesting properties along with great biocompatibility, such as ability to swelling/shrinking that helps on the release of drugs and electrochemical characteristics that can mimic electrochemical signaling between cells.\textsuperscript{1-3} Addition of electroactive materials to the hydrogel structure could improve the ability of the material to connect by electrical signals with biomolecules, since hydrogels have a nonelectrical behavior.\textsuperscript{4} Nowadays some materials that are used as neural interfacing are stiffer than neural tissues. High stiffness can lead to a miss match that could decrease the functional biological interaction at the cell/biodevice interface leading to the development of a chronic inflammatory response and reduced implant lifetime and efficiency.\textsuperscript{5} In this research, gelatin methacryloyl (GelMA) and liquid crystal graphene oxide (LCGO) is studied for developing of an electroactive hydrogel (EAH – Figure 1). The electrochemical behaviour of the composite GelMA-LCGO was investigating by cyclic voltammetry and electrochemical impedance spectroscopy. The presence of LCGO increased the faradaic current of EAH and decrease the material resistance. Increasing amounts of LCGO showed an increase in compressive modulus of the composite. Cellular studies will be developed to confirm non-toxicity of EAH.

Figure 1 – Representation of electroactive hydrogel – GelMA and LCGO

Electrochemical reduction of CO₂ (CO₂ ER) at room temperature can produce value-added chemical feedstocks and liquid fuels. It is considered as an attractive way for the CO₂ recycling. Selective and efficient catalysts are required for the practical implementation of CO₂ ER. Copper is the mostly investigated catalyst for CO₂ ER, as it can form different products including hydrocarbons and alcohols. Herein, we demonstrate an efficient catalyst, copper nanowires (Cu NWs) on copper mesh that are prepared by the thermal oxidation in combination with the electrochemical reduction. This catalyst demonstrates a product selectivity dependence on the nanowire length with a product preference between formate and carbon monoxide. Cu NWs with a length of 2.32 µm are favourable for the generation of CO with a faradaic efficiency ratio of 2.52 between CO and HCOO at -0.8 V (vs. reversible hydrogen electrode); in contrast, this ratio became 0.71 for Cu NWs with a length of 2.73 µm which with formate as the dominant product.
Optimisation of the solvent|electrolyte system for efficient electrocatalytic dinitrogen reduction to ammonia under ambient conditions

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Developing technology for storing renewable energy as carbon free, light weight and energy dense materials such as ammonia is critical for the purposes of energy distribution. This will enable Australian renewable energy industry to expand from servicing local energy needs to supplying the international market. Ammonia is a carbon free alternative to energy exports such as coal and methane gas and offers superior chemical storage to conventional solar fuels such as hydrogen. However, the current industrialised method of ammonia production consumes almost 2 % of the world’s annual energy budget just to meet existing demand. Clearly this method of synthesis has no viable future as a renewable energy storage solution. To monopolise ammonia as a form of energy storage, a highly efficient and reliable production method is required. One such approach is through the electrochemical reduction of dinitrogen. Nørskov\(^1\) and co-workers employed density functional theory to predict high catalytic activity of iron for N\(_2\) electroreduction. Iron is also an effective catalyst for producing hydrogen gas, meaning the competitive reaction that severely reduces the efficiency of the process. Herein we present our investigation into the mitigation of such side reactions through control and design of the electrolyte environment.

I completed my undergraduate studies in a double degree of materials engineering (honours) and biomedical science at Monash University in 2016. I enrolled to become a PhD student at the University of Wollongong in 2017, based at St Vincent’s Hospital in Fitzroy. My PhD project is on development of in vitro neuromuscular junctions towards a prosthetics interface. There are drafts for publications being written from work done during the PhD, however two articles have been published during summer internships while in undergraduate.

### Electrical Stimulation of Neural Cells on Multielectrode Arrays

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Neural cells derived from primary fibroblasts using viral transfection and cultured on a multielectrode array. The neural culture exhibits spontaneous and synchronous action potential bursts. Multielectrode array systems were used to characterise the bursting pattern of the culture and electrically stimulate it extracellularly. A series of different stimulation protocols were applied to determine the effects of various voltages (500mV, 750mV, 1000mV), number of biphasic pulses (1-20) applied and the number of parallel stimulation events (1-20). The cells exhibited a dynamic refractory period post stimulation that depended on the intensity of the stimulation parameters. However, excessive stimulation of the neural cells lead to decreased spontaneous activity. The stimulation parameters developed using NGN2 neural cells will be applied towards stimulation of other neural cells.
Poster #8 
Buddhika Gayani 

Buddhika Gayani is a first year PhD student at University of Wollongong, Australia under the supervision of Pro. Michael Higgins and Dr. Paul Molino. Her PhD research title is Single Cell Analysis of Cell-Material Interactions for Discovery of Phenotypic Disease Biomarkers. The research work explores how the physical properties and interactions between cells and materials can relate to cancer identification based on atomic force microscopic measurements. She holds a BSc special in Chemistry and a Master of Philosophy in Physical Chemistry from the University of Sri Jayewardenepura, Sri Lanka. Her background is about chemical antimicrobial properties of nanomaterials including activated carbon, superhydrophobic surfaces and layered double hydroxides.

Single Cell Analysis of Cell-Material Interactions for Discovery of Phenotypic Disease Biomarkers

Buddhika Gayani1,2, Michael J. Higgins1,2

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Single-cell analysis has emerged as a potential technique for the identification of personalized cancer treatments since heterogeneity in tumors commonly fuels deterioration and resistance to treatment. Although this heterogeneity comes through genetic and phenotypic variations, phenotypic features provide the advantage of universality and their reflection of the cell’s molecular expressions. However, the relative importance of factors influencing phenotypic heterogeneity and their subsequent impact on genetic variations remain unclear to present them as a universal biomarker. For instance, the force-induced mechanical changes of the cell and its surrounding microenvironment such as cell stiffness, adhesion dynamics and physical molecular interactions with the extracellular matrix can be delivered as a live-cell phenotypic biomarker as they determine the adhesive and migratory ability of cells in cancer metastasis. Hence, a systematic integrative analysis of such live-cell phenotypic biomarkers with the combination of genomic tests would be the key to address intratumor heterogeneity. We present the preliminary stage of our project focusing on measuring changes in single-cell properties using AFM in response to the extracellular matrix. We are currently developing a microwell array system as the platform to combine AFM data with other downstream analysis such as gene sequencing.
Electrochemically converting CO₂ into useful chemicals or fuels currently face key challenges of poor energy efficiency and poor product selectivity owing to the sluggish reaction, complicated reduction pathways, and competitive H₂ evolution [1]. Robust and highly selective catalysts hold the key to the conversion performance. Manipulating the interfacial properties of catalysts derived from nanostructures or surface modification is an effective approach to tune the local chemical environment, electronic structure of active sites and binding ability to key intermediates for an enhanced performance. We have done a series of works on engineering the nanostructured metal catalysts for the two-electron reduction of CO₂ to CO due to the relatively facile product separation and large profit margin predicted. The selectivity of copper nanowires (CuNWs) is sensitive to the wire length, as evidenced by the corresponding main product change between formate and CO. The decoration of Sn nanoparticles on copper oxide nanowires can selectively convert CO₂ to CO with a high CO faradaic efficiency, a high CO partial current density at a moderate overpotential [2]. The electrocatalytic activity and selectivity of nanostructured Sn modified nitrogen-doped carbon nanofiber can even be tuned: Sn nanoparticles can drive efficient formic acid formation, while atomically dispersed Sn species switches the dominant product from formic acid to CO [3]. Ultrasmall Au NPs can be stabilized by graphene sheets, and this catalyst can promote the CO₂-to-CO conversion process offering a very high mass current density, as well as a high selectivity via a simple amine modification strategy to suppress H₂ evolution [4]. A Au-polyaniline nanocomposites catalyst also promotes the CO₂-to-CO conversion by suppressing H₂ evolution reaction through the direct axial coordination of amino group to Au catalytic centre.

Catherine Simpson completed a Bachelor of Science in Materials (2013) and Honours in Chemistry (2014) at the University of Wollongong (UOW). During her Honours project she studied triplet-triplet annihilation upconversion for dye-sensitised solar cells, supervised by Dr. Andrew Nattestad and A/Prof. Adam Trevitt. Catherine is now a PhD candidate under the supervision of Professor Michelle Coote in the Computer Aided Chemical Design Group at The Australian National University. She is currently using computational methods to study the effects of electric fields on chemical reactions.

**Activation of a Non-Redox Isomerisation Using Static Electricity**

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Despite electrolytes and electrostatic interactions being ubiquitous in chemical, material and biological sciences, there is still much to learn about the impact of static electric fields on the reaction rates and equilibrium positions of non-redox chemical systems. Recently there have been developments in experimental and computational methods to investigate electrostatic catalysis\(^1\). This work uses computational chemistry to study the effect of oriented electric fields on the ring opening of spiropyrans. Spiropyrans can undergo a ring opening reaction when exposed to various stimulants such as UV light or heat. Here we show that static electric fields can also yield measurable changes to the equilibrium between a ring-closed spiropyran molecule and its ring-opened form, due to its increased polarity. The electric field effects are found to be strongly directional.

