ARC CENTRE OF EXCELLENCE FOR ELECTROMATERIALS SCIENCE ANNUAL REPORT 2018

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Our Vision is to be the pre-eminent world centre for research in the field of electromaterials science and integrated device assembly.

To achieve this we strive:

- To use our research into advanced materials to deliver innovative device solutions for clean energy and medical bionics.
- To deliver research programs that produce world class graduates with not only exceptional technical skills, but skills in science communication, research management, commercialisation, and an awareness of the ethical, social and environmental impact of their research.
- To realise commercial opportunities for our research through delivery of step-change technologies that positively impact on quality-of-life issues for the global community.
- To educate, inspire and engage stakeholders and the broader community, by effectively communicating our research messages.

# THE ACES PARTNERS

We have established a global network of partners integral to our success in research, training, commercialisation and engagement. ACES, led by the University of Wollongong, incorporates eight Australian collaborating organisations and five international partner institutions known for their expertise in materials and device fabrication.

The collaborating organisations are Deakin University, Monash University, University of Tasmania, The Australian National University, The University of Melbourne, Swinburne University of Technology and the University of New South Wales.

The international partner institutions

are Dublin City University, Ireland; University of Warwick, UK; Friedrich Alexander University of Erlangen, Germany; Hanyang University, Korea and Yokohama National University, Japan.

Each node comprises of individuals with key research strengths that when combined, place ACES in a powerful position to design, discover and develop new electromaterials.

# **OUR FUNDING**

The Australian Research Council invested \$25 million in ACES over 2014-2020 to translate our materials science knowledge into practical, game-changing devices that will have a significant impact in the areas of diagnostics, energy, health and soft robotics.

The NSW Government invested \$500,000 through its Research Attraction and Acceleration Program (RAAP) to help us facilitate the commercialisation of our research. This is to assist in developing innovative approaches that encourage entrepreneurship and commercialisation.

Our core funded activities provides a fundamental research program, facilities and expenditure that has enabled us to pursue new opportunities through MedTech and Pharma Growth Centre connect (MTPConnect) funded projects, CRC funded projects, ARC linkage (project and training hubs), NHMRC and ARC discovery projects.

As we work towards our goals, we embrace the challenge of training the next generation of multidisciplinary research leaders, and providing new manufacturing and industrial opportunities for Australia.

The challenges are numerous, but the opportunities are even greater. The ACES team is committed to building a knowledge base in an environment that ensures effective training that will be used to deliver economic returns for Australia.

# **DIRECTOR'S REPORT**

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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.

This privileged position was afforded to us by our peers who reviewed and critiqued our ideas, our research plans, and our skill set, and gave us the public backing to pursue our goals. We recognise we have a responsibility to complete our journey and return the benefits of our research to our communities.

In 2018, we reached a critical juncture where we turned our attention towards using our fundamental knowledge in electromaterials to create strategic, high impact applications. More and more, we have found ourselves at the forefront of technological, clinical and industry breakthroughs, working side by side with experts to bring about better social outcomes.

We must continually strive to stretch ourselves beyond the laboratory. While we continue to hone our technical skills, we also recognise that those skills alone will not see our knowledge or advanced materials turned into next generation technologies.

For effective engagement and translation of discoveries, researchers need to develop skills in intellectual property creation and management, coupled with relevant regulatory policy information. At ACES, we have the advantage of experience with regulatory, ethical and community engagement activities thanks to the integration of the skills of our colleagues in ethics, policy and public engagement. We also work with those with a flair for the development of new commercial models to ensure activities are sustainable, meaning we are well positioned to translate our discoveries through to engagement with end-users.

Our researchers can not complete this journey alone. Through our activities in ACES, our strong national network is growing into a global, multidisciplinary network. At present, we have numerous active collaborations in more than 50 countries.

2018 has been a time of strengthening

these links with existing research partners as well as building new connections, which has steered us into exciting, ground-breaking territory. In the past year, we have celebrated our research achievements with our global collaborators as we actively take our research to the world.

Our researchers, innovators and collaborators share a common vision. A vision to take ideas to industry, and to use fundamental research and knowledge as the fuel to create end-user opportunity. Through the efforts of many we have laid the foundations for a truly global engagement program.

As we have grown as a Centre, we have continued to embrace the challenge of attracting and training the next generation of multidisciplinary research leaders. We want our researchers to break through traditional academic boundaries to confront significant issues in the real world by working with teams of highly skilled individuals who have the ability to communicate outside their field of expertise. As well as providing high quality training for our students and early-career researchers, we also launched our Equity and Diversity Committee in 2018 to ensure that we provide, support and foster a truly inclusive work environment and culture for all our staff.

We are grateful for the world-class facilities and equipment we have access to, but it is our people that bring our vision to life. I thank all of my colleagues and our collaborators for their hard work and committment in 2018. I am proud of the efforts from the entire ACES team to further their research while focussing on delivering practical outcomes that bring about real knowledge advancement, and social and economic benefits.

Together, we will confront the challenges ahead and deliver the best outputs possible.

**Best Wishes** 

Prof Gordon Wallace Executive Director of ACES

# INTERNATIONAL ADVISORY COMMITTEE REPORT

"The IAC was impressed to note the impact of ACES as its excellent fundamental research is benefitting the community. This is noteworthy in two important ways. Its commitment to the production of broadly trained students through its innovative training programmes is widely recognised. The IAC was pleased to note too that ACES researchers are now focussed on ensuring their results are translated into commercial ventures. The IAC looks forward to seeing these important impacts continued during the remaining years of the current ARC Centre support to ACES."



The International Advisory Committee met twice to review progress, June 2018 and February 2019. I would like to take this opportunity to thank all our International Advisory Committee (IAC) members who have supported ACES engagement and engagement impact.

ACES was established with a seven year funding cycle in 2014, and since then the research, publications, outreach and training activities have all grown substantially. ACES spent the first half of the Centre undertaking its proposed fundamental research program, building and creating new knowledge and intellectual property, whilst also establishing an extensive global network of partners and collaborators. This has placed ACES in a strong position to be able to translate those advances in materials science and material fabrication and characterisation into targeted strategic areas of application, across the broad areas of health, energy and ethics.

The IAC commends ACES on the depth and breadth of the work undertaken in the Centre. The Centre's research program summaries in this report provide many examples of ACES current activities at home and globally. ACES core funded research outputs are of high quality and key performance indicators have been met and often exceeded.

ACES, with the investment provided by the Australian government, has carried out a world-class fundamental research program as well as enhancing capabilities at the nodes, including research infrastructure. Many ACES nodes are now equipped with state-of-the-art facilities, thanks to strategic partnerships such as with the ANFF material node, enabling the delivery of new material advances into applications, but also importantly to attract innovation partnerships and potentially new investment.

ACES have significant collaborations between universities, publicly funded research organisations, other research bodies, governments and businesses in Australia and overseas, all to support their outstanding research activities.

The acceleration of translational activities within the Centre has been impressive over the last few years. ACES has been able to channel its knowledge to pursue new translational opportunities through MedTech and Pharma Growth Centre connect (MTPConnect), NSW Medical Device and ARENA funded projects or into existing commercialisation networks through Co-operative Research Centre funded projects. The Centre has also built new translational activities with existing companies via ARC linkage grants (both project and training hubs).

The ACES network of members and collaborators continues to grow, testament to a growing ACES global reputation, and in turn gaining international recognition for Australian research. Over 50% of the ACES 2018 publications had international collaborators across 33 countries (160 research institutions) as co-authors. Since 2014, researchers in over 101 countries have cited ACES publications. In addition to the numerous investigator to investigator relationships, 8 new strategic Centre to Centre partnerships have been established since 2016. The ACES global network allows members, including students and early career researchers, to showcase their skills and present their outcomes for researchers worldwide to critique.

ACES innovative training programs are creating, nurturing and preparing the next generation of well-rounded researchers to ensure effective knowledge dissemination. A strong focus in this Centre has been on establishing a number of training programs (MOOC, graduate certificates, masters and PhD) available to younger generation scientists, giving them an array of options to begin a career in STEM. ACES initiated an entrepreneurship and innovation course, with a view to establish an atmosphere of entrepreneurship and to start researchers and students thinking about real-world implications and applications of their research. Now with over 70 students completing the certificate, this course has been a success. The number of students enrolling in the Masters programs is increasing each year, although with greater increases for the Biofabrication program. The MOOC continues to attract interest from the international community wanting more information on developments available through 3D Biofabrication.

Another success has been how ACES trained graduates are building both the national and international research capacity as well as taking up opportunities with end-users, providing a highly trained workforce for industries of the future. Tracking ACES alumni employment and reporting where they have been gainfully employed since graduating from ACES supports this claim.

Bidet fivie

Dr (Dame) Bridget Ogilvie (AC, DBE, FAA, FRS, FMedSci), chair of the ACES International Advisory Committee.

# **ACES RESEARCH**



The research focus in this fifth year of ACES, 2018, has been on using the fundamental knowledge in electromaterials, reactive systems, materials processing and fabrication approaches, developed in the first four years of the Centre, to create high impact and translational outcomes in the five ACES themes.

The themes are electrofluidics and diagnostics (EFD), soft robotics (SR), synthetic energy systems (SES), synthetic biosystems (SBS) and ethics, policy and public engagement (EPPE).

# ACES STRATEGIC PLAN GOAL 1: RESEARCH

Our goal is to deliver integrated nano-assembly and fabrication technologies with the capacity to build truly biomimetic electrochemical systems by drawing on advances in materials, 3D printing and fibre spinning, characterisation and modelling.

# ADVANCING OUR GOAL

As indicated in the 2018 Activity Plan, the primary Centre research focus has been to utilise the knowledge gained to:

- develop devices for carbon dioxide (CO<sub>2</sub>)/ nitrogen (N<sub>2</sub>) reduction
- develop the 'brain on a bench' system
- develop a soft robotic hand
- develop strategies to address ethical, policy and regulatory issues that arise from technical advances in each of the above areas.

Outcomes from these and other developments in the technical theme areas have significant potential in the commercial sector, some of which are described in the 'Research in Action' case studies placed throughout this report. However, in order to achieve such outcomes, the need to create complex 3D electromaterial structures targeted at specific applications, using the ACES Generation 1 and 2 structural, electroactive or reaction centre materials (see Tables 1 and 2, 2017 ACES Annual Report) that have been developed over the last four years, remains.

Consequently, this year there has been a reduced focus on fundamental electromaterials studies with an increased development of electromaterial composites that are capable of being structured or fabricated using the customised fabrication approaches developed in the Centre.

## 3D ELECTROMATERIALS

The key to creating highly efficient electrochemical devices whether for energy generation and storage or for synthetic biosystems lies in the control of the properties of the structural, electroactive or reaction centre materials that make up the complex 3D electromaterial device structures. The challenge that ACES is addressing is not the development of the best type of individual structural. electroactive or reaction centre material for each of the applications but the development of the best complex combinations of these materials that allows fabrication of outstanding electrochemical devices.