**References:**

Dr. Chong-Yong Lee is currently a research fellow at the ARC Centre of Excellence for Electromaterials Science/Intelligent Polymer Research Institute, University of Wollongong. He received his PhD in Electrochemistry from Monash University Australia under the supervision of Prof. Alan Bond. Following postdoc studies at the University of Erlangen-Nuremberg, and the University of Cambridge (as a Marie Curie Research Fellow), he assumed a University of Wollongong Vice Chancellor’s Research Fellowship position in 2015. His research interests are on electrochemistry, nanomaterials, 3D printing, metalloenzymes, catalysis and solar fuels. He employs electrochemical, photocatalytic and photoelectrochemical approaches for activation of small molecules such as H₂O, O₂, and CO₂ to valuable fuels and chemical feedstocks. Particularly, he is highly enthusiastic in developing novel strategies in clean energy technologies, which he is hoping some of the ideas could contribute towards creation of a more sustainable world.

In-situ electrochemical reduction and storage of CO₂ in calcium containing electrolytes

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Innovation in CO₂ storage technology is required if implementation of an industrial scale electrochemical CO₂ reduction technology is to be realised. Particularly, the technology to capture an excess CO₂ during electroreduction would be attractive. Herein, we devise a strategy that enables in-situ electroreduction and the storage of excess CO₂. The integrated system enables efficient and selective conversion of desirable products from the reduction process and capture of excess CO₂ as calcite. By employing a Ag catalyst deposited on a gas diffusion electrode with a backside flow of CO₂, we demonstrate in-situ and concurrent CO₂ electroreduction and storage is readily achieved by employing calcium containing electrolytes. The local pH change during the electrochemical CO₂ reduction promotes calcification to store CO₂. This bioinspired work integrates the naturally occurring calcification process in oceans, to an electrochemical technology offers a new avenue towards realisation of a potentially scalable technology for CO₂ conversion and storage.
**Poster #12**  
**Chunyan Qin**

Chunyan Qin is currently a PhD candidate in ARC Centre of Excellence for Electromaterials Science (ACES) and Intelligent Polymer Research Institute (IPRI) at the University of Wollongong. She received a Bachelor degree of Macromolecule Material and Engineering in 2013 from Hubei Engineering University and a Master degree of Analytical Chemistry in 2016 from Hubei University. Now her research focused on the developing of conducting polymer based wireless bipolar setup for the growth and stimulation of cells.

**Bipolar ElectroStimulation - A Wireless Platform for Cell Stimulation enabled by Conducting Polymers**

Chunyan Qin, Zhilian Yue, Yunfeng Chao, Robert J. Forster, Xu-Feng Huang, Gordon G. Wallace and Jun Chen

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Conventional organic conductive polymers (CPs)-based electrical stimulation (ES) systems have been extensively explored in modulation of cell and tissue functions for biomedical applications. Bipolar electrochemistry could offer an effective pathway to modify these systems into a more desirable contactless working mode. In this study, we present for the first time the development of a CP-based bipolar electric stimulation (BPES) system for cells. Polypyrrole (PPy) films with different dopants have been developed, demonstrating reversible and recoverable bipolar electrochemical activity in PBS under a low driving DC voltage ($\leq 5.5$ V). A BPES prototype enabling wireless and programmable cell stimulation has been devised using PPy-DS-collagen as a bipolar electrode and rat pheochromocytoma cells as a model cell line. All the findings, including enhanced cell proliferation and differentiation, established the foundation of CP-based BPES system for cell stimulation, which provides an attractive wireless approach to advance the field of medical bionics.
Poster #13
Cuong K. Nguyen

I am currently a Ph.D. student under the supervision of Prof. Douglas MacFarlane and Dr. Alexandr Simonov at Monash University. My project is developing catalysts for N₂ photo(electro)-fixation. I have strong interests in photocatalysts, PEC as well as synthesis of materials for energy conversion applications. B.Sc. In Material Science (University of Science- Vietnam): Polymeric materials, Conductive polymers for flexible solar cells. M.Sc. in Chemistry (Sogang University – South Korea & KCAP – Korea center for Artificial Photosynthesis): Photocatalyst for water-splitting and CO₂ photoreduction.

Nitrogen Photocatalytic Fixation on mesoporous Titanium Dioxide

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Ammonia (NH₃) is an essential chemical in modern society because of its vital role not only in living organisms but in renewable energy resources. A facile, solar-based strategy to produce ammonia in aqueous media under ambient conditions, via N₂ reaction with transiently photogenerated H-atoms upon appropriate semiconductor materials is ideal. However, if such materials are to become widely adopted, they must be cheap to produce and operate. Therefore, the development of photo(electro)catalysts for this process that comprise only inexpensive, earth-abundant elements is critical. In this work, by using facile hydrothermal conditions, we synthesized mesoporous TiO₂ and applied them in a photo(electro)chemical setup to photosynthesize ammonia. The NH₃ generation rate and the stability of photocatalysts under one sun illumination have been investigated. Besides the interested product ammonia, nitrite and nitrate, other valuable chemicals, have also been detected in the photo-driven system. The evolution in nitrate concentration alongside ammonia concentration was suggested that the formation of NOₓ species from the photocatalytic reaction. Moreover, the origins of NOₓ species in this system have been discussed in detail from a physicochemical standpoint.
Electro stimulation of 3D Bioprinted Neural Tissues in Disease Model

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The aim of the project will be to investigate the effects of electrical stimulation (ES) on 3D bioprinted neural tissues generated from healthy and schizophrenic patient donor human induced pluripotent stem cells (iPSCs). Project objectives will include analyses of the cellular and molecular effects of ES during and after neural tissue induction, thereby providing proof-of-concept of advanced neural tissue engineering in vitro, abetment of transplanted autologous tissue survival, and in vivo therapeutic brain stimulation.
Poster #16
Gerardo Alan Montoya Gurrola

Mexican mechatronics engineer from the Laguna Institute of Technology. With more than 6 years of experience working in the manufacturing industry, worked as full-time teacher at 2 of the main technological universities in southern Mexico. With his team, was awarded as National (Mexico) and World champion in 2013 of the Vex Robotics Competition which made him enter the STEM hall of fame of the REC Foundation. He has participated in altruistic projects as co-founder of RE: Purpose for good, an association responsible for making technological assistance accessible to people with disabilities, using recyclable materials for the fabrication of prostheses and wheelchairs. Currently a PhD student, under the tutelage of Professor, Gursel Alici at Wollongong University in the Soft Robotics area and an active member of the Centre of Excellence for Electro materials Science ACES.

Adaptive Neural Interface to Control Prosthetic Devices: Design, Fabrication and Performance Evaluation

Gerardo Montoya
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Neural Interface is a direct communication method between a nerve system and an external piece of hardware, this hardware can be prosthesis, a transportation device or even a property [1]. Nowadays, there are interfaces that depend on certain physical capacities, which are not available to all persons with disabilities, having a direct impact on their independence and their adaptation to the environment in which they live. The development of this type of interface can help not only the manipulation of a prosthesis, but once developed the system can be extended and adapted to other technologies, such as Domotics, manufacturing and telemetry, in addition to helping us to understand a little more how the nervous system works in certain states and environments. This research proposes a new approach in the obtaining and recording of data through the Nervous System, more specifically the median and ulnar nerves. The proposed device seeks to solve the problems that have been presented during the last decades with respect to obtaining data of this nature. The research also aims to develop a technology that is usable in the day a day of patients, as well as facilitating the manipulation of upper limb prosthesis, helping haptic communication [2] with the environment that surrounds them.

References:
Hao Zhou received the B.S. degree in building environment and facility engineering from Tongji University, Shanghai, China, in 2004, the M.S. degree in mechanical engineering from the University of Queensland, Brisbane, QLD, Australia, in 2008, the second M.S. degree in engineering practice (mechanical) from the University of Wollongong, Wollongong, NSW, Australia, in 2009, the Ph.D. degree from the School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, Wollongong, Australia, in 2014. He is currently a Research Fellow with ARC Centre of Excellence for Electromaterials Science, University of Wollongong, mainly focusing on soft robotics for prosthetic devices. His research interests include mechanical design of prosthetic hands, soft actuators, soft sensors, human machine interface based on bio-signals (e.g., electromyogram), simulations and analysis of electromagnetics, simulations and analysis of the biomechanics of small intestine, mechanics of viscoelastic materials, and active locomotion of wireless capsule endoscopy.