This is beautifully exemplified by the development of state-of-the-art CO<sub>2</sub> electrochemical reduction catalytic systems that derive from the porphyrin and graphene material developments achieved in the Centre. Iron porphyrins with targeted functionality have been synthesised that allow the controlled self-assembly of porphyrin graphene frameworks (FePGFs). As heterogeneous electrocatalysts, these FePGFs are highly selective for carbon monoxide (CO) production with 98.7% faradaic efficiency leading to one of the highest cathodic energy efficiencies reported for immobilised metal complex catalysts. The same approach can be used to fabricate a unique 3D porphyrin graphene hydrogel composite electrocatalyst that shows an exceptional CO<sub>2</sub> reduction performance in water at an extremely low overpotential (280 mV).

These types of composites are highly amenable to integration into a large scale  $CO_2$  reduction electrochemical flow cell that is being developed based on electrochemical flow cell designs produced from previous ACES research with spin-off company AquaHydrex. This work represents a further step towards the Centre goal of translating research into practical devices for  $CO_2$  reduction.

Nonetheless, fundamental studies into improving a number of the electromaterials commonly used in ACES, such as graphene, continued in 2018. The purity of electromaterials is critical to device performance and researchers across ACES have demonstrated that silicon is a ubiquitous contaminant in graphene derivatives and if it is not removed, has significant impact on device performance. When non-contaminated graphene is used to fabricate supercapacitor microelectrodes, a capacitance value close to the predicted theoretical capacitance for graphene is obtained.

Exciting progress has been made in the development of a scalable graphene, edge functionalised graphene platelets (EFGPs). This patented process produces a highly aqueous dispersible graphene. Potential applications across all themes in the Centre are currently being explored; including for composite development, batteries and conductive bioinks.

Other 2D electromaterials have been increasingly used in Centre projects, typically in combination with other materials. Advanced composite 2D materials comprising graphene and molybdenum disulphide ( $MoS_2$ ), manganese dioxide (MnO<sub>2</sub>), and graphitic carbon nitride have been produced by simultaneous anodic and cathodic exfoliation. These composites proved to be effective hydrogen evolution catalysts and supercapacitor electrode materials. Similarly, MoS<sub>2</sub>/graphene composites comprised of MoS<sub>2</sub> nanoparticles uniformly anchored on graphene nanosheets are promising anode materials for lithium-ion batteries. A composite of N-doped carbon nanofibres and  $MoS_2$  nanosheet arrays proved to be a promising material for sodium-ion batteries.

Hydrogels have been the key to many of the bioink and printing developments in SBS. Consequently, new hydrogels continue to be explored and modifications of existing hydrogels undertaken. Hydrogels are useful as material delivery systems and in this regard new star shaped diblock copolypeptide hydrogels have been developed that respond to redox stimuli, which could allow for controlled, targeted delivery of therapeutic payloads. In the same vein, alginate hydrogels, containing water-soluble molecules of different molecular weights, have been encapsulated in polycaprolactone (PCL) porous templates. These PCL templates appear to be a promising candidate to form composite delivery systems for both drug delivery and tissue engineering applications.

Improving the mechanical properties of hydrogels is essential for their

application as tissue scaffolds, actuators in soft robotics and in batteries.

A new composite material, comprised of poly(N isopropylacrylamide) (PNIPAm), alginate, and carbon nanofibres that gives a composite ionic-covalent entanglement (ICE) hydrogel network, has been produced. The properties are such that this has potential applications in soft robotics and microfluidics.

A self-assembled tough elastomeric composite structure that is biocompatible, conductive, and has high flexibility was fabricated using polyetherbased linear polyurethane (PU), poly(3,4ethylenedioxythiophene) (PEDOT) doped with poly(4-styrenesulfonate) (PSS), and liquid crystal graphene oxide (LCGO). This hydrogel can support human neural stem cell (NSC) growth and their differentiation to neurons and supporting neuroglia.

Hydrogen bonds are known to play an important role in determining the mechanical performance of the type of polyether-based PU hydrogels. An investigation into this was undertaken and published.

PU-based hydrogels and a range of different polymers, including polyvinyl alcohol (PVA), sodium carboxymethyl cellulose (Cmc), polyacrylamide (PAAm) have been used to produce quasi-solid-state electrolytes with a ferricyanide redox couple. The hydrogel electrolytes have sufficient mechanical properties to prevent leakage, allow improved device flexibility and safety, whilst permitting the incorporation of various ionic liquids to enhance their electrochemical and mechanical properties as well as thermal energy harvesting performance.

Ionic liquids (ILs) research remains a key activity in ACES. ILs are especially important for electrolyte development and in electrocatalytic reduction. In 2018, ACES researchers have written reviews on the fundamental issues associated with ILs as well as the use of ILs and organic ionic plastic crystals (OIPCs) as advanced electrolytes for safer high performance sodium energy storage technologies.

Two further review publications gave an overview of recent developments in ionic liquids as electrolytes for both magnesium-air and sodium-air and provided a discussion of the 4th evolution of ILs in which molecular species are mixed with salts.

The development of ILs suitable for electrocatalytic reduction has involved

the synthesis and determination of the physicochemical properties of fluorinated ionic liquids. These ILs display high nitrogen gas solubility and their electrochemical window extends past the reduction potentials required for  $N_2$  reduction.

The use of polymerisable ionic liquids has become increasingly prevalent. A study was undertaken on the impact of comonomer chemistry on the phase behaviour of polymerisable ionic liquid crystals that have the potential to mimic biological membranes.

Solid-state poly(ionic liquid) gels have been fabricated for simultaneous CO<sub>2</sub> adsorption and electrochemical reduction as well as for all-solid rechargeable zinc/PEDOT batteries. Proton conducting membranes based on poly(ionic liquids) having phosphonium counter-cations have been made for the first time.

The solid OIPC family of electrolyte materials are providing a universal material family for use in many electrochemical devices. As a result, studies on the effects of other materials on OIPCs have continued. For example, the influence of electrospun poly(vinylidene difluoride) (PVDF) nanofibre matrix on the ion dynamics of a protic OIPC has been investigated as has the influence of anion chemistry on the ionic conductivity and molecular dynamics in the same protic OIPC. The importance of microstructures on the ion transport rate and pathways of OIPC materials has been demonstrated in a study of the structure and ion dynamics of imidazolium-based protic OIPCs. Remarkably efficient quasi-solid-state dye-sensitised solar cells (DSSCs) have been fabricated using small phosphonium OIPC electrolytes based with varying amounts of silica  $(SiO_2)$  in collaboration PI Guldi.

lonogels are a new class of hybrid materials where ionic liquids are immobilised by a macromolecular support. An elastomeric magnetorheological (MR) ionogel has been made, following the application of magnetic nanoparticles into an ionic liquid containing minimum crosslinking agent, whose physical properties are co-controlled by simultaneously applied UV light and an external magnetic field. Ionogels have been incorporated into commercial porous supports to prepare supported ionic liquid gel membranes (SILGMs) for use as both electrolytes and separators for supercapacitors.



SCHEMATIC 1: ACES CORE 3D ELECTROMATERIALS RESEARCH THEME AND ASSOCIATED APPLICATION THEMES

# ASSEMBLY AND FABRICATION

#### **FIBRES**

Fibre production is a facile approach to the fabrication of complex 3D electromaterials and a wide variety of structural, electroactive or reaction centre materials can be incorporated into fibres for specific applications. This is well exemplified by the fibre work undertaken in the Centre in 2018.

Graphene oxide, graphene and composites of these materials have been fabricated into fibres. These have been used as biological probes and active components of wearable energy storage devices. A highly flexible graphene fibre has been used to integrate small (20µm) nerve bundles *in vivo*. Unprecedented signal to noise ratios have been achieved for recording and high spatial resolution obtained for nerve stimulation.

Biocompatible fibres, containing microcapsules, have been fabricated to achieve pre-programmed drug delivery profiles.

A high performance fibre based

supercapacitor has been created from superelastic wet-spun hybrid carbon nanotube graphene fibres followed by electrodeposition of polyaniline. Spring-like coiled fibres coated with an elastic polymer not only showed an extraordinary elasticity and stretchability but enabled 500% strain for thousands of supercapacitor cycles with no significant change in performance.

Weavable carbon nanotube yarn supercapacitors for electronic textiles have been fabricated by embedding high loadings of reduced graphene oxide as anode and manganese dioxide as cathode into carbon nanotube yarn host electrodes. The yarn electrodes were mechanically strong enough to be woven into commercial textiles. The resulting textile supercapacitor exhibited stable electrochemical energy storage performances during deformations.

Supercapacitors were also constructed from flexible graphene/polypyrrole nanofibre film using surfactant-exfoliated graphene. The nanofibres increased the electrochemical performance and ensured flexibility of the supercapacitors that had a capacitance retention rate of over 80% after 5000 cycles. The simple fabrication of graphene oxide (GO)-based fibres with an infiltrated nylon-6,6 polymer by wet spinning was achieved. These fibres could be twisted and coiled to form actuators, which could lift loads over 100 times heavier than itself. This novel kind of GO-based actuator has potential for a wide range of applications such as artificial muscles, robotics, and temperature sensing.

Carbon nanofibres have also been extensively used in composites for a variety of applications. A low-cost tin (Sn)-modified N-doped carbon nanofibre hybrid catalyst was developed for switchable CO<sub>2</sub> electroreduction to CO or formate. Electrospun cobalt-selenium-N-doped carbon nanofibres show highly capacitive lithium (Li) storage in Li-ion batteries. Vacancy-induced sodium-ion storage in sodium-ion batteries has been achieved with N-doped carbon nanofibre-MoS<sub>2</sub> nanosheets as the anode material. Carbon nanofibres were also used to prepare composite ionic covalent entanglement (ICE) hydrogel networks from poly(Nisopropylacrylamide) and alginate. Devices based on these ICE materials are expected to find potential applications in soft robotics and microfluidics.

New methods of fibre spinning have been developed to create different types of fibres, such as core shell electromaterial fibres. Biopolymeric continuous core sheath fibres, with either an inner core of chitosan and an alginate sheath or an inner core of graphene and chitosan sheath, had previously been wet spun. This has now been extended to triaxial fibres with conductive polymer inner and outer layers sandwiching the biopolymer layer. These fibres with two electrodes showed good electrochemical and mechanical properties. They were also cytocompatible, which make them useful for potential applications as biosensors, electrodes, tissue scaffolds or biobatteries.

ACES researchers have developed an approach that produces a distribution of preformed fibres throughout the core of a 3D coaxial structure. A combination of wet spinning and in line electrospinning has enabled a continuous process wherein micron diameter conducting fibres based on PEDOT are coated with a nanoweb of cytocompatible polymers.

#### INKS

Given the potential of 3D printing for the fabrication of electrochemical devices, the development of targeted inks is a critical feature of that. For example, SR

#### RESEARCH IN ACTION THE IMPACT OF RENEWABLE ENERGY

Challenge: Assessing the social impact of renewable energy technologies

Solution: Members of the ACES Ethics, Policy and Public Engagement (EPPE) theme have been assessing the policy and supply chain aspects of renewables to determine their impact on equity, access, conflict and resilience, to then develop an approach to engagement of key stakeholders in new energy technologies. One of our projects assesses the ethical implications of using La Trobe Valley lignite brown coal in Victoria to produce hydrogen for export to Japan's 'green' hydrogen economy and fuel cell automotive industry. Sustainable energy is a critical focus across the planet, however there's no point in supporting green economies when the production of fuels is not so green. In the case of La Trobe Valley, the jury is still out on the scientific merit of claims that the planned coal-fired gasification plant will sufficiently reduce fuel production emissions. This proposed project also relies on the contested merits of carbon capture and storage in Bass Strait with unproven carbon-neutral strategies. While coal jobs are a priority for the Victorian Government, the project will have to compete with more ethically produced solar energy hydrogen in states like Queensland.