**A soft robotic prosthetic hand with pattern recognition based myoelectric control**

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Conventional prosthetic hands require assembly of rigid parts (e.g., links and joints) and they usually lack mechanical compliance. By combing the techniques of soft robotics and additive manufacturing (3D printing), we have developed a novel soft robotic prosthetic hand, which has a monolithic structure and its fabrication is much more cost-effective compared to that of those conventional prosthetic hands. With programed intrinsic compliance of the soft body, this hand prosthesis has better performance in terms of adapting to unknown surfaces when grasping objects. Wireless surface electromyography (EMG) sensors together with pattern recognition algorithm are utilized to analyse the muscle activity from a user’s residual arm and predict the intention of hand movements. As a human-computer interface (HCI), this system can provide a user with more intuitive control of the robotic prosthetic hand than most commercial myoelectric hands on the current market, by which it can potentially reduce the rejection rate of myoelectric hands. Our soft robotic hand is demonstrated to be able to perform the commonly used hand patterns for activities of daily living (ADLs). The final outcome of the whole project is creating a cost-effective soft robotic hand prosthesis with an intuitive control system, programmable mechanical compliance, integrated sensors and a neural interface system.
Comprehensive Assessment of the Electrocatalytic Activity of Molybdenum-based Materials towards Dinitrogen Reduction to Ammonia

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Molybdenum disulphide promoted with Mo metal particles (Mo/MoS2) was suggested by DFT to provide energetically favourable binding with N2 molecule, hence to be catalytically active for the NRR at low overpotentials.1 However, MoS2 is a well-known hydrogen evolution catalyst rendering any reasonable selectivity for the N2 reduction with Mo/MoS2 in aqueous medium essentially impossible, as confirmed in our experiments. Therefore, we applied two aprotic ionic liquids providing high N2 solubility,2 viz. [C4mpyr][eFAP] and [P66614][eFAP], as electrolyte media for testing the electrocatalytic properties of molybdenum-based materials. Molybdenum metal and Mo/MoS2 catalysts were synthesised by reducing 2H-MoS2 with H2 at 950 and 850 °C, respectively. In [C4mpyr][eFAP], metal catalyst did not demonstrate significant rates of the NRR, but Mo/MoS2 enabled the electrosynthesis of ammonia at the yield rate of 17 pmol cm−2 s−1 and faradaic efficiency of ca 50% at an applied potential of −0.97 V vs. NHE, when using a mixture of 90% dry N2 and 10% H2O-saturated N2 as a feed gas. However, there no ammonia was detected when Mo/MoS2 was tested in [P66614][eFAP] under the same as well as other potential and humidity conditions. Juxtaposition of cyclic voltammograms of Mo/MoS2 recorded in two ionic liquids reveals very different electrochemical behaviour of the material in [C4mpyr][eFAP] and [P66614][eFAP], which is likely to explain the lack of activity in the latter medium. Further tests in tetrahydrofuran as a solvent and using a conventional lithium triflate electrolyte have further supported the hypothesis on the catalytic activity of Mo/MoS2 for the NRR, although the ammonia yield rate (3 pmol s−1 cm−2) and faradaic efficiency (ca 3%) were very low. However, further control experiments are needed before the final conclusion on the genuine NRR catalytic activity of this material can be achieved.

Improving usability, intuitiveness of controlling prosthetic hand via non-invasive approach

Hong Quan LE

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The human hand possesses a sophisticated structure. With more than 25 degrees of freedom, 18 tendons cross the wrist, 19 articulations and opposable thumbs it capable of carry out extremely fine and complex movement. Possessing that high level of dexterity, the human hand is a useful enable us to interact with environment for communicating with each other with ease. Losing the hand lead to detrimental consequence. Post-operation, artificial limbs are chosen by patient with the hope restoring function and look of their lost segment. Nevertheless, most prosthetic hand on the market fails to satisfy customer needs due to their lack of control intuitiveness. Rejection rate among prosthetic users is as high as 40%. My research project aims to improve robustness and intuitiveness of functional prosthetic hand via non-invasive method. Current non-invasive prosthetic control is affected by various factors; high input lag between intention and actuation, performance degradation across sessions and different limbs position. To control myoelectric prosthetic hand, Machine learning is applied for accurately decoding user intention in fix, seated pose from electromyography signal. For tackling performance degradation of varying limb position and across session, transfer learning is applied with the objective of achieving satisfactory performance with minimum calibration.
A PhD student Inseong Cho works with his supervisors professor Attila Mozer and professor Peter Innis at the Intelligent Polymer Research Institute (IPRI) within the University of Wollongong the centre of nodes in ACES. He studies fundamental electron transfer (ET) mechanisms between redox-active organic or metal-organic molecules in specific one attached to electrode surfaces and the other one dissolved in electrolytes. In particular, he focuses on the factors that affect (enhance or slow down) ET kinetics such as electronic coupling and energy difference between redox-active molecules (driving force, $\Delta G$) by designing molecular structures of the redox molecules. He is specialised in characterising the designed redox-active molecules using various electrochemical and spectroscopic techniques in different conditions.

In particular, he mainly utilises custom-built time-resolved transient absorption spectroscopy setups with sub-nanosecond to microsecond time-resolutions at which ET between the redox-active molecules at the interface takes place. Last year in 2018, he published a paper showing enhanced ET kinetics by alkyl-alkyl intermolecular interactions between electron donor and acceptor molecules (*J. Am. Chem. Soc.* 2018, 140, 13935), suggesting a new way to design ET interfaces. Now he is focusing on other intermolecular interactions as well as motifs on the redox molecules that influence electronic couplings and hence ET kinetics, using surface-bound porphyrin molecules and a series of Co$^{2+/3+}$ redox mediators.

The significant effect of small substitutions of redox mediators on electron transfer kinetics between surface-bound porphyrins and Co$^{2+/3+}$ polypyridyl complexes

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Electron transfer (ET) between surface-bound molecules attached to electrode surfaces and electron donor molecules dissolved in electrolytes is fundamentally important to design efficient energy conversion devices. Initially, this work aimed to investigate ET kinetics influenced by electrostatic interaction between lone-pair electrons of surface-bound porphyrins and Co$^{2+/3+}$ complexes in electrolytes by comparing ET kinetics of Zn-porphyrins and free-base porphyrins. However, we found that small structural changes on the ligands of Co$^{2+/3+}$ mediators more significantly affect ET kinetics than the free-energy differences (driving force, $\Delta G$) by influencing electronic coupling between donor and acceptor molecules. This finding is important because molecular structure is often selected to control $\Delta G$ and the effect of ligand structure on electronic coupling is ignored when substituted by simple groups such as methyl and methoxy. The findings in this work suggest that the effect of even minimal structural changes should be examined when designing charge transfer interfaces. The $\Delta G$ values for the ET were determined by cyclic voltammetry and differential pulse voltammetry, allowing us to interpret the results using Marcus theory of ET. The ET kinetics were determined using time-resolved transient absorption spectroscopy (TAS).
Jawairia Khan is a PhD scholar in University of Wollongong. Her PhD work focusses on “Textile based Microfluidics” for separation and diagnostic science. Her background is textile engineering with masters in advanced materials. Her research interest includes surface functionalization of textiles materials to customize the separation properties of chemical and biological mixtures for multiplex assay.

3D textile structures as electrophoresis platforms for selective delivery and separation of complex mixtures

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In recent decades, microfluidics has emerged as a game changer in the field of clinical diagnostics. These in-situ, on-site microfluidic portable devices have a great potential to substitute traditional analytical labs. However, the complex fabrication techniques and pumping system to drive fluids are a potential barrier towards practicality of microfluidic devices. In a simpler approach, the inherently built microchannels in textile substrates facilitate fluid movement without an external source provides a great potential for a far simpler approach than the microfluidic chip. In this work, textile-braided structures have been developed and investigated for the demonstration of on-fiber capillary electrophoresis and Isoctachophoresis. These provide an open surface accessible separation platform, which contrast conventional closed glass capillaries or chips, where direct access to sample zone during separation is nearly impossible. These braided structures were further functionalized for modification of electroosmotic flow, selective delivery of different analytes and to enhance the overall efficiency of the process. This on-fiber surface accessible separation of different analytes demonstrated the advantages of simplicity, flexibility, speed and selectivity for the targeted separation and characterization of complex biomolecules (including blood, plasma, and urine). The developed technology will provide significant new inverted-microfluidic capabilities in bioanalysis, proteomics and rapid clinical diagnostics.

References
Jeremy graduated with Bachelor of Science (Medical Biotechnology) and Master of Philosophy (Biofabrication) from the University of Wollongong (UOW), followed by a Master of Science at Utrecht University. He is currently undertaking PhD research in 3D printing implants through a joint program between the UOW and Anatomics (Melbourne-based Medical Devices company), at the Intelligent Polymer Research Institute (IPRI) within the Australian Institute for Innovative Materials (AIIM) at Wollongong University’s Innovation campus. His main focuses have been tissue engineering skin, liver and bone.

3D Printed Porous Structures Based on StarPore™

Jeremy Dinoro1, Kuan Phang Chan1, Joshua Daniher1, Philip Lewis2,3, Robert Thompson2, Zhilian Yue1, Stephen Beirne1, Gordon Wallace1

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Bone defects are known to be difficult to repair due to variabilities in mechanical strength and complex vasculature. Suitable 3D printing technologies are emerging yet must be coupled with advances in materials that are easily processed, tailorable and biocompatible. This work aims to develop a customised AM platform based on a powder bed fusion technology commonly called selective laser sintering (SLS). The platform was designed to sinter trilobal high density polyethylene (HDPE) particles. A theoretical sintering model was established to gauge laser energies necessary to melt and bind HDPE particles. Various laser parameters (wavelength, technology, speed, lens diameter) were explored to establish efficient sintering. Differential scanning calorimetry revealed a narrow ‘sintering window’ in which HDPE should be maintained within for adequate coalescence of particles. The influence of laser irritation was not deemed detrimental to the polymer following thermogravimetric analysis and Fourier-Transform infrared spectroscopy analysis. Mechanical testing showed welding efficiency of sintered parts to be ~50% that of the moulded equivalents. µCT analysis proved porosity could be tailored between 65 – 85% via printing, where moulded scaffolds remained at 55%, proving this custom sintering system has the capacity to match the internal architecture of bone dependent on age, location and site of injury.
Poster #23
Justin Bourke

Justin has been a member of the ARC Centre of Excellence for Electromaterials Science since early 2014, and has extensive experience in electrophysiological system design, biosignal processing, and 3D biomaterials-based culture systems for functional cell testing. With extensive experience in embedded systems and system design, Justin has set up functional calcium imaging and various electrophysiological recording systems for functional assessment of cells and tissues at St Vincent’s Hospital, Melbourne. These systems include multielectrode arrays for 2D and 3D neural and neuromuscular cultures and neural organoids, in vivo electrophysiological systems for implanted 3D printed muscle constructs, and extracellular recording systems for novel graphene electrodes produced by the ARC Centre of Excellence for Electromaterials Science. Justin was recently seconded to University of Wollongong as a Visiting Research Fellow to further research into functional assessment of neural organoids and to set up systems in Wollongong for recording and verifying signals from novel graphene electrodes. Justin is currently a director of Women in STEMM Australia.

Electrophysiological Systems for Tissue Engineering Applications within ACES

Dr Justin Bourke

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Bioprinting and tissue engineering will bring advances in medical interventions and personalized drug selection systems. Functional assessment of tissue engineered constructs is critical to translate these technologies into clinical applications. Functional assessment of bioengineered tissues can take various forms, and for electroactive cells the most direct form of functional assessment revolves around electrophysiology; direct recording of cellular transmembrane currents. Assessment of single cell function is important, but intercellular interactions for engineered tissues are crucial to ensure the functional capacity of the overall resultant tissue in replicating organ function, and to optimize integration into the body when implanted. This presentation will provide a rundown and discussion of the various systems that have been set up by Dr Bourke within the ARC Centre of Excellence for Electromaterials Science for functional assessment of bioengineered neural and muscular tissues in culture and post-implantation into the body.
One Step Synthesis Of Vanadium Metal Organic Framework For Supercapacitor Application

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Compared to traditional metal oxides, metal-organic frameworks exhibit excellent properties, such as a high surface area, significant thermal stability, low density, and excellent electrochemical performance. Here, a simple process is proposed for the fabrication of vanadium metal-organic frameworks (V-mbpdc), mbpdc = dimethyl-4,4’-biphenyl dicarboxylate, and the effect of the structure on the electrochemical performance is investigated via a series of electrochemical measurements. The VIV(O) (mbpdc) electrode exhibits a maximum specific capacitance of 147 F g⁻¹ at current densities of 0.5 A g⁻¹. This superior performance confirms that VIV(O) (mbpdc) electrodes are promising materials for applications in super capacitors.
I am a PhD candidate at IPRI, UoW. My project is graphene fiber towards energy and health.

Neural stimulation and recording with flexible freestanding graphene fiber based microelectrodes

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The emerging neural prostheses and therapies based on neural stimulation and recording involve electrodes chronically interfaced to the central and peripheral nervous systems. Typical implantable electrodes used for neural stimulation and recording are composed of rigid metal or crystalline silicon materials, which are inadequate for the miniaturization needs of neuronal-scale microelectrode due to their poor electrochemical properties, intrinsic high stiffness and density. As a result, those electrodes intend to induce glial scaring and fail in vivo application. In this work, we demonstrate a neural stimulation and recording microelectrode made from graphene fiber. Highly electro conductive and mechanical strong graphene microfibers are prepared by wet spinning and fabricated into flexible and freestanding microelectrodes. In vitro characterization shows that the impedance of the fabricated microelectrodes is remarkably lower and the charge injection capacity is obviously higher than that of typical neural electrodes. In vivo studies show that the implanted microelectrodes create stable neural interface with remarkable high signal to noise ratio (SNR) and outstanding capability of detecting neuronal activates. The high flexibility, biocompatibility and the very high SNR make our microelectrodes promising candidate to establish a highly sensitive, instant, and precise feedback for analysis of unknown electroceutical mechanisms.
One of the fundamental challenges in the electrochemical CO₂ reduction is the high concentration overpotential due to the low solubility of CO₂ in water, and an important breakthrough has been already demonstrated with the successful implementation of gas diffusion electrodes to improve mass transfer. An electrochemical static and flow cell containing Gortex-based gas diffusion electrodes with cobalt and iron phthalocyanine (CoP) immobilized on carbon paper has been proven to convert CO₂ to CO.
Mr. Kyuman is a Ph.D student in Intelligent Polymer Research Institute and ARC Centre of Excellence for Electromaterials Science at University of Wollongong.

Synthesis of Cuprous Oxide using Electrodeposition Method as a Photo-electrochemical Catalyst

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Cuprous oxide (Cu$_2$O) is an attractive p-type oxide with sufficient Cu active sites for photo-electrochemical hydrogen evolution and CO$_2$ reduction, because Cu$_2$O has a band gap that can utilize the visible light of the sunlight spectrum, and furthermore, it is high abundant and low toxic. Several studies have reported electrodeposited Cu$_2$O which has high selectivity and efficiency as a photo-electro catalyst. In this work, as a first establishment of my Ph.D project, we report electrodeposition of Cu$_2$O by following previous papers and investigate photo-electrochemical activity as well as the reproducibility to establish reproducible reference system. The synthesized Cu$_2$O will be used for comparison with improved systems by further experiments during my Ph.D period to make high efficient and selective photo-electrocatalytic systems.
Electrofluidic fibre-based analytical devices coupled with ambient ionization mass spectrometry

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Fibres and fabrics have been frequently investigated as a group of inexpensive materials for the fabrication of low-cost, disposable microfluidic devices. The soft and flexible nature allows easy cutting, knotting or sewing of fibre onto various support materials to achieve suitable hydrophilic-hydrophobic balance. The porous structures between these inexpensive and commercially available materials are capable of transporting aqueous fluids through capillary action without the requirement of external pumping. However, fluid movement due to wicking varies significantly based on length, interfibre bonding and the types of gaps and voids in the structures of fibres, yarns, and fabrics. This project aims to develop fibre-based electrofluidic devices coupled with ‘on-fibre’ ambient ionisation mass spectrometry for direct and rapid characterisation of chemical and biochemical species, separated from complex mixtures and matrices. DESI is an ambient ionization technique for the detection of solid or liquid sample under ambient environment with little or without sample preparation. However, the lack of chromatographic separation makes it difficult to qualify and quantify analytes in complex samples. Therefore, it is meaningful for the combination of low-cost electrofluidic fibre-based analytical devices for sample preconcentration or separation from complex samples with ambient ionization mass spectrometry for rapid qualitative and quantitative detection.
Poster #29
Lijuan Yu

Lijuan finished her PhD at the University of Western Australia in 2017 and joined the Coote group in Dec 2017. She is currently a Postdoctoral fellow. Her research interests include investigating reactions mechanism through quantum mechanical calculations, e.g. ab initio, density functional theory (DFT), composite methods, quantum mechanics/molecular mechanics (QM/MM) simulations, etc. Now she is working on the effects of external electric field on the barrier heights of SN1 and SN2 reactions, catalytic metal-organic frameworks (MOFs), QM/MM MD simulations for enzymatic systems.