In 2017, the Intergovernmental Panel on Climate Change – the United Nation's body for assessing the science related to climate change – released a special report on the impacts on global warming of 1.5°C above preindustrial levels and related greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change and sustainable development. In light of this report, the Australian government will need to consider the current domination in policy of fossil fuel path dependency, and respond to increasing global demands for ethically sourced renewable energy and energy exports that meet global ethical 'energy security' demands.

**Engagement:** In order to impartially assess the social impact of the policy and supply chain aspects of renewables, ACES researchers have engaged with a diverse range of national and international participants in this space, from academic researchers, company representatives, policy experts to community members.

**Impact:** This research has had significant impact both in publications and in the community. ACES EPPE CI Prof Linda Hancock and research fellow Dr Natalie Ralph have published on ethical supply chain protocols for batteries and alternative solar technologies (*Journal of Cleaner Production 2018*) together with SES researchers, as well as a number of other publications on energy material supply chains and the corporate role. Along with her membership of the Hepburn Wind Board and related activities, Dr Hancock and other EPPE researchers have contributed to a diverse range of national and international energy meetings and fora including the 7th International Workshop on Advances in Cleaner Production (USA) and United Nations Global Compact/PRME Business for Peace Working Group and Network.

researchers have utilised a conductive graphene ink in the fabrication of 3D printed reusable flexible concentric electrodes. They have demonstrated their effective performance in electrotactile stimulation and sensory feedback for soft robotic prosthetic hands.

For energy applications, extrusion printing of interdigitated electrodes, offers an attractive fabrication route to produce flexible microsupercapacitors. A simple ink based on a waterdispersible graphene oxide (GO)/ polyaniline (PANi) composite has made the scalable fabrication of flexible microsupercapacitors possible.

Hydrogel inks have proved very effective in the development of scaffolds for cell growth. A photo-crosslinkable methacrylated gelatin (GelMa) ink was essential for use with the biopen. EM and SBS researchers continued to explore the characteristics of GelMa. They have demonstrated that the mechanical properties of GelMa hydrogels produced across a wide range of crosslinking conditions can be predicted. This may be used to aid rational choices of gelatin methacryloyl (GelMa) photocrosslinking conditions, especially in cell encapsulation experiments where minimising the cytotoxic elements in the reaction is a priority.

A new nanocellulose-based hydrogel ink for cell growth scaffolds has been developed. The resulting 3D printed scaffolds render nanocellulose a new member of the family of promising support structures for crucial cellular processes during wound healing, regeneration and tissue repair.

Another hydrogel ink based on starshaped copolypeptides has been produced and shown to be 3D printable and degradable. The star copolypeptide ink allows for rapid prototyping enabling the fabrication of defined intricate microstructures, providing a platform for complex scaffold development that would otherwise be unattainable with other processing techniques, such as molding or casting.

#### PRINTING

3D printing has had a profound impact across all areas of ACES research and this has continued in 2018.

EFD researchers have reviewed the significant impact of 3D printing on the separation sciences. They have also 3D printed a new radial flow cell for chemiluminescence detection and a low cost passive sampling device with an integrated porous membrane.

SR researchers have 3D printed helical soft pneumatic actuators that generate bending and twisting motions. These can be used as a gripper to handle slender objects.

Additive manufacturing techniques open up a range of new possibilities for the design of electrochemical systems. SES researchers have 3D metal printed electrodes that show improved gas reactant transport for electrochemical reactions.

3D bioprinting continues to be the cornerstone of the SBS theme and developments in this area are discussed in the SBS theme report.

The fabrication of soft, stimulusresponsive structures with sub-micron resolution has been achieved, in collaboration with PI Diamond at DCU, using the two-photon polymerisation of poly(ionic liquid)s. Due to their flexibility and soft, responsive nature, these structures are much more akin to biological systems than the conventional, highly crosslinked, rigid structures typically produced using this type of fabrication.

The 3D printing of many materials relies on crosslinking procedures such as photopolymerisation. In this regard, new photoinitiators for free radical polymerisation and fast 3D printing under visible light have been developed.

## **CHARACTERISATION**

A focus in the Centre has been the development of contactless characterisation techniques. Given the importance of hydrogels across the Centre themes, a contactless approach for monitoring the mechanical properties of swollen hydrogels using ultrasound has been pursued and shown to provide a direct relationship between a simple thickness measurement and Young's modulus. This approach has also been used to monitor the proliferation of living cells in 3D structures.

The development of a variety of electrochemical characterisation techniques have been undertaken by SES researchers, in collaboration with AI Bond. The use of fourier transformed alternating current voltammetry (FTACV) in electromaterials research for the direct visualisation of important underlying electron transfer processes has been reviewed. FTACV has also been used to compare the applicability of models of electrode kinetics and quantitative comparison of voltammetric methods for investigating electrode kinetics.

The use of specialist characterisation techniques in SBS projects is important to advance understanding of cell interactions. Single cell force spectroscopy has been used to study the effect of electrochemical oxidation and reduction on cell de-adhesion at the conducting polymer-live cell interface. Cell adhesion on conducting polymers is important in organic bioelectronics, including applications such as electronically switchable surfaces and electrochemical transistors.

#### **MODELLING**

Modelling, part of all the technical themes, provided new insights into the specific research area. For example, modelling was critical for the design of visible light photoinitiators for 3D printing leading to new fast photoinitiator systems for radical and



cationic polymerisation under green LEDs. This markedly improves the versatility of 3D printing systems.

The exciting research on the effect of electric fields on chemical reactions discovered by ACES researchers and published in Nature 2016, has been extensively expanded in 2018, with modelling a key component. A major literature review has been published. In other outputs, it has been demonstrated that the electrostatic effects on excited states are massive allowing for selective tuning of energy levels and photochemical reactivity. An extensive theoretical study of the effects of chemical structure on nitroxide redox potentials was undertaken and the cleavage mechanism of alkoxyamines and its dependence on electric fields (STM) and electrolytes and solvent (CV) was explored.

Understanding the control of some polymer synthesis has also benefited from modelling. Theory has been used to explain kinetic behaviour and stereopreferences in terms of the chemical structures of monomers and additives.

Modelling has continued to enhance the development of ionic liquids as electrolytes. An in depth theoretical study of ion dynamics in a concentrated room temperature ionic liquid focussed on how the solvation structure of the cation changed with salt concentration and how this affected its dynamics.

ACES researchers have also used modelling for synthetic energy projects.

A book chapter has been prepared on density functional theory (DFT) modelling tools in  $CO_2$  conversion. In work on nitrogen reduction to ammonia, DFT investigations revealed that the reaction proceeds via a dissociative mechanism on ruthenium surfaces. On the contrary, the reaction on the iron surface adopts an associative distal pathway, entailing N<sub>2</sub> adsorption and its further reduction by successive transfers of six protons and electrons. The feasibility of spontaneous activation of the N<sub>2</sub> molecule upon adsorption onto the iron surface was also predicted.

In another study, modelling was used to understand the effects of adhesive strength on the electrochemical performance of silicon electrodes for advanced lithium ion batteries.

# THEMES

ACES research has become increasingly cross-themed, moving from an electromaterial and structure/function focus to a device focus. The impact of the electromaterial, fabrication, characterisation and modelling knowledge gained over the previous four years can be clearly seen in the theme research reports below as well as in the Research in Action boxes.

# **SOFT ROBOTICS**

The objective of the research in SR is to use the mechanical actuation and sensing properties of selected

electromaterials to develop new robotic systems such as a controlled multi-digit and highly dexterous 3D robotic hand that has programmable mechanical compliance, integrated sensors and a neural interface system. Such a device would deliver new benchmarks in performance for applications in industrial, personal and prosthetic robotic systems.

This not only requires material and device development but also sensor and control system creation. In this regard, sensory feedback mechanisms are important and, as a result, EFD researchers have reviewed noninvasive sensory feedback methods for prosthetic hands, and investigated combined mechanical pressure and skin stretch, and the use of tactile apparent movement from vibration motors.

#### **SOFT ROBOTIC HAND**

Considerable advances have been made in the development of a soft robotic hand. Myoelectric soft robotic hands equipped with three and four servo motors have been designed, fabricated and tested using an inhouse built wireless myoelectric control system, including a surface electromyography (EMG) armband to detect user movement. Other advances in this area have included the design and fabrication of a portable embedded pattern recognition system. The system is used for the training or calibration of hand patterns and can be done anywhere and anytime for a prosthetic user. Electronic circuit design controls the hand DC motors and improves the hand's grasping ability.

Peripheral nerve signal sensing is important. A 3D-printable soft, stretchable and transparent hydrogelelastomer device has been developed that is able to detect simulated 'nerve' signals. This provides the framework for the future development of a soft, 3D printable, capacitive coupling device that could be used for detecting peripheral nerve signals.

Sensory feedback has been provided through a reusable flexible concentric electrode for electrotactile stimulation. Printed using Ninjaflex, then spray coated with a thin layer of graphene for conductivity, its performance was comparable to disposable electrodes typically used. This will enable use of a greater range of electrode shapes and sizes depending upon the application.

The current control systems for prosthetic hands are limited and fail to

provide natural control. SR researchers are using machine learning models to translate the human intention into control signals to create a natural and intuitive solution.

#### **ACTUATION**

Novel soft vacuum actuators (SOVAs) have been directly 3D printed using a Fused Deposition Modelling (FDM) 3D printer. SOVAs have many advantages including high actuation speed, large output forces and long lifetime. The performance of SOVAs was optimised and predicted using finite element modelling which agreed well with the experimental data obtained. In addition. the SOVAs can be used in diverse robotic applications including locomotion robots, soft adaptive grippers, artificial muscles and modular robots. This work was a gold medal winner at the 2018 IEEE International Conference on Robotics and Automation (ICRA) that took place in Brisbane in May.

Analogous to this, soft and 3D printable soft linear actuators (LSOVAs) have been fabricated for use in a diverse range of robotic applications. These include soft manipulators, soft prosthetic hands, soft crawling robots, soft adaptive grippers and soft artificial muscles. The LSOVAs were used to drive a fully 3D Printed Omni-Purpose Soft Gripper (OPSOG) to pick up objects with different weights, shapes, textures and stiffnesses. This work also won a gold medal at ICRA.

Soft pneumatic sensing chambers (SPSC) that can be used as soft push buttons, soft linear sensors, soft bending sensors and soft torsional sensors have been 3D printed. These soft chambers have multiple advantages including linearity, negligible hysteresis, long lifetime, repeatability and stability over time.

In other areas of actuation, a new concept for tensile artificial muscles has been formulated in which the torsional actuation of a twisted polymer fibre drives a twist-to-writhe conversion in an attached elastomeric fibre. An energy harvester has been developed that uses coiled yarn artificial muscles, comprising well aligned shape memory polyurethane (SMPU) microfibres, to convert thermal energy to torsional mechanical energy, which is then electromagnetically converted to electrical energy. This has the potential to be a practical, cost effective system for the conversion of low grade waste heat to electrical energy.

# ELECTROFLUIDICS AND DIAGNOSTICS

3D printing has become increasingly important in the EFD theme. Those 3D printing developments are described in the projects below.