Re-Examination of Proline-Catalyzed Intermolecular Aldol Reaction: A Theoretical Study of the Mechanism and Stereoselectivity

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Full catalytic cycle of proline-catalyzed intermolecular aldol reaction of acetone and p-nitrobenzaldehyde in acetone solvent has been investigated by G3(MP2,CC)//M062X/6-31+G(d) level of theory. The SMD solvent model was used to calculated the solvation Gibbs free energies at M062X/6-31+G(d) level of theory. Proline catalyzes the aldol reaction according to the enamine mechanism. The initial reaction between proline and acetone was reinvestigated. The stereoselectivities of reactions of enamine with syn- and anti-arrangement and the re and si attack modes of p-nitrobenzaldehyde have been analysed. Finally, the electrostatic effects on the barrier heights and reaction energies were also studied.
Linbo Li received his M.Eng. (2016) at Capital Normal University. He is currently pursuing his Ph.D. in Monash University. His research interests focus on (1) development of electrochemical sensors and fluorescent chemosensors based on carbon nanomaterial (carbon nanodots, graphene quantum dots, carbon nanotubes, etc.), (2) advancement of functionality of nanomaterials through atomic modification and molecular conjugation, and (3) study of the heterogeneous materials for electrochemical catalysis, such as CRR, ORR, Lithium-Oxygen cell, etc.

Facets-etching Tuning Strategy on Copper Oxides for Electrochemical CO2-to-Ethanol Conversion

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The electrosynthesis of higher-order alcohols from carbon dioxide addresses the need for the long-term storage of renewable electricity. Here we present a facets etched catalyst design of copper oxides with the goal of producing a specific reaction-intermediate-rich local environment, which promotes the electroconversion of C₂H₅OH from CO₂ and H₂O. We perform the strategy by precise <110> facet etching with a family of <100> dominated CuOx that catalyse CO₂ to CO. Using DFT, and in situ Raman spectroscopy, we speculate that the high concentration of local CO facilitates carbon–carbon coupling and steers the reaction pathway towards ethanol. We report a CO₂-to-ethanol Faradaic efficiency of 31% and a partial current density of 57.6 mA cm⁻² at −0.58 V versus the reversible hydrogen electrode tentatively.
Linda Wollersheim is a PhD Candidate in Politics and Policy Studies at Deakin University. Her work explores policy aspects of renewable energies and environmental and social justice implications of renewable energy technologies. Her PhD project focuses on identifying opportunities of renewables to facilitate more democratic, bidirectional energy systems, and analyses policy levers facilitating just, low-carbon energy transitions in Australia and in Germany.

Analysing the framing of renewable energy actors in Australia and Germany

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In the contest for Australia’s – and the world’s – renewable energy (RE) future, the model that eventually prevails matters significantly as it will impact society in multiple ways. Low-carbon energy transitions are not purely technological transitions but are also social, economic and cultural in nature with lasting environmental consequences. RE technologies are transforming previously highly-centralised and one-directional energy systems into more decentralised, bidirectional, and potentially democratic ones, thereby altering socioeconomic conditions more broadly. Yet, accelerated RE deployment and technologies themselves are not neutral, nor do they emerge in a social or political vacuum. Social forces shape and underpin system transitions and technologies, determining their form, utility and power relations (see Curran 2019; Smith 2005). My analysis identifies three types of RE activity (individual, community, commercial), whilst noting that they are not mutually exclusive, and explores how current (sub-)national policies frame each category. Analysing the framing of RE actors is vital as it reveals critical underlying assumptions about the political roles and importance of stakeholders in future energy systems. The analysis focuses on the framing of RE actors in Australia and Germany in a comparative manner, revealing several key similarities and fewer yet important differences.
Poster #33
Luciana Yumiko Daikuara

Luciana is a PhD candidate in Biofabrication at the Intelligent Polymer Research Institute, University of Wollongong. Her research focus on the development of human platelet lysate platforms for wound healing application using 3D bioprinting. Luciana obtained her bachelor’s degree in pharmacy and Biochemistry from Universidade Federal de Santa Catarina, Florianopolis, Brazil in 2015 and started her PhD in 2017.

Human Platelet Lysate-based platforms for Wound Healing Application

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The skin is a highly innervated organ. When injury occurs and the skin is disrupted, the nerves are also destroyed. If nerve regeneration process is imperfect, it can lead to abnormal sensations, chronic pain or even permanent sensory deficits. Therefore, the restauration of not only the aesthetic aspect but also the skin sensation and perceptions could have a huge impact in patients’ quality of life. Our research aim is to provide a supportive matrix that can guide the new tissue as well nerve regeneration, which is crucial to achieve reconstruction of a fully functional skin tissue. Here we demonstrated our 3D printed human platelet lysate hydrogel supported several neurite outgrowths from human embryonic stem cell (hESC) derived neurospheres after just a week of co-culture with human dermal fibroblasts (HDF), expressing of general and mature neuronal markers. Showing promising application as a platform for the development of an innervated skin model. Future directions involve the functional characterisation of the neurospheres, study of the neurite outgrowth directionality and co-culture of fibroblasts, keratinocytes and neutrospheres to develop a full-thickness skin model.
India has come a long way in just a few years to rank fifth globally in renewable energy capacity. The Indian Prime Minister has doubled the renewables target to 450 gigawatts at the UN Climate Summit in September, signaling that the country’s focus on renewable energy is one for the long-term. As per the estimates of power planning body, Central Electricity Authority, India’s capacity mix will look predominantly green in 10 years with coal-fired projects constituting merely a third of total installations. However, Natural disasters have made coastal areas extremely vulnerable and solar installation and wind energy becomes very vulnerable to disasters. No contemporary conversation on energy security can take place without speaking of energy storage. India needs a storage policy in place as it implements its renewable energy targets swiftly. In addition, there is a need to tap into multiple storage technologies, including pumped hydro, instead of depending on any one technology in the interest of domestic energy security. There is an increasing reliance on storage with lead acid batteries. Recycling of these batteries is almost impossible in remote areas and they pose a danger in disasters such as floods. The future of the energy divide in India will be poor battery storage technology for rural areas and coal-based energy through the grid for high consumption urban areas.
Poster #36
Mitchell Blyth

I am a PhD candidate in the Computer Aided Chemical Design Group at the Australian National University, working under Professor Michelle Coote. My research focuses on using computational methods, particularly quantum chemistry, towards a practice-oriented understanding of electrostatic catalysis.

Oriented Internal Electrostatic Fields Cooperatively Promote Ground & Excited State Reactivity: A Case Study in Photochemical CO₂ Capture

Mitchell T. Blyth, Benjamin B. Noble, Isabella C. Russell, Michelle L. Coote

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Oriented electrostatic fields can exert catalytic effects upon both the kinetics and the thermodynamics of chemical reactions; however, the vast majority of studies thus far have focused upon ground-state chemistry and rarely consider any more than a single class of reaction. We revised the mechanism of CO₂ storage via photochemical carboxylation of o-alkylphenyl ketones, and then demonstrated that oriented internal electrostatic fields from remote charged functional groups can selectively and cooperatively promote both ground- and excited-state reactivity at all points along the revised mechanism. The observed effects are otherwise difficult to access via classical substituent effects (i.e. electron-withdrawing or -donating groups). In a particularly striking advance, we demonstrate that electrostatic field effects upon key photochemical transitions are predictably enhanced in increasingly polar solvents, thus overcoming a traditionally-held limitation of electrostatic catalysis.

Effect of Comprehensive Passivation on the Charge Recombination at the Sensitized Surface

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Recombination of the injected electrons with the oxidized cobalt mediators at the charge-transfer interface decreases the efficiency of the ruthenium dyes. Many functionalized bulky sensitizers were exploited to block the Co³⁺ centers but enhancing the injected electron lifetime remains a challenge. In this work, six cobalt mediators were examined, and it is found that the alkyl substituents around cobalt redox mediator decelerate the recombination reaction, increase the electron lifetime and consequently enhance the open-circuit voltage ($V_{OC}$) and the short-circuit current density ($J_{SC}$). A judicious structure-property correlation between the redox couples and two well-known dyes have been carried out in the presence and absence of tert-butyl pyridine. The impact of alkyl barriers was more visible in the absence of tert-butyl pyridine and it helps to understand the injection and recombination kinetics at the ideal interface of dye and mediator. The concomitant increase of $J_{SC}$ and $V_{OC}$ by using the bulky redox mediator brings the scope of interfacial charge transfer control by altering the redox mediator. Stepped-light induced measurements rendered the interfacial electron transfer characteristics, the long electron lifetime in the case of CO6C9 is due to the comprehensive passivation of the surface by the alkyl functionalities.
I obtained a master degree of chemistry, specialized in “fields and materials under extreme conditions” at the University of Orléans in France in 2015. Then I conducted a co-supervised PhD between the University of Orléans with Prof. Michael Deschamps and Deakin University in Australia, with Dr. Luke O’Dell and Prof. Maria Forsyth in order to study the structure and the interactions between ions in ionic liquid electrolytes by Nuclear Magnetic Resonance (NMR). I’m currently conducting post-doctoral research at Chalmers University of Technology with Prof. Patrik Johansson in order to study electrolytes for calcium batteries applications, with a focus on a new type of electrolytes called localized highly concentrated electrolytes (LHCE).