#### COMPOSITE AND MULTI-MATERIAL FIBRES FOR 3D FUNCTIONAL DEVICES

Work in this area was aimed at delivering an integrated fibre based electrofluidic diagnostic platform for whole blood analysis, metabolite studies and DNA isolation/concentration. In 2018, this has involved the practical demonstration of multi-material printing and application of printed porous membranes as well as the development of new 3D printed fibres of hard and thermally conductive synthetic micro-diamond-polymer composite. A demonstration of the unique fluidic properties of composite fibres has been undertaken along with their application in microfluidics.

#### MICROCAPILLARY AND FIBRE-BASED ELECTROFLUIDICS

EFD researchers and their collaborators have reported on recent advances in enhancing the sensitivity of electrophoresis and electrochromatography in capillaries in microchips (2016–2018), part of a series of biannual reviews.

Metal ion binding, detection and release in continuous flow microcapillary sensors has been achieved, in collaboration with PI Diamond and his team in Ireland. They have created an advanced nanostructured switchable surface inside of microcapillaries using spiropyran polymeric brushes for selective ion binding. In addition, selective capillary electrophoresis separation of mono and divalent cations within a high surface area-to-volume ratio multi-lumen capillary was successfully achieved. A similar approach using a simple and rapid capillary electrophoresis method with capacitively coupled contactless conductivity detection (CE-C4D) has been used for the simultaneous determination of inorganic and organic anions in liquid product obtained from the hydrothermal treatment of biomass residues.

In the fibre based electrofluidic area, a thread based electrofluidic platform for direct metabolite analysis in complex samples has been developed as a demonstration of fibre based electrofluidics for real sample analysis/ diagnostics.

Processable thermally conducting polyurethane composite fibres have been produced as a new functional low cost processable material for application in additive fabrication.

#### 3D MICROFLUIDIC DEVICES AND BRAIN-ON-A-BENCH MICROFLUIDIC PLATFORM

In this project, EFD researchers aim to develop a first generation integrated microfluidic/ electrofluidic platform for culture and study (chemical stimulation and electrochemical observation) of neural cells in collaboration with SBS researchers.

3D printing has proved essential for the development of the microfluidic devices including a 3D microfluidic distributor and flow cell for chemiluminescence detection. The benefits in response and performance of the chemiluminescent flow cell have been reported for the ion chromatographic determination of hydrogen peroxide in urine and coffee extracts.

# SYNTHETIC ENERGY SYSTEMS

In 2018, SES research has been driven by the requirement to develop first stage device prototype designs for

- $\triangleright$  a solar driven CO<sub>2</sub> or N<sub>2</sub> reduction cell
- > a sodium-air battery and
- > a thermoelectrochemical cell

Key to achieving some of these goals has been the design, construction and optimisation of electrolyser devices that can be scaled up. Tests have been undertaken in these devices using electrocatalysts for both CO<sub>2</sub> reduction and water splitting.

The successful development of all of these devices requires advances in materials, electrodes, electrolytes and fabrication as detailed in the projects below.

# ELECTROCATALYTIC CO<sub>2</sub> REDUCTION

Research directions in this project during 2018 focused on developing new catalysts with outstanding performance and understanding the mechanism of electrochemical  $CO_2$  reduction using advanced electrochemical techniques. Catalysts were either metallic or

### RESEARCH IN ACTION ADVANCED ENERGY STORAGE TECHNOLOGIES

Challenge: Enhance the lifetime and cyclability of Sodium (Na)-Air batteries

**Solution:** ACES researchers and collaborators have been working together to increase the cyclability and the performance of sodium (Na)-air batteries using advanced electrolytes - ionic liquids (IL). The improvements achieved are likely due to the solvation of Na<sup>+</sup> in the electrolyte mixtures containing different Na<sup>+</sup> concentrations; the coordination of Na<sup>+</sup> by the anion of the ionic liquid dictates the discharge product morphology. At low concentrations, Na<sup>+</sup> is strongly coordinated to the anion of the ionic liquid, and this also can have a detrimental effect on its mobility. However, at high Na<sup>+</sup> concentration, this interaction is weakened and beneficially favours mass transport before product deposition (*The Journal of Physical Chemistry C 2018, Chemical Communications 2018; Advanced Energy Materials 2018*). Diluted electrolyte mixtures form more compact, uniform and larger crystallites on the electrode surface, which passivate the air cathode and is detrimental to device performance, whereas concentrated electrolyte mixtures lead to dense and porous deposits that enable longer term cyclability.

**Engagement:** These results are the combination of different institution and researchers from different backgrounds, bringing different set of skills together. Former ACES members (Cambridge University), ACES collaborators (CIC Energigune) and ACES members (Deakin University).

**Impact:** The research carried out in advanced energy storage technologies have had significant impact. For instance, Dr Pozo-Gonzalo has been invited to write a feature article on the key reactions taking place in metal-air batteries (*Chemical Communications 2018*), and ACES researchers have contributed to the state of the art of Na batteries (*Advanced Energy Materials 2018*). Additionally, the results have been disseminated in invited presentations at the International Conference in Sodium Batteries, November 2018, France, and a seminar at CICEnergigune (Spain) November 2018.

molecular based with nanostructuring having a significant impact on their performance. In this regard, SES researchers reported on recent advances in the nanoengineering of electrocatalysts for  $CO_2$  reduction.

As described earlier, iron porphyrin graphene electrocatalysts have been prepared and demonstrated exceptional  $CO_2$  to CO reduction performance. This work demonstrates the value of the multimaterial development and fabrication that has been at the heart of ACES research.

Silver (Ag) is one of the most promising  $CO_2$  reduction catalysts. A first proofof-concept self powered hybrid  $CO_2$ electrolysis to CO was demonstrated by the coupling of a magnesium anode to a nanoporous Ag cathode in seawater. Nanostructured Ag was also investigated for  $CO_2$  reduction. It was obtained by electrodeposition of Ag in the presence of a polyoxometalate and the resulting catalyst showed high faradaic efficiencies over a wide range of applied potentials for CO production. Ultrasmall nanoparticles (NPs) with high mass activity have great potential for practical applications in CO<sub>2</sub> electroreduction. The improved performance of ultrasmall gold NPs has been achieved through engineering surface amine modifiers. Ultra-small copper NPs have been embedded in N-doped carbon arrays and shown improved electrocatalytic CO<sub>2</sub> reduction to formate, the salt of the industrially important formic acid.

Bismuth (Bi) electrocatalysts have been investigated extensively for  $CO_2$ reduction to formate. Defect-rich Bi electrocatalysts derived from  $Bi_2S_3$  have shown enhanced formate selectivity as a result of the surface defect induced lattice disordering structure rather than the presence of sulphur. Structure has again been shown to be important for an ultrathin few layer Bi nanosheet catalyst in which the 2D structure enhanced the activity of formate formation and hence lowered the overpotential.

Formate is also a reduction product from tin (Sn) electrocatalysts.

#### RESEARCH IN ACTION SOFT ACTUATORS FOR ROBOTIC APPLICATIONS

Challenge: Develop low cost 3D printable soft actuators.

**Solution:** We developed novel 3D printable bioinspired soft vacuum actuators (SOVA) that can be used in diverse soft robotic applications including walking robots, hopping robots, soft artificial muscles, soft adaptive grippers and modular robots. These actuators that are inspired by sporangium of fern trees, have many advantages including fast response, high output forces, high actuation speed, high payload-to-weight ratio and long lifetime. SOVA were fabricated directly in one manufacturing step without requiring any post-processing using a low cost and open source fused deposition modelling (FDM) 3D printer and an off-the-shelf soft material. SOVA work is a gold medal award winner in the Soft Component Technology Competition at the 2018 IEEE International Conference on Robotics and Automation (ICRA). The competition aimed to showcase newly developed soft robot technologies, including new actuators, sensors or other component technologies that advance the field of soft robotics. The entries were judged for significance, originality, functionality and quality of documentation.

**Engagement:** The soft robotics team at ACES and UOW is making significant contributions in the field of soft robotics. The novel soft actuators developed, and their applications are attracting many companies that are interested in soft robotic applications including soft grippers and soft prosthetic hands.

**Impact:** This work has been published in Soft Robotics (SoRo) journal, and a linear version of these actuators have been used to build an omni-purpose soft gripper called (OPSOG). We envisage that this and other versions of this gripper will be used in handling and harvesting agricultural products.

A range of dendritic Sn catalysts have been synthesised to investigate a new substrate effect that enhances electrochemical  $CO_2$  reduction. This work suggests that a strategy that not only focuses on material design but also considers the entire catalytic system is optimal. A low cost Sn modified N-doped carbon nanofibre hybrid catalyst has been developed that allows switchable  $CO_2$  electroreduction in aqueous medium. Sn nanoparticles drive efficient formate formation whereas atomically dispersed Sn species promote conversion of  $CO_2$  to CO.

Alcohol is an important  $CO_2$  reduction product target. SES researchers have prepared a hierarchically ordered nanochannel array membrane reactor with 3D electrocatalytic interfaces for the electroreduction of  $CO_2$  to alcohol.

#### SELECTIVE ELECTROREDUCTION OF DINITROGEN TO AMMONIA

In 2018, the work focused on:

I. the identification of new electrocatalysts to enhance the rate

of ammonia  $(NH_3)$  synthesis;

- II. the design of new solvent-electrolyte combinations to enhance the selectivity of the process;
- III. the upgrade of existing and the design of new high productivity cells for NH<sub>3</sub> electrosynthesis;
- IV. understanding the reaction pathways using DFT modelling.

SES researchers achieved for the first time very low overpotential nitrogen reduction in aqueous solutions. They were also able to design aprotic electrolytes to work optimally with iron catalysts for ammonia production. Further optimisations of the solventelectrolyte compositions enabled significant improvements in the faradaic efficiency, reaching outstanding levels of 85-95%.

In contrast, comprehensive testing of vanadium and niobium nitrides as catalysts for the nitrogen reduction reaction (NRR) under a wide range of conditions unambiguously demonstrated their inability to catalyse the electrosynthesis of ammonia from dinitrogen.

#### WATER OXIDATION

Water oxidation is important as the coupled process to reduction. SES researchers have prepared new water oxidation catalysts based on highly dispersed and disordered nickel-iron hydroxides.

The role of morphology on photoanodes for water oxidation has been investigated using disordered hematite photoanodes. The modification of a hematite photoanode with nickel oxide nanoparticles has produced a high performance photoanode.

A water oxidation catalyst that forms in situ and maintains reasonable activity in weakly acidic solutions such as natural waterways has been identified.

#### **METAL-AIR BATTERIES**

This project ranges from fundamental to applied research focusing on electrolyte (ionic liquid electrolyte mixtures), electrodes (metal and 3D carbon matrices) and full metal-air cell. The identification and development of electrolyte/redox couple/catalyst combinations to support charge and discharge reactions at an air-cathode is the core component of the project. Consequently, SES researchers were invited to write a feature summarising ACES and other groups' oxygen reduction research in ionic liquid electrolytes for metal air batteries.

An in-depth study of the effect of electrolyte composition on the discharge products on the interface electrolyte/ electrode for sodium (Na)-air batteries was carried out, gaining understanding of the effect of electrolyte interactions with the electrogenerated species.