**Study of structure and interaction in localized highly concentrated electrolyte for new generation calcium-batteries**

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Since a few couples of years Calcium based electrolyte showed a promising future, however these electrolytes exhibit slow motion of calcium and thus in overall a low conductivity. A novel type of Ca-based electrolytes called LHCE (Localized Highly Concentrated Electrolytes) can help to overcome this problem. Those electrolytes are highly concentrated in calcium salt, but with a low viscosity. Indeed, increasing the salt-to-solvent molar ratio increase the number of calcium ion in the electrolyte, but also reduce the amount of free solvent molecules. However, the viscosity will increase and therefore the conductivity and the wettability of the electrolyte will be reduce. The principle of the LHCE is therefore to dilute this highly concentrated electrolytes (HCE) with a so called non solvating diluent which give the advantages of reducing the viscosity of the electrolyte without breaking the solvation structure of the HCE. Therefore high conductivity can be obtained thanks to the localized high salt concentration, with low viscosity due to the dilution with the co-solvent. However, the current understanding of the structure, and how the calcium ions moves, is very little understand and as there is a large number of potential diluent, the need to interpret this structural organization is crucial.
Poster #42
Saimon Silva

Doctor M. Silva obtained his PhD from University of New South Wales (UNSW) in February 2018. He obtained his master in Analytical Chemistry and B.Ed Chemistry from University Federal dos Vales do Jequitinhonha e Mucuri (UFVJM - Brazil). In May 2018 he was recruited by Swinburne University of Technology, to a postdoctoral research fellow position. His research goal is to develop smart surfaces for use in a variety of biomedical applications including liquid biopsy, bionic implantation, drug delivery systems, and neural cell stimulation.

Lubricin and GelMa: a hybrid biomaterial resistant to biofouling

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Hydrogels have been widely studied in biomedical fields including tissue engineering, regenerative medicine, drug delivery and electrical cell stimulation. In order to be applied in the biomedical fields, tunable chemical and physical properties are required for hydrogels. In this sense, a lot of efforts have been devoted to investigate the impact of combinations of comonomers, crosslink density, and synthetic conditions on the physicochemical properties of hydrogels.¹ Hydrogels possess three-dimensional hydrophilic polymer networks, which has the ability to swell when in aqueous solutions and become larger than their original weight without dissolution. Even though hydrogels are hydrophilic, proteins and other large biomolecules with hydrophobic functionalities can bind to inner domains by cumbolic forces.² This makes hydrogels susceptible to protein adsorption and biofouling. This work investigate the incorporation of lubricin, a glycoprotein commonly found in synovial fluids with antiadhesive properties, to gelatin-methacryloyl (GelMa) in order to address the issue of biofouling. The effect of nonspecific adsorption of proteins on the prepared surfaces were investigated using electrochemical techniques such as cyclic voltammetry and impedance spectroscopy. Lubricin showed to prevent the biofouling caused by large proteins while not changing significantly the GelMa physicochemical and electrochemical properties.

Poster #43
Samuel Rathbone

After graduating with a Bachelor of Medical Sciences with distinctions, Sam completed a first class honours project focused on wireless electrical stimulation platforms. After successful conclusion of this project, Sam was awarded a PhD candidature to further explore the potential of wireless electrical stimulation platform within a 3D cell culture systems. Apart from spending his time pushing the boundaries of science as far as they can go, Sam also contributes his time to teaching anatomy and physiology to 1st year university students, which often involves dissection of cadaveric material. On the rare chance Sam gets spare time, he can be often found either in his garden struggling against the onslaught of constant weeding or in the kitchen cooking up a storm.

Ultrasound Mediated Piezoelectric Stimulation of Human Neural Stem Cells

Samuel Rathbone¹, Eva Tomaskovic-Crook¹,², Andres Ruland Palaia¹, Jeremy Crook¹,²

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Differentiation of human neural stem cells to mature neuronal cells can be augmented by electrical stimulation, providing platforms to model neurological diseases and in vivo growth. However, traditional electrical stimulation methods rely on insertion of potentially fouling electrodes into the cell culture. We found that by utilising piezoelectric nanoparticles alongside ultrasound stimulation, small local potentials can be generated in a manner reminiscent of traditional electrical stimulation. When we employed this ultrasound mediated piezoelectric stimulation platform within human neural stem cell cultures, differentiation was positively augmented, as evidenced by increased synaptophysin expression as well as increased cell signalling and activity. In addition, stimulation employing this platform directed neural stem cells to a neuronal phenotype at a greater level than glial cell induction. Our results highlight the potential of this novel stimulation platform for wirelessly stimulating cells to augment differentiation and activity. Although this novel platform is in its early stages of development, the potential applications for disease modelling and in vivo stimulation to correct neurological dysfunction are numerous.
Poster #44
Sangwon Park

Master course student at Department of printed Electronics
Sunchon National University Sunchon, South Korea

Ion exchanged P2-K$_{0.62}$Na$_{0.08}$[$\text{Cr}_{0.85}\text{Sb}_{0.15}$]O$_2$ with higher electrochemical performance than as-synthesized P2-K$_{0.70}$[$\text{Cr}_{0.85}\text{Sb}_{0.15}$]O$_2$ as potassium-ion batteries cathode

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In this work, we report the comparative studies of P2-type K$_{0.7}$[$\text{Cr}_{0.85}\text{Sb}_{0.15}$]O$_2$ (KCSO) and P2-K$_{0.62}$Na$_{0.08}$[$\text{Cr}_{0.85}\text{Sb}_{0.15}$]O$_2$ (IE-KCSO) as cathodes in potassium-ion batteries. Despite near-identical compositions and structures, IE-KCSO, which was prepared via an electrochemical ion-exchange of P2-Na$_{0.7}$[$\text{Cr}_{0.85}\text{Sb}_{0.15}$]O$_2$, shows electrochemical properties (rate performance and cyclic stability) that are better than those of KCSO. The reason for the superiority is disclosed because Na$^+$ ions remaining in IE-KCSO facilitate fast K$^+$ diffusion and reduce the dimensional change during charge/discharge. The ion exchange process is also fully characterized. This work suggests that the preparation of KIB cathode materials via an ion-exchange of Na$^+$ could be a more efficient way than via a direct synthesis, particularly when the latter approach makes it difficult to obtain phase-pure target compounds.
Dr. Shaikh Nayeem Faisal is working as Research Fellow affiliated with ARC Centre of Excellence for Electromaterials (ACES) & Intelligent Polymer Research Institute (IPRI) at University of Wollongong. He has completed his PhD in Chemical Engineering from University of Sydney. His area of research is developing nanocarbon, 2-dimensional and 3-dimensional nanomaterials based advanced composites for sustainable energy and environment related applications. Before joining UOW, he worked as research Engineer in the R&D at Hazer Group Ltd. for developing a process to produce clean hydrogen and synthetic graphite from biogas. As an early career researcher he has publishes 03 patent applications, 22 peer reviewed journal papers with citation index of 12 and over 800 citations.

Next Generation Magnetic Plastics, Doughs, Gels and Liquid droplets

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Magnetic materials are generally solid with fixed shape. The introduction of magnetic properties in flexible polymers, soft dough and gel or liquid form can open up a new era of wireless controllable materials for next generation composites, biomedical, drug delivery and energy related applications. The recent interest of forming liquid magnetic droplets using iron oxide nanoparticles with surfactant is an excellent example. [1] Here we have synthesized a highly dispersible iron oxide dispersed edge-functionalized graphene that is highly dispersible both in water and organic solvents. [2] This high dispersible properties lead us to fabricate magnetic polymer film by mixing with polymers, binder-free soft magnetic doughs, magnetic paste or gel. In parallel with the different three-dimensional configuration we have also prepared magnetic liquid oil droplets in water and water droplet in oil that can me moved by magnetic force as micro-robot. This interesting finding will help us to develop next generation micro or nano vehicles for drug delivery or carrier.

References
Shuai Zhang is currently a PhD candidate in ARC Centre of Excellence for Electromaterials Science (ACES) and Intelligent Polymer Research Institute (IPRI) at the University of Wollongong. Shuai received a Bachelor degree of Electrical Engineering in 2012 from Agricultural University of Hebei and a Master degree of Micro Nano System Technology in 2017 from South-East University of Norway. His research interests lie in the area of flexible carbon electrodes, 3D printing carbon electrode materials, and the fabrication of wearable thermocell.