A practical lithium (Li)-air battery using a composite molybdenum carbide (Mo<sub>2</sub>C)/carbon nanotube promoter gave a high round trip efficiency and improved cycling performance. This work provided improved understanding of the general role of solid promoters and will enable rational design of promoters towards practical Li-air batteries.

#### LITHIUM AND OTHER BATTERIES

Many of the materials used in the development of sodium batteries are useful for lithium, zinc and other batteries. In this regard, SES researchers reviewed for the first time the use of molybdenum and tungsten chalcogenides as anode materials for lithium/sodium-ion batteries. A 3D porous molybdenum disulfide/ graphene electrode in combination with a phosphonium cationic IL was shown to produce thermally stable high performance lithium-ion batteries. The polymeric binder distribution within electrodes, crucial to guarantee the electrochemical performance of lithium-ion batteries, was also measured.

A superior performance of an all solid rechargeable zinc/PEDOT Battery was achieved using iongels based on imidazolium ionic liquid as electrolyte.

#### NON-AQUEOUS FLOW BATTERIES

Following on from earlier research in ACES, the investigation of this unique battery chemistry in which the discharged state is the same for both anolyte and catholyte so that they can be mixed, has continued. Optimised structures for the active ions and solvent systems are being developed. Specifically, the cycling performance of an ionic liquid with water additive has been reported for the first time under realistic flow conditions using a 3D printed flow half-cell prototype for application in a zinc-based redox couple.

#### **THERMOCELLS**

Research in 2018 primarily concentrated on developing new water based and ionic liquid-based quasi-solid state electrolytes. Four new cobalt (Co) based complexes were prepared and their Seebeck coefficients, electrochemical characteristics, diffusion, reversibility on different electrodes and thermocell performance was studied. The first use of a water soluble Co redox couple for thermal energy harvesting was achieved and cellulose was used to make quasisolid state electrolytes with this couple.

As discussed earlier, hydrogels containing an iron based redox couple and ionic liquids were prepared and their thermal energy harvesting performance studied. Alternative soft gels produced by gelation of an organic solvent based electrolyte system containing a cobalt redox couple with PVDF polymers showed good thermocell performance and stability over 25 hours of thermocell operation.

The thermal energy harvesting performance of another PVDF based electrolyte, albeit a non-volatile, flexible redox active quasi-solid state one, was also studied.

# SYNTHETIC BIOSYSTEMS

The key 2018 SBS activity was the development of the 'brain on the bench' system. This requires advances in the 3D neural modelling platform, bioink development and fabrication processes. Advances in all of these areas have led to a wide variety of applications in other areas of SBS research as described below.

#### BIOMATERIALS, BIOFABRICATION AND BIOPRINTING

The biomaterial and biofabrication expertise within the Centre combined with clinical collaborators and others to produce a number of reviews.

An insightful review on biomaterials for corneal bioengineering details the requirements for fabricating synthetic and semisynthetic corneas for *in vitro* modeling of tissue development and disease, pharmaceutical screening, and *in vivo* application for regenerative medicine.

SBS and fabrication expertise combined to review advanced fabrication approaches to controlled delivery systems for epilepsy treatment. Addressed were the critical issues, recent advances, and future directions of 3D printing and cell therapy for wound repair.

In addition, a review of the potential of 3D bioprinting in the area of auricular cartilage regeneration, particularly in relation to the functional requirements of an ear scaffold, was published.

Biomaterial based implantable drug delivery systems (DDSs) have emerged as promising therapeutic platforms. SBS researchers have reviewed the recent advances and future outlook of biopolymers for antitumor DDSs.

The engineering of muscle cells has also been a focus of the SBS Theme. SBS researchers along with AI Chong have reviewed this area with a focus on moving from 2D to 3D constructs.

Research into 3D bioprinting for cartilage regeneration using the ACES developed biopen was undertaken in 2018, courtesy of Arthritis Australia funding. The results showed that real time, *in vivo* bioprinting with cells and scaffold is a feasible means of delivering a regenerative medicine strategy to regenerate cartilage.

Conductive biomaterials are

important for the tissue engineering of electroresponsive cells such as nerve and muscle cells. The polymer properties, protein and cell interactions, and influence of electrical stimulation on neuronal cell differentiation of conducting polymer (PEDOT) films doped with algal, mammalian and synthetic dopants were investigated. The cytocompatibility of the biomaterials was demonstrated and shown to significantly enhance the differentiation of neuronal cells under electrical stimulation.

SBS and members of local seaweed company, Venus Shell Systems, have undertaken a study of the fabrication and *in vitro* characterisation of electrochemically compacted collagen/ sulfated xylorhamnoglycuronan (SXRGlu) scaffold for wound healing applications; the scaffold closely mimicked the major structure and components in natural skin tissue. These results suggest that the scaffold is a potential candidate as a dermal substitute with enhanced biostability and biocompatibility.

A method has been developed for fabricating human neural tissue by 3D printing human neural stem cells as part of a bioink. The bioink uniquely comprises the polysaccharides alginate, water soluble carboxymethyl-chitosan, and agarose. Importantly, the method could be adapted to fabricate neural and non-neural tissues from other cell types, with the potential to be applied for both research and clinical product development.

The development of ways to create fully vascularised tissues and organs is critical for tissue engineering. SBS researchers have made a significant advance in this with the engineering of perfusable double layered vascular structures using a photocrosslinkable gelatin hydrogel.

#### MATERIALS AND MODELLING FOR BRAIN ON THE BENCH

Studies continued in the development and characterisation of functional materials that can be 3D printed for application as neural structures to model neurological disorders. These studies mainly focused on the formation of neural cell-bearing hydrogels. As noted earlier, the tailoring of the mechanical properties of gelatin methacryloyl (GelMa) hydrogels through the manipulation of the photocrosslinking conditions was investigated. GelMa was shown

#### RESEARCH IN ACTION EXPORTING RENEWABLE ENERGY

**Challenge:** Australia has an enormous capacity to generate renewable energy, especially solar, in remote areas of central and northwestern Australia. Solar farms just the size of our two or three largest cattle stations could supply the electricity needs of the whole world. The challenge is to transport it from those remote locations to the export market.

**Solution:** ACES researchers have refined a way to make ammonia using renewable energy (*Energy and Environmental Science 2017, ACS Energy Letters 2018*) and nitrogen from the air around us. Ammonia is an easily transported liquid that can be used directly as a fuel or split into hydrogen and nitrogen. Converting nitrogen into ammonia at room temperature and pressure is not a new concept, but doing so efficiently is very challenging. The ACES team have shown how ionic liquid electrolytes can create a high efficiency process. Improved yields are the next step for researchers to tackle and this will require improvement in the structure and the catalysis of the reduction reaction.

**Engagement:** The ACES research has attracted the interest of one of the world's largest ammonia producers and a working party involving a number of interested commercial parties has been formed.

**Impact:** The development is great news for the environment, and it also ties in nicely with ACES' goal of producing useful fuels and chemicals from solar energy. This device does just that, from nothing more than water and nitrogen from the atmosphere. Other applications ACES is pursuing include using this process as a means of generating ammonia for fertilisers at the local level; one day every farm could generate its own fertilisers from the sun. Our work was highlighted in *Science* in July 2018 and in *Chemical and Engineering News* in May 2018.

to support good development and integration of neural outgrowth from human induced pluripotent stem cell (iPSC)-derived organoids.

In parallel, protocols were generated and refined for neuronal cell subtypes derived from human iPSCs to enable construction of these structures from patient-derived cells. The aim is to use the structures for developing *in vitro* diagnostic platform to determine personalised drug treatment for patient specific neural dysfunction.

The development of scaffolds for human stem cells is vital for tissue engineering and implantable medical devices. Graphene-cellulose paper has been shown to be suitable for traditional planar two dimensional (2D) or three dimensional (3D) human cell support by adipose derived stem cell (ADSC) culture and osteogenic differentiation. The papers can be configured to 3D constructs by lamination with alginate and further modified by folding and rolling for 3D "origami-inspired" cell laden structures.

With the use of multichannel extracellular microelectrode arrays, SBS researchers have shown that 3D neural cultures produce networks that mimic native brain activity. This is the first report of 3D biofabricated neural structures' performing neural function similar to native brain tissue. It has also been shown that 3D printing human neural stem cells as part of a bioink provides a simple way to fabricate human neural tissue.

With the increasing use of stem cells, in ACES and worldwide, and the rapidity that new human pluripotent stem cell (hPSC) lines are generated, exchanged, and implemented, it is essential that unambiguous cell line authentication is maintained. SBS researchers have been involved in an international effort to create a standard nomenclature for referencing and authentication of such pluripotent stem cells.

# ETHICS, POLICY AND PUBLIC ENGAGEMENT

Our EPPE theme provides critical input to our technical themes. This input is particularly important as we progress towards translation into practical applications with our end-user network. In 2018, five areas involving EPPE researchers and ACES researchers within the SR, SBS and SES themes in collaboration have been explored.

#### ENGAGING KEY STAKEHOLDERS IN RENEWABLE ENERGY TECHNOLOGIES

This project identifies and critically assesses key stakeholder concerns related to the development and deployment of renewable energy systems at a range of levels. It seeks to identify social, environmental and political concerns associated with "big energy" and energy transitions, and to identify approaches to avoiding or mitigating these concerns in the transition to renewables.

During this year, the ways that reliance on scarce minerals in the development of batteries, as well as poor labour, safety and environmental practices has contributed to conflict, have been considered with a view to developing new protocols for identifying supply chain concerns in the development of batteries and renewable technologies. That is, a "decision tree" protocol to allow scientists and students in the lab to assess and ensure that their research does not contribute to the demand for "conflict minerals" has been proposed.

In addition, in an exploration of the debate on production of lithium batteries, the desire for cleaner technologies has cultivated unusual governance arrangements via public private partnerships (PPPs) between state enterprises and foreign owned private corporations. Research has been carried out to evaluate and develop a framework for how public private partnerships might best interface with the United Nations sustainable development goals in order to facilitate cleaner lithium production.

A study of the role of alternative energy corporations in ethical supply chains and corporate peacebuilding has shown that a corporate peacebuilding strategy can address a company's impacts on conflict whether on the ground or through the supply chain. Companies reframing their corporate social responsibility towards corporate peacebuilding, are better able to deal with the governance around international conflict minerals and sustainable resources.

EPPE researchers have also compared Germany and Australian renewable energy policies. This has involved assessing the potential for renewables to provide greater democratic control over and fairer access to energy as well as assessing the role of renewables in promoting national and international energy security. An energy security framework/index was expanded that can inform development of new transnational renewable energy and electricity projects, and improve forward thinking on risk management.

#### HOW CAN RENEWABLE ENERGY SYSTEMS BE DESIGNED TO SUPPORT DISASTER RESILIENCE?

This project explores vulnerability, particularly in developing countries, to disaster and the ways that renewable energy systems can foster resilience to disasters and be used to reduce the harmful impact of disaster on vulnerable communities.

The policy implications of low cost renewable energy systems and their impact on disaster risk reduction and energy resilience have been studied with a view to developing a framework for disaster risk resilience in disasterprone countries like India. This has led to discussions with a number of officials in disaster management including funders in the International Aid/Disaster Resilience sector such as the Indian President of the Bill and Melinda Gates foundation.

EPPE researchers have also explored the potential for renewable energy technologies to contribute to sustainable international development and aid projects.

#### CHALLENGES FOR REGULATION AND CLINICAL APPROVAL OF PERSONALISED MEDICINE

This project aims to identify and anticipate regulatory and clinical hurdles and controls for the ethical translation of personalised 3D bioprinted and bionic devices. There is a need to reconsider the epistemic significance and threshold requirements for clinical trials of personalised medicine, given the role that evidence from prior clinical trials plays in both the ethical evaluation of further research on clinical applicants and in regulatory approval.

The need to assess the epistemic grounding for claims of the effectiveness of personalised medicine as well as the need to manage public expectations of this emerging area of research was considered in a joint study by EPPE and SBS researchers. A further joint study on the epistemic basis for and limitations of clinical trials in personalised medicine and the importance of including patient perspectives in evaluating the clinical outcomes of personalised medicine was also undertaken.

The general ethical concerns associated with the use of bioprinting in medicine and the more particular ethical issues related to experimental testing on humans, and the lack of current international regulatory directives to guide these experiments have been explored. Given the mass media attention to this area, a report and discussion of the ethical consequences of coverage of 3D bioprinting in the media was undertaken. This showed how enthusiastic media reports influenced patients to seek unapproved experimental treatments with potentially fatal consequences, examined the lack of regulation and absence of discussion about risks associated with bioprinting technology and explored how media misunderstanding is dangerously misleading the narrative about the technology.

Given the increasing fabrication of patient-specific devices using 3D printing, a study was undertaken into whether randomised controlled trials (RCT) can be used to evaluate patient-specific devices and population level evidence evaluating therapeutic interventions with such devices. It was concluded that although theoretically possible to use RCTs to evaluate some patient-specific medical devices, there are significant difficulties for ensuring the validity of such trials, with implications for how we should think about methods of evidence gathering and regulatory approaches for these technologies.

Designing and manufacturing medical devices for specific patients is becoming increasingly feasible with developments in 3D printing and 3D imaging software. A study of the 'gold standard' method for evaluation of patient-specific devices, the RCT, reveals significant difficulties for ensuring the validity of such trials, with implications for how we should think about methods of evidence gathering and regulatory approaches for these technologies.

An analysis of the ethics around the turning off of cardiac pacemakers has been undertaken in order to facilitate a more comprehensive approach to ethics and the cardiac pacemaker.

#### CHALLENGING ASSUMPTIONS ABOUT PROSTHESES

This project seeks to clarify the ethical significance of disability and how prosthetic devices should be understood ethically. It has been informed by "user centred" and "inclusive" "design" approaches, and by collaboration with the SR theme.

During 2018, work focussed on two aspects: analysis of a survey of upper limb prosthetic users conducted with the SR theme, and clarification of how the relationship between a person and that person's prosthetic device should be understood - especially how that relationship is understood where the prosthetic has been designed specifically for that person or is implanted in the person. These considerations are important for understanding the responsibilities of designers to prosthetic users, where it is appropriate for them to regard protheses as more like body parts than objects.

#### CHALLENGES FOR REGULATION AND CLINICAL APPROVAL OF NEURAL IMPLANTS

The aim of this project is to identify and anticipate regulatory and clinical hurdles and controls for the ethical translation of bionic neural devices from the lab to clinical practice. EPPE, SBS and ACES associate investigators explored a number of research aspects by consideration of debates concerning individual identity and authenticity.

New brain implants detect specific neuronal activity patterns and provide information to help patients respond to upcoming neuronal events, but this information may affect patients' decisional capacities and autonomy. The ethical issues and risks involved in being kept in the decisional loop have been explored.

In an analogous way, deep brain stimulation (DBS), as a therapeutic modality for people with Alzheimer's disease, has also been attributed as a potential threat to identity and selfhood. In order to help understand the ethical implications of DBS on people with Alzheimer's disease, a tripartite model of selfhood has been developed, focusing on adapting informed consent procedures and care provided throughout a clinical trial to account for both positive and negative plausible effects on each of the three kinds of selfhood.

# PUBLICATIONS

Publishing ACES research is essential for knowledge translation. Publishing both in academic journals and explaining the potential impact of that research to our community through our website portal provides an important means in which we disseminate the body of ACES knowledge.

# ACES RESEARCH OUTPUTS -HIGH QUALITY INTERNATIONAL STANDING

In 2018, 224 articles (SCOPUS data 4.1.19) were published that have ARC Centre of Excellence for Electromaterials Science in the address line indicating ACES members' involvement in that research.

The overall publication and citation activity for ACES affiliated publications 2018 and 2014-2018 is shown in Table 1. Please note that not all publications listed in Scopus (224) were available in the SciVal database (206).

In 2018, 61.6% of the journal publications were apportioned across at least two FOR codes at the two digit level, highlighting the interdisciplinary nature of the research supported by the Centre.

## **BOOK CHAPTERS**

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TABLE 1: OVERALL PUBLICATION AND CITATION ACTIVITY FOR ACES AFFILIATED PUBLICATIONS 2014-2018 (SOURCE, SCIVAL BASED ON SCOPUS DATA 4.1.19)

Output Description	2018	2014-2018
Number ACES publications (SCOPUS)	224	961
Number of ACES publications (SciVal)	206	943
Number of subject areas (main categories) ACES published in	21	22
^^ Views count	3,430	40,518
^Views per Publication (articles and reviews)	16.7	43.0
Outputs in Top 1% of world views	6 (2.9%)	78 (8.3%)
Outputs in Top 10% of world views	73 (35.4%)	489 (51.9%)
Outputs in Top 25% of world views	129 (62.6%)	749 (79.4%)
Number of citations	362	13,653
Number of citing countries	52	101
Average citations/publication	1.8 (98 cited pubs)	14.5 (778 cited pubs)
Outputs in top 1% most cited	11 (5.3%)	66 (7.0%)
Outputs in top 10% most cited	62 (30.1%)	344 (36.5%)
Outputs in top 25% most cited	98 (47.6%)	605 (64.2%)
Field Weighted Citation Impact (#FWCI - for articles and reviews)	1.71	1.92
International collaboration	122 (59.2%)	525 (55.7%)
National collaboration	65 (31.6%)	333 (35.3%)

**Legend:** ^^ Views count is total views received by publications of the selected entities (Source: SCOPUS data)

\*The average number of views per publication (Source: SCOPUS data) # The Field Weighted Citation Impact (FWCI) - World Average is 1.00.

 Puckert C., Higgins M.J. (2018) Force Spectroscopy. In: The Surface Science Society of Japan (eds) Compendium of Surface and Interface Analysis. Springer, Singapore, 2018, Print IBSN 978-981-10-6155-4; Online ISBN 978-981-10-6156-1.

# JOURNAL ARTICLES

Some ACES journal articles were selected as hot topics and showcased on online websites. For example, the article 'Engineering Surface Amine Modifiers of Ultrasmall Gold Nanoparticles Supported on Reduced Graphene Oxide for Improved Electrochemical CO<sub>2</sub> Reduction' (*Advanced Energy Materials* **2018**) was promoted by Wiley as an April hot topic: gold as well as hot topic: carbon dioxide (*onlinelibrary.wiley.com/doi/toc/10.1002/*  (ISSN)1521-3765.hottopic-gold and /doi/ toc/10.1002/(ISSN)1864-564X.hottopicco2).

It was also reported in ChemistryViews and by the Chinese media Cailiaoren. (https://www.chemistryviews.org/details/ news/11083211/ Improved\_Selectivity\_in\_CO2\_

Electrochemical\_Reduction.html and http://www.cailiaoniu.com/146730. from=singlemessage& isappinstalled=0)

ACES research was also accepted as journal covers or frontispieces.

# 2018 ACES JOURNAL PUBLICATION LIST

The 2018 ACES publication list below is reported in order starting from the highest journal impact factor.

- Ciampi, S.; Darwish, N.; Aitken, H. M.; Díez-Perez, I.; Coote, M. L., Harnessing electrostatic catalysis in single molecule, electrochemical and chemical systems: a rapidly growing experimental tool box. *Chemical Society Reviews* **2018**, *47* (14), 5146-5164, Impact Factor = 40.182.
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# **RESEARCH TRAINING**

scope

# ACES STRATEGIC PLAN GOAL 2: RESEARCH TRAINING

Our goal is to deliver innovative research training and mentoring programs that ensure the development of world class graduates and early career researchers with excellent research skills as well as science communication, research management and commercialisation skills, coupled with an ethical awareness of the impacts of their scientific endeavour.

Our target audience is primarily prospective students. ACES provides an inclusive and supportive global research training opportunity; giving access to the most innovative and dynamic research training programs that are facilitated by our global connections.

# TOWARDS OUR GOALS

ACES is a national institution with international connections and as such, it provides a unique training environment that opens up global opportunities for our graduates.

ACES has established a culture of collaboration wherein an appreciation and respect for individual talents and an awareness of the value of the team approach is continually highlighted. Our students and researchers have access to a global network of partners as well as a dynamic end-user network.

Students and researchers alike benefit from ACES linking with other initiatives. For example:

- with RMIT, QUT and Deakin universities in the ARC Linkage Training Hub in Biofabrication;
- with UniSA and UTAS in the ARC Linkage Training Hub in Portable Analytical Separation Techniques or
- with fourteen organisations across government and industry, and four other Australian universities, in the newly awarded ARC Training Centre for Future Energy Storage Technologies.

Material scientists and engineers from ACES are collaborating on multidisciplinary projects with neuroscientists and cell biologists via the Illawarra Health and Medical Research Institute (IHMRI) to deliver next generation medical devices and therapies. IHMRI and ACES have jointly funded three PhD scholarships, from mid-2017, to work on:

- the use of novel electromaterials in reversing cellular phenomenon associated with schizophrenia (with ACES AI Prof X-F Huang and DCU Ireland);
- developing controlled delivery strategies for oncology, (with Kara Perrow IHMRI and Wollongong Hospital oncologist Dr Mori Aghmesheh)
- new materials for wound healing (Daniella Skropeta IHMRI and clinician Prof Chris Baker at St Vincent's Hospital Melbourne)

ACES utilise our alumni network to enhance end-user engagement and increase the number of collaborative facilities accessible to ACES members.

# BEYOND TECHNICAL TRAINING

ACES understands technical research training is at the core of what we do—but today's graduates need to be able to adapt, re-skill and take on new challenges. Therefore, in addition to being trained to be at the forefront of their craft from a technical perspective, ACES offers our students and ECRs training in:

- communication, to enable them to engage across disciplines and explain their research to the wider community.
- commercial awareness, entrepreneurship and innovation provided via an intensive short certificate course.
- ethics and public engagement, so they have the ability to recognise ethical and regulatory issues that might need to be addressed to ensure the real impact of fundamental discoveries is delivered to those that can use them.

The ACES Research Training Group (RTG) is responsible for designing, establishing and implementing an innovative research training and career development/mentoring program, including various industry and webbased programs.