Wearable Thermo-electrochemical Cells: Using Redox-Gel Integrated Flexible Electrodes to Covert Body Heat into Electricity

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With the rapid development of next-generation wearable electronics, such as hand-held portable devices and soft portable electric digital devices, there is a great demand for lightweight, flexible and environmental friendly energy devices. Among versatile energy devices, wearable thermo-electrochemical cells have attracted increasing interest due to their ability to successively turn human body heat into electrical energy. However, flexible, lightweight and portable thermocells are still hard to develop because of the difficulty in preparing flexible thermo-electrode materials with robust mechanical properties and excellent electrode performance. In this work, we developed a novel laser-etched flexible electrodes for wearable thermocells, this 3D porous electrode film will provide the cross-sectional area which can allow a high degree of electrolyte exposure to the electrode for redox reactions to occur, resulting in increased power density. Meanwhile, we also fabricated two types of thermogalvanic gel electrolytes with positive and negative thermo-electrochemical Seebeck coefficients, respectively, which correspond to the n-type and p-type elements of a conventional thermoelectric generator. Such gel electrolytes exhibit not only moderate thermoelectric performance but also good mechanical properties. This wearable thermocells was fabricated in a serial 18 pairs arrays with an output voltage approaching 0.4 V which can charge up different capacitors when temperature difference is 10°C, and power typical commercial LED by utilizing body heat. This work may offer a new train of thought for the development of self-powered wearable systems by harvesting low-grade body heat.
In July 2014, I finished the undergraduate program and received a Bachelor of Engineering Degree from School of Chemical Engineering, Tianjin University, China. In 2015, I went to University of Edinburgh to do my master degree and joined Prof. Neil Robertson’s group. The research project was the Synthesis of New Organic Dyes for Dye Sensitized Solar Cells. A Master of Science by Research Degree was admitted in November 2016. From October, 2017, I started my PhD program in School of Chemistry, Monash University and worked with Prof. Douglas Macfarlane. My research project is Advanced Redox Materials for Electrolytes in Non-aqueous Redox Flow Batteries.

Fe(II) Mixed Ligand Complexes for High Energy Density Non-aqueous Redox Flow Batteries

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Redox flow batteries are recently considered as a promising technology for large scale energy storage systems. Although some types of the battery have been commercialized, their low working voltages caused by the aqueous electrolytes limit their further applications. Using organic solvents has previously been attempted and the idea of non-aqueous redox flow batteries is proposed. However, the low solubilities and poor electrochemical properties of the redox couples inside the organic electrolytes have become the main issue. In this work, to improve the solubility, a series of Fe (II) based “mixed ligand” complexes were synthesized and their chemical and electrochemical properties were discussed. We confirm that for Fe (II) complexes the ligand equilibration occurs in solution. We also understand how the mixed ligands will affect the redox potentials of the Fe (II) complexes. Furthermore, we confirm that the mixed ligand structure can improve the solubilities of the complexes. We believe that at least one of these complexes is suitable as the redox couple in a flow battery. The mixed ligand effect will also be beneficial for designing other new high solubility redox materials in non-aqueous flow batteries.
Si-Xuan Guo obtained her PhD degree from the Department of Chemistry, National University of Singapore. She is currently a Research Fellow in the School of Chemistry and the ARC Centre of Excellence for Electromaterials Science, Monash University. Her research focuses on the synthesis of nanomaterials and their applications in energy conversion.

Electrohydrogenation of Carbon Dioxide using a Ternary Pd/Cu₂O–Cu Catalyst

Jing Li,† Si-Xuan Guo,† Feng Li, Fengwang Li, Xiaolong Zhang, Jiantai Ma,* Douglas R. MacFarlane, Alan M. Bond, and Jie Zhang*
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A simple one-pot method has been developed to synthesize a palladium/cuprous oxide-copper (Pd/Cu₂O–Cu) material with a well-defined structure, by modification of Cu₂O–Cu with Pd through a galvanic replacement reaction. Compared with the well-known copper/cuprous oxide (Cu/Cu₂O) catalysts, the Pd/Cu₂O–Cu material can catalyze the electroreduction of CO₂ into C₁ products with much higher faradaic efficiencies at lower overpotentials in a CO₂-saturated 0.5 m NaHCO₃ solution. In particular, the highest faradaic efficiencies of 92% for formate and 30% for methane were achieved at −0.25 and −0.65 V (vs. the reversible hydrogen electrode), respectively. The improvement is suggested to be the result of a synergistic effect between PdH and the catalytically active copper sites during electrochemical CO₂ reduction.
Poster #49
Sujani Abeywardena

Sujani B. Y. Abeywardena obtained her B.Sc. in Chemistry, Statistics and Mathematics from University of Peradeniya, Sri Lanka, and later completed her M.Sc. in Nanoscience and Nanotechnology at the same university with a GPA of 3.6. She did her M.Phil. (Moisture management of textiles) at University of Moratuwa, Sri Lanka, during which she published five international journal papers. In July 2019, she started her Ph.D. at Intelligent Polymer Research Institute, University of Wollongong, Australia, under the supervision of Prof. Peter C. Innis and Dr. Zhilian Yue. Her Ph.D. is on Media/drug delivery and cellular metabolite interactions with threads in gels.

Charged species on GelMA coated core-shell 3D textile structures in electrofluidics

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Thread-based electrofluidics have promising applications in drug delivery in cellular environment. Charged species can be transported on yarn or thread under electric field, which actively controls the movement. Currently, core-shell 3D textile structures have been made using polyester braids and different core diameters of nylon fishing lines. Movement of charged species was observed using fluorescein and 2.5 mM TRIS/CHES buffer, where braids with smaller (<0.5 mm) core diameters showed greater electro-osmotic flow, resulting in higher mobility and narrower band. A biological buffer which maintains physiological pH and osmolarity is needed for good cell viability in electrofluidics. 5 mM TRIS/HEPES buffer with 300 mM glucose was selected over highly conductive phosphate buffer saline, as it moved the charged analyte species more effectively due to its larger ionic size and lower ionic conductivity. Gelatin methacryloyl (GelMA) hydrogel (a cellular support material) closely resembles some essential properties of native extracellular matrix, which allows cells to proliferate and spread. Preliminary studies of braid-in-gel systems showed that the high viscosity of GelMA suppressed the electro-osmotic flow of GelMA coated braids, where charged spices moved to counter electrodes, electrophoretically. Cell viability testing of selected buffer is ongoing.
Iron-based non-aqueous Redox Flow Battery

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Redox flow batteries (RFBs) are seen as an alternative to lithium-ion technology for the storage of excess renewable energy from domestic- to grid-scale. Positive and negative electrolytes are (dis)charged on electrodes separated by a membrane and stored in external tanks, which enables flexible scalability of power and energy density. Symmetric cells utilizing the same electrolyte on both sides avoid cross-contamination and only lose efficiency in case of mixing through the membrane, but require materials with at least three accessible redox states. Metal complexes with non-innocent ligands can meet this requirement and utilize the electrochemical window of aprotic solvents for increased energy density, but often suffer from low solubility [1]. We are working on a system based on the iron-tris(2,2′-bipyridine) bis(ﬂuorosulfonyl)imide complex [2] which shows one metal-centered oxidation and up to three ligand-centered reductions, providing a symmetric RFB with 2.4 V cell potential. However, these processes have been shown to be solvent-dependent [3] and the electrochemistry in different solvents and mixtures was studied. Properties like density, viscosity and conductivity were measured over a temperature range as well as the solubility of the active material in all states of charge. Further points like cost, safety and environmental impact were considered as well.

Vincent joined the Coote group in 2018. After three research projects, he is now completing Honours with the group. From his time in the group, Vincent had gained valuable skills in using QM computational methods to help develop new synthetic methodologies for multiple research disciplines, ranging from controlled radical polymerisation, to electrosynthesis, and electrostatic catalysis for both ground and excited state procedures. His Honours currently focuses on two main topics: exploring using charged functional groups to influence both the ground and excited state chemistry of tetrazoles; and, developing both traditional and photoinduced controlled radical polymerisation techniques, particularly ATRP and RAFT. Outside his research, Vincent enjoys cooking (a lot) and reading philosophies.

Computational Design of Highly Activating Ligands for Atom Transfer Radical Polymerisation

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Atom Transfer Radical Polymerisation (ATRP) has revolutionised polymer synthesis; enabling the precise construction of sophisticated macromolecules under mild conditions. In ATRP, a redox active metal mediator (usually Cu) activates a ‘dormant’ organohalide initiator, generating carbon-based radicals that can be harnessed for polymer chain growth. Crucially, this reaction is reversible and so ‘living’ polymerisations can be achieved by carefully balancing this activation/deactivation equilibrium ($K_{ATRP}$). While current ATRP methodology can polymerise a wide-array of monomers, activation of less-stabilised alkenes remains problematic. Indeed, for monomers such as vinyl chloride and vinyl acetate, the N-based ligands usually employed in Cu-based ATRP are not sufficiently activating. In this work, we use high-level computational theory to assess the performance of P-based ligands in Cu-based ATRP. First, we examine how structural features of a diverse set of ligands affect $K_{ATRP}$ (Figure 1). Next, we establish rational design criteria based on electrostatic arguments and ligand-field theory. Finally, using these design criteria, we propose a range of ‘next-generation’ ATRP ligands that are predicted to have unprecedented activity.
I am an ARC DECRA research fellow at the UTAS node. My research is focused around 3D printing microfluidic platforms for electrofluidic and diagnostic applications. My research interests are based on my interdisciplinary background in material science, additive manufacturing, microfluidics, pharmaceutical sciences, analytical chemistry, and computational fluid dynamics.