# SUCCESSFUL TRAINING INITIATIVES

Successful training initiatives undertaken by ACES since 2014 include:

- Joint Masters of Philosophy
   Electromaterials Science launched by
   UOW and Deakin (2016-current)
- Master of Philosophy in BioFabrication



launched by UOW, with ACES support, in collaboration with QUT, Utrecht University (Netherlands) and the University of Wurzburg (Germany) (2014-current)

- Entrepreneurship and Innovation Certificate through UOW and UOW's Sydney Business School (2015-current)
- Massive Open Online Course (MOOC) in Additive Biofabrication developed by ACES and ANFF Materials Node staff (2015-current)
- Online Graduate Certificate of Additive BioFabrication building upon the MOOC (2018-current)

# ACES COMMUNICATIONS TRAINING

Science in Public conducted a science communications course for ACES. This course was targeted to show ACES PhD and ECRs specifically how to communicate their research to the media and our community. Delivered over a half day (18 July) the course featured: (i) a Q&A session with 3 professional journalists (Alicia McMillan – Chief of Staff, Channel 7; Lucie van den Berg, Herald Sun; Alexandra Hansen (The Conversation) and (ii) a "make your pitch session" where the participants presented their work to the audience in a three minute pitch.

ACES currently employs two communications officers who not only focus on ACES media, end-user and outreach activities, but also provide educational tips and assist in in-house training for ACES members.

Our ACES Communications officers are in the process of developing fact sheets to assist our researchers. In late 2018 a Conversation fact sheet "Be Pitch Perfect for The Conversation" was developed, designed and distributed to all ACES and affiliated members. Tips included were on:

- steps prior to pitching a story
- the one line pitch and 200 word outline
- the brief outlining the direction of said article
- the article itself writing tips (newsworthy), readability and referencing.

The communications team travel to all nodes, as well as attend Centre meetings, to interview members of our ACES team about their research and assist our members to produce short articles, pictures and videos for ACES social media platforms, YouTube channel and website. See the communications chapter in this report.

## ACES ENTREPRENEURSHIP & INNOVATION TRAINING

ACES, in collaboration with UOW's Sydney Business School, developed the 'Certificate in Entrepreneurship and Innovation (E&I)'. Through this course, young researchers are challenged and encouraged to maximise end-user engagement and consider commercial opportunities that may arise from their research activities.

Led by ACES CI Mozer and Dr Tillmann Boheme from Sydney Business School, a group of twenty ACES and affiliated members, commenced the certificate in October. Expert tuition was given from the Sydney Business School and industry professionals, plus each group was assigned mentors (ACES CIs and AIs) for the technical aspects of their project.

This program was has been developed to place ACES projects in a business context with a commercial lab based opportunity; culminating with each group giving a feasibility pitch at the conclusion of the program.
The course content of this certificate is constantly being evolved. New additions for 2018 included:

- members from successful start-ups talking about their experiences
- a private equity fund manager talking about seed funding and cash flow style proposals required
- expanded innovation focus to include Asia as well as North America and Europe after consideration to the origin of students attending the course each year
- a social entrepreneurship session -ACES research fellow Dr Natalie Ralph designed and presented this three-hour session on 'Ethical renewable energy and biomedical entrepreneurship'

The strength of this ACES training program is that we take real world challenges or problems and find not only the technical but also the business solutions to these challenges.

#### BIOFABRICATION TRAINING INITIATIVES

#### MASTERS TRAINING PROGRAM IN BIOFABRICATION

This world's first Master of Philosophy in BioFabrication, run by the University of Wollongong, with ACES support, in collaboration with Queensland University of Technology, Utrecht University (the Netherlands) and the University of Wurzburg (Germany), trains graduates for the field of biofabrication - an emerging field in which a connection is made between medicine and technology.

The purpose of this program was to build Australia's credibility and global profile in the provision of training in the emerging field of 3D biofabrication. In attracting more than the anticipated student numbers from overseas we are achieving that goal. The program has also allowed us to build global research collaborations with Utrecht and Wurzburg Universities.

UOW through the BioFabrication masters course implemented clinical mentors into the student projects and in doing so created a clinical research network in Australia.

Graduates upon completion have a track record of collaboration with the world's leading bionics, fabrication and bioethics experts, an international network of potential collaborators, and an appreciation of the processes involved in taking an idea through to commercial reality. Twelve of the 27 enrolled have completed the ACES Entreprenuer and Innovation certificate.

To date ACES UOW has hosted 28 BioFabrication masters students.

- Twelve Utretch students (two have graduated from both Australia and Utretch, six have completed their exchange at ACES UOW and a further four commenced at ACES UOW in November 2018 for ten months).
- Six Wurzburg students (all have completed their exchange at ACES UOW and are in the process of submitting their thesis).
- Four Australian students (two have graduated from both Australia and Utretch, another has completed his Wurzburg thesis with his Australian thesis under review and another is on exchange in Wurzburg until mid 2019 having already submitted his Australian thesis).
- A further six students are enrolled for two years in the Australian BioFabrication masters course as they are either ineligible or unable to complete a ten month exchange abroad. Two have submitted their thesis.

The BioFabrication masters has also created a career pathway for domestic students. Two Australian graduates who completed the first year in Australia and the second in Europe have returned and enrolled in PhD degrees at UOW (in collaborations with CSIRO and Anatomics).

The dual BioFabrication masters was the platform for the further development of a massive open online course (MOOC) and graduate certificate in biofabrication.

The program was also the catalyst for the establishment of the ARC funded training hub in Biofabrication that has attracted the participation of Australian Industry including Cochlear and Anatomics.

#### MASSIVE OPEN ONLINE COURSES (MOOCS)

The use of training tools such as Massive Open Online Courses (MOOCs) and short courses are offered to boost skills for research students and professionals.

ACES and ANFF (Materials Node) staff produced an eight hour (two hours per week for four weeks) MOOC on Bioprinting in 2017. The Bioprinting MOOC is now in its 9th run with over 27,500 people having joined and learnt more about the revolution in medicine that 3D bioprinting is making possible. ACES and affiliated members also gain experience moderating the online forums for the MOOC.

#### ONLINE GRADUATE CERTIFICATE BIOFABRICATION

ACES through the University of Wollongong offer a Graduate Certificate BioFabrication - 'Introduction to Additive Biofabrication (AIIM900)' and 'Practical Learning and Training in Additive Biofabrication (AIIM901)'. AIIM900 was launched in spring 2018, with four student enrolments, and AIIM901 is scheduled for 2019.

The AIIM 900 subject introduces fundamental topics and methodologies of biofabrication such as printable materials and their rheological properties; biopolymers and bioinks; techniques and instrumentation such as commercial and customised 3D printers, rapid prototypers, extrusion printers, metal printers, bioplotters and live cell printing. The topics are introduced via a 'real-world' case study on cartilage repair for the knee and development of a 'biopen' to enable biofabrication. The issues around ethics and regulatory matters associated with the development and use of 3D printing facilities and biofabrication-based therapies and devices in clinical settings are also explored throughout the subject.

The second AIIM901 subject provides practical training and experience with major topics that include: collaboration in the 3D biofabrication space, biofabrication examples based on case studies of the ear, islet cell and 'brain on the bench'. Other topics include developing and characterising biopolymer, bioink and printable formulations; step-by-step training and operation of various additive biofabrication instrumentation, bioplotters and live cell printers. The subject teaches workflow processes, including design of software models and their integration through to printing 3D objects and post production. The subject content and activities enables the student to create 3D structures and critically evaluate their potential for innovative technology, commercial and business opportunities.

With biofabrication expected to generate innovation and technology in biomedical sciences and play a significant role in future manufacturing industries - UOW's Graduate Certificate in BioFabrication has been designed to provide participants with the opportunity to gain



the skills and expertise necessary for employment in the rapidly growing field of 3D printing and biofabrication.

ACES CIs Higgins and Wallace conducted a live chat in June 2018 so potential applicants could ask questions to learn more about the course. Another live chat is scheduled for February 2019.

The Graduate Certificate in Biobrication also provides an entry pathway into the Masters of Philosophy (BioFabrication) which involves undertaking a research project in the ACES laboratories.

#### ELECTROMATERIALS TRAINING INITITATIVES

#### MASTERS DEGREE ELECTROMATERIALS SCIENCE

Launched by UOW and Deakin in 2016, this unique two year course offers the first Australian joint postgraduate Masters degree in Electromaterials Science (MPhil EM). The course is designed to ensure that students gain maximum benefit from the unique multidisciplinary expertise available in ACES in a bid to prepare skilled people to progress electromaterial technologies.

A particular challenge in recruiting PhD students into ACES is finding high achieving graduates with an appropriate mix of scientific backgrounds (chemistry, physics, biology in some cases and engineering sciences), enabling them to rapidly engage in PhD studies.

In 2018, the first student graduated from this masters course. Three further students completed the two electromaterials core courses in 2018 and are now working towards completing their research thesis – two at UOW and one at Deakin University.

The core courses are taught by researchers across ACES and video streamed between UOW and Deakin. These lectures were also open to all ACES PhD students. A week of intensive laboratory classes were held in the first trimester of 2018 at Deakin Unversity and a week at UOW in the second trimester.

#### MASTERS PROGRAM IN MATERIALS SCIENCE AND CHEMICAL ENGINEERING

ACES, through Deakin University, are involved in a European Masters course 'Materials for Energy Storage and Conversion' (MESC). MESC is designed to provide a two year education program in materials science and electrochemistry.

Partners in the program include five universities in four European countries (France, Poland, Slovenia and Spain), universities in USA (Drexil) and Australia (Deakin), a European research institute (ALISTORE), the French Network on Energy Storage (RS2E), the Slovenian National Institute of Chemistry (NIC) and a leading research centre in Spain (CIC Energigune). These Institutions host world renowned, leading research laboratories in the field of energy related materials.

In 2018, ACES at Deakin University hosted two MESC students for their six month research thesis (Karolina Biernacka and Aleksandra Grzelak).

ACES Deakin are now part of the formal MESC program, supported by Erasmus Mundus funding, until 2024. In 2019, ACES Deakin will host a MESC student to work on a thermal energy harvesting project.

### ENCOURAGING PHD ENROLMENTS

#### MASTERS TO PHD SCHOLARS

UOW BioFabrication masters graduates Malachy Maher (affiliated joint PhD with UOW and CSIRO) and Jeremy Dinoro (PhD with the BioFabrication Training Hub) began PhD studies wth ACES in 2018. Beginning 2019, ACES will welcome Matthew Russo, the first MPhil Electromaterials graduate, into his PhD studies at Deakin University. Karolina Biernacka, a 2018 MESC student hosted in ACES, also begins her PhD at Deakin University in 2019.

#### SUMMER SCHOLARSHIP PROGRAM

The ACES summer scholarship program is designed to encourage undergraduates into ACES postgraduate programs. In 2017-18, two undergraduate students worked at ACES UOW as part of a ten week summer scholarship. For 2018-19 ACES UOW are hosting six students, five from UOW and one from University of Melbourne. Four of the six students spent the duration of the scholarship at TRICEP, Australia's newest 3D Bioprinting.

Listed below are the students and their projects:

Benjamin Filippi – Computational

modelling of coaxial melt electrowriting head

- Nafis Ahmed Six axis manipulation of biofabrication tools
- Jordan De Barros Characterisation of hydrogel extrusion forces
- Dipixa Sharma Microvalve Printing
- Thanushi Peiris Microparticle Synthesis
- Geetika Maddirala –Coaxial experiments with variety of advanced materials
- Mohammed Zoubai Coaxial printing microparticles
- Thomas Battye-Smith Robot Driven 3D Printing

## **HOSTED WITH ACES**

38 students from international universities were hosted with ACES in 2018.

- Xiaomin Zhang from Nanjing University, China was hosted on a postgraduate research exchange at ACES Monash University from 29 September 2016 through to 3 March 2018.
- 2. Maxim Brodmerkel, Wurzburg University in Germany, spent ten months at ACES UOW completing the second year of the dual degree, from July 2017-March 2018.
- Juliane Kade, Wurzburg University in Germany, spent ten months at ACES UOW completing the second year of the dual degree, from July 2017- March 2018.
- 4. Marius Berthel, Wurzburg University in Germany, spent ten months at ACES UOW completing the second year of the dual degree, from July 2017- March 2018.
- Rhiannon Morris, Cardiff University, hosted at ACES UOW, 20 August 2017-1 May 2018.
- Bing Lin, Beijing University of Chemical Technology China, hosted at ACES Deakin from 25 September 2017-June 2018.
- Diego Castañeda Garay, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017-July 2018.
- 8. Stefan Zaharievski, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017-July 2018.
- 9. Laura Blanco Peña, Utrecht



University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017-July 2018.

- 10. Max Renes, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017-July 2018.
- 11. Gilles van Tienderen, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017-July 2018.
- 12. Gregor Weisgrab, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017-July 2018.
- Fleurine Eberle from Wurburg University, Germany was hosted at ACES UOW to undertake 6 months of her masters thesis working on metal 3D printing from 1 October 2017 to 31 March 2018.
- 14. Ms Ellie Stepaniuk, 3rd year exchange student from the Department of Chemistry, University of Warwick, was hosted by ACES Monash to work on research training in the area of electrochemical CO<sub>2</sub> reduction, 2018.
- 15. Koralina Biernacka from Amiens France, undertook her masters

project at ACES Deakin, January to August 2018.

- 16. Alexandra Grzelak, undertook her masters project at ACES Deakin, January to August 2018.
- 17. Tony Pointu from France was hosted at ACES Deakin for his internship from January to June 2018.
- Barthélémy Hugon, a French exchange student was hosted at ACES Deakin for her internship from January to June 2018.
- Florentin Guilbault, a French exchange student was hosted at ACES Deakin for internship from January to June 2018.
- Sylvie Riber, PhD student from Senentxu's group in Portugal spent 2 months at ACES UOW working with Cl Higgins on high speed AFM, 15 January - March 2018.
- 21. Heidi Kaisvuo, Tampere University Finland, at ACES UOW working on her masters project, February – July 2018.
- 22. Annika Ahtiainen, Tampere University Finland, at ACES UOW working on her masters project, February – July 2018.
- 23. Anne Gruska, Wurzburg University, Germany spent ten months at ACES UOW completing the second year of the dual Masters degree, 1 March -

20 December 2018.

- Markus Ebert, Wurzburg University, Germany spent ten months at ACES UOW completing the second year of the dual Masters degree, 1 March – 20 December 2018.
- 25. Hannah Haag, Biofabrication Masters student University Hospital Wurzburg, completing the second year of the dual Masters degree, 1 March- 20 December 2018.
- 26. Danielle Bruen, PhD student at PI Diamond's group Dublin City University studied at ACES UOW developing glucose sensors by 3D printing from 6 March-16 May 2018.
- 27. Mr Kun-Lin Tsou and Mr Yu-Wei Lin, from Institute of Electronics (BETRC) at the National Chaio-Tung University (NCTU) in Taiwan were hosted at ACES UOW to collaborate on printer development for cell printing and microvalves, 2-29 July 2018.
- 28. Dexter Cole, Cardiff University, hosted at ACES UOW to work on 'redox gel electrolytes' from September 2018-June 2019.
- 29. Marleen Kristen, Utrecht University in Netherlands, spending ten months at ACES UOW completing the second year of the dual degree, from November 2018.
- 30. Jacopo Bani, Utrecht University in

Netherlands, spending ten months at ACES UOW completing the second year of the dual degree, from November 2018.

- Ane Urigoitia Asua, Utrecht University in Netherlands, spending ten months at ACES UOW completing the second year of the dual degree, from November 2018.
- Ane Albillos Sanchez, Utrecht University in Netherlands, spending ten months at ACES UOW completing the second year of the dual degree, from November 2018.
- Borja Sanz Gutierrez, Utrecht University in Netherlands, spending ten months at ACES UOW completing the second year of the dual degree, from November 2018.
- 34. Karen Butina, PhD student in organic bioelectronics from Karolinska Institute Sweden, spent 3 weeks at ACES UOW using AFM to study bacteria on conducting polymer surfaces, from 3 November 2018.
- 35. Mark Buckingham, PhD student from King's College London, is being hosted by ACES UOW to work with CI Jun Chen on the collaborative project "thermal harvesting devices", 20 November 2018 – 18 January 2019.
- 36. Lei Yan, a Yokohama National University (YNU) masters student hosted at ACES UOW to refine his work on the electrical stimulation of hair follicle cells with a polypyrrole platform, 13-18 December 2018.
- Sena Ozawa, PhD at YNU working on tissue origami so was interested in ACES cell printing techniques. Visited ACES UOW, 13-18 December 2018.
- Yoshili Tate, PhD at YNU working on electrical cell detachment and hair regeneration, visited ACES UOW to use the QCM to monitor the detachment process, 13-18 December 2018.

## RESEARCH TECHNICAL TRAINING INTIATIVES

#### **WORKSHOPS**

The ACES workshop program targets the professional development of research staff and postgraduate students, as well as key areas of continuing technical and scientific education. The workshops were undertaken in the form of:

ACES Full Centre Meeting (5 February

2018) – included a two hour workshop run by Positive Psychology Coach, Jody Cooper, on "Presentation Skills".

- ACES Full Centre Meeting (20 July 2018) – began with a student-led and organised session with activities 'PhD Strategies for Success', 'studentsupervisor relationships' and 'Careers after PhD'.
- Weekly theme meetings (4 March 12 December 2018) between all nodes within the Centre via video link. The ACES all virtual meeting is once per month as are each of the individual virtual theme meetings.
- A number of face to face targeted ACES research theme workshops.

Targeted research theme workshops held in 2018 included: advanced electrochemical methods; impedance and related AC Methods in electrochemistry masterclass; collagen; nitrogen reduction catalysis; printer design and fabrication; applied 3D fluidics; advanced drug delivery and processing cells for bioprinting.

These workshops provide specialist research training for PhD and early career researchers (ECRs), and include mentoring for research planning and positioning for career opportunities (see appendix 1 for a table listing all these activities and number of participants).

#### **INDUSTRY ENGAGEMENT**

Meaningfully engaging industry involves:

- Manufacturers forging new commercial partnerships and helping identify the training needs for a future workforce.
- Researchers engaging with industry to show that modern research labs are occupied by dynamic and highly skilled professionals, aware of the gaps in knowledge that need to be filled to overcome highly relevant, real-world challenges.

The establishment of TRICEP at UOW, the BatTRI Hub at Deakin and the Biofab3D@ACMD at St Vincent's hospital, allows ACES to train a new generation of scientists to undertake 'biofabrication' research in combination to learning about innovation and business. Read more about these interactions in the Translation chapter in this report.

## CROSS-NODAL EXCHANGES

Students and ECRs are supported to attend and present their work globally

at conferences as well as to undertake collaborative visits.

In addition, the exchange of personnel between nodes is also a vibrant area of activity within ACES. Members regularly attend ACES targeted workshops organised as part of ACES research training activities. Members also travel between the nodes to undertake multidisciplinary research tasks: brainstorming, project meetings, laboratory measurements, etc. Support for cross-nodal interactions is provided by the Centre where appropriate. Examples of cross-nodal visits (60 in total) are listed in appendix 2. These visits are additional to the support provided to attend targeted workshops or ACES events/conferences.

## EFFECTIVE TRAINING

The ACES team is committed to research excellence in an environment that ensures effective training for future research leaders or researchers equipped with the skills for next generation manufacturing.

ACES are often asked "Where are your graduates now?" After contacting a group of ACES alumni we found they have been employed in varying professions since completing their PhD with ACES. Jobs were with:

- Industry
- Government Organisation Research
- University Research
- Start ups
- In IP development
- Journal Editor
- Science Communication
- University Lecturers
- Regulatory authorities
- Business service providers
- Professional staff

## ACES CAREER DEVELOPMENT IN ACTION

Our ACES website and social media platforms featured a number of interviews across a range of our members - they all make up the great team that is ACES.

Shaun Geitmann PhD Swinburne http://www.electromaterials.edu.au/

## WHERE CAN AN ACES PHD TAKE YOU?

WE ASKED OUR ACES ALUMNI ABOUT THE OPPORTUNITIES THAT OPENED UP FOR THEM AFTER COMPLETING AN ACES PHD.

## INDUSTRY



- Manager, Mobile Energy, Timcal Graphite and Carbon, Singapore
- Advanced Technology Research Laboratories, Panasonic Corporation, Japan
- Senior Researcher, Korea Electronic Technology Institute (KETI), Korea
- Hardware Development Engineer, Apple, USA
- > Technology Consultant, Altran, Germany
- > PCD and CMP Process Engineer, Intel, Ireland
- Senior Program Director, Sober Steering Sensors, Canada
- Development Chemist, Bostik Ltd, UK
- Medical Representative, Servier, Canada
- > Senior Product Engineer, Johnson Controls, China
- Development Chemist, Dulux Group, Sydney
- Product Development Engineer, Danish Power Systems, Denmark
- Software Evaluator, Agilent Technologies, USA
- Battery System Design Engineer, Geely R&D, China
- > Technical Advisor, Waters Pty Ltd, Australia

## PROFESSIONAL SERVICES STAFF

- Manager of BioFab3D@ACMD, St Vincent's Hospital Melbourne
- Faculty Research Grants Officer, University of Wollongong
- Argos Reporting Officer, Australian Catholic University
- eResearch Consultant, University of Sydney
- Fabrication Technician, Australian National Fabrication Facility (ANFF) Materials Node

## GOVERNMENT ORGANISATIONS

- Environment Department, Wollongong City Council
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France
- ▶ CSIRO
- Defence Science and Technology Group (DSTG)
- National Science and Technology Development Agency (NSTDA), Thailand



## UNIVERSITY ACADEMICS

- Lecturer Analytical Chemistry, University of Shahrood, Iran
- Lecturer, College of Chemistry and Chemical Engineering, Shaanxi University of Science and Technology, China
- Senior Lecturer, Shanghai Jiao Tong University, China
- Lecturer, University Malaysia Terengganu, Malaysia
- Professor and Assistant Director, Institute of Advanced Materials for Nano-Bio Applications, Wenzhou Medical College, China
- Assistant Professor, King Saudi University in Saudi Arabia
- Assistant Professor, Head of Textile Department, University of Guilan, Iran



## POST-DOCTORAL RESEARCH AND BEYOND

- University of Wollongong
- **RMIT**
- University of Newcastle
- Monash University
- University of New South Wales
- University of Sydney
- Macquarie University
- Nanyang Technological University, Singapore
- Uppsala, Sweden
- Industrial Research Limited (IRL), now Callaghan Innovation, New Zealand

- Florida State University, USA
- Shanghai Jiao Tong University, China
- Shinshu University, Japan
- Nanyang Technological University, Singapore
- Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany
- Daejin University, China
- Oxford University, UK
- Case University, USA
- China International Joint Laboratory
- Chalmers University, Sweden
- University of Toronto, Canada