Three-dimensional Bifurcating Microfluidic Distributors to Realise a Brain-on-a-Bench System

Vipul Gupta and Brett Paull

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Microfluidic distributors that can uniformly distribute fluid from a single channel to multiple channels and into or across 3D spaces, and vice versa has always represented a challenge. Hence, herein, unique single-piece three-dimensional bifurcating microfluidic distributors have been designed and developed using 3D printing, which can distribute fluid from a single channel to multiple parallel channels and deliver fluid evenly into a receiving chamber/structure, and equally collect from this space in a similar manner to a single outlet. The distributors have resulted in low-dispersion divergence and convergence of flow to and from 64 parallel channels while operating at flow-rates ranging from 0.25 mL/min \(^{-1}\) to 2 mL/min \(^{-1}\), as characterised through computational fluid dynamic simulations and solid-phase extraction studies. The three-dimensional distributor has been used to develop a miniaturised perfusion chamber for three-dimensional cell culture growth and analysis and a high surface area multi-capillary column. The perfusion chamber has been designed to fit within a conventional electrochemical sensor to study cell’s electrical response to various stimuli in order to gain a better understanding of epilepsy. Moreover, multiple such chambers can be easily assembled together to develop an elaborate system, such as a Brain-on-a-Bench.
Poster #54
Xifang Chen

Xifang Chen is currently a PhD student (4th year) studying at University of Wollongong, Australia. Previously she gained a B.Sc in Biological Science in 2009 from China Three Gorges University, China, and a M. Sc in Biochemistry & Molecular Biology in 2014 from Beijing Institute of Technology, China. Her research field is generally focused on biomaterials, 3D bioprinting and skin tissue engineering.

3D bioprinting dermal-like structure and full thickness skin using sulfated polysaccharide ulvan

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Extrusion-based 3D bioprinting has been increasingly employed in skin tissue engineering by virtue of its automatic process and space-controlling feature. However, this technique is hitting a bottleneck due to a paucity of suitable bioink formulation that is both biomimetic and printable. In this study, we developed bioinks based on ulvan, a sulphated seaweed polysaccharide from a controlled source of Australian ulvacean macroalge, for 3D bioprinting dermal compartments with embedded human dermal fibroblasts (HDFs). Full thickness skin were reconstructed by co-culturing the dermal compartments with the epidermal compartments of seeded HaCaT keratinocytes for up to 41 days. Our results demonstrated that the dermal compartments supported cell proliferation and extracellular matrix (ECM) deposition. Real-time quantitative polymerase chain reaction (qPCR) revealed that ulvan may downregulate the gene expression of collagen I (non-significantly) and collagen III (significantly) by HDFs. This could be potentially useful for preventing scar formation in wound healing. The full thickness skin constructs based on different formulations showed the development of two-layered structures with certain levels of stratification of the epithelial layer. Overall, the present work provides insights into the utilization of ulvan for skin tissue engineering and wound healing.
Yongwoo Jang, is a Professor in the Department of Biomedical Engineering at Hanyang University. After receiving Ph.D degree from Seoul National University in 2012, he continued his research as a research fellow in the Mclean Hospital of Harvard Medical School for four years. Currently, his scientific interests include the development of bio-hybrid intelligent artificial muscles for soft robotics, and biological applications of carbon nanotube yarn for human health monitoring and treating systems.

Self-powered gastric sensor for stomach motility

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Recently, a coiled carbon nanotube (CNT) yarn has revealed to convert tensile or torsional mechanical energy into electrical energy. For its application to gastric system, we attempted to characterize an electrochemical performance for the strain percent and low frequency in various simulated body fluids. In those electrolytes, a coiled CNT yarn showed stable open-circuit voltage (OCV) responding to the deformation by the frequency (0.02~0.1 Hz) and the strain (10~30%). To test performance of CNT yarn to volumetric change like gastric motility, we established in vitro artificial gastric system that applied CNT yarn sensor on the surface of the rubber balloon. Consequently, a coiled CNT yarn sensor generated a self-responsive OCV as an output voltage for volumetric change without no need for external input voltage. The electrical signals from CNT yarn represented the cycle and amplitude of volume’s change with a linear correlation, and importantly discriminated the disturbed cycle per minute of gastric motility shown in the patients with gastroparesis. The present study shows that a self-powered CNT yarn sensor can not only monitor the changes in frequency and amplitude of volumetric change but also generate electrical power by periodic deformations of the balloon.

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Zhi Chen is an associate research fellow of ARC Centre of Excellence for Electromaterials Science (ACES) at the University of Wollongong where he has been a faculty member and completed his PhD since 2015. Zhi received a Bachelor degree of Clinical Medicine in 2009 from Wuhan University of Science and Technology and a Master degree of Ophthalmology in 2013 from Institute of Advanced Materials for Nano-bio Applications at Wenzhou Medical University in China. His research interests lie in the area of biomedical engineering, ranging from theory to design to implementation. He has collaborated actively with clinicians in several other disciplines of medical and biological science, particularly corneal and neural bioengineering for clinical application.

Building biomimetic human cornea using electro-compacted collagen

Zhi Chen¹, Xiao Liu¹, Jeremy Crook¹,⁶,⁷, Jingjing You², Yihui Song, Gerard Sutton²,³,⁴,⁵, Gordon Wallace¹

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Corneal transplantation remains the main treatment for severe cornea damage. However, the shortage of suitable corneal tissue donors, transplant rejection and the increasing risk of transmissible diseases underpin the urgent need for qualified substitutes for corneal tissue replacement. Engineering substantia propria (or stroma of cornea) that mimics the function and anatomy of natural tissue is vital for in vitro modelling and in vivo regeneration. There are, however, few examples of bioengineered biomimetic corneal stroma. Here, we describe the construction of a 3D corneal stroma model (CSM) using electro-compacted collagen (EC) films to include orthogonally arranged collagen fibrils and primary human corneal stromal cells (hCSCs), which is analogous to the anatomical structure of native human cornea. Our work represents a significant advance for synthetic corneal engineering, with the potential to be used for full-thickness and functional cornea replacement as well as informing in vivo tissue regeneration.
My name is Tran Phu Thanh. Currently, I am a PhD student at Australian National University under supervision of Prof. Antonio Tricoli. My research topic is to fabricate nanomaterials for water splitting and carbon dioxide reduction.

**Nanostructured β-Bi₂O₃ Fractals on Carbon Fibers for Highly Selective CO₂ Electroreduction to Formate**

Thanh Tran-Phu, Rahman Daiyan, Zelio Fusco, Zhipeng Ma, Rose Amal, Antonio Tricoli

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Three-dimensional Bi₂O₃ fractal nanostructures (f-Bi₂O₃) were directly self-assembled on carbon fiber papers (CFP) using a scalable hot-aerosol synthesis strategy. This approach provides high versatility in modulating the physiochemical properties of the Bi₂O₃ catalyst by a tailorable control of its crystalline size, loading, electron density as well as providing exposed stacking of the nanomaterials on the porous CFP substrate. As a result, when tested for electrochemical CO₂ reduction reactions (CO₂RR), these f-Bi₂O₃ electrodes demonstrated superior conversion of CO₂ to formate (HCOO⁻) with low onset overpotential and a high mass-specific formate partial current density of -213 mA cm⁻² mg⁻¹, which is ~3 times higher than that of the drop-casted control Bi₂O₃ catalyst (-62 mA cm⁻² mg⁻¹), and a high Faradaic efficiency (FEHCOO⁻) of 87% at an applied potential of -1.2 V vs reversible hydrogen electrode (RHE). Our findings reveal that the high exposure of roughened β-phase Bi₂O₃/Bi edges and the improved electron density of these fractal structures are key contributors in attainment of high CO₂RR activity.
Poster #59
Isabella C Russell

After 3 undergraduate projects with the Coote group, Isabella started her honours project with the group this year. Her work has varied from computational studies on the atmospheric collisions of aldehydes to the effect of remote charged functional groups on reactions. Her honours project is focused on investigating carbon dioxide functionalization. Apart from Chemistry, Isabella also enjoys playing ice hockey and drinking tea.

Investigating a Novel ATRP Inspired Carbon-Based Radical Mediator

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Despite its common use in organic synthesis, tributyltin hydride is a toxic and hard to remove radical mediator, with trace amounts often remaining after purification. Although there have been recent efforts to find a suitable alternative, this has proven difficult to find. This work investigates the potential of an atom transfer radical polymerization (ATRP) inspired radical mediation process utilizing the reducing agent 1,3-dimethyl-2-phenylbenzimidazoline (DMPBI). As a proof of concept, the efficiency of this novel method was tested by performing dehalogenation reactions on 1-(allyloxy)-2-iodobenzene and phenyl 2-bromo-2-methylpropanoate.
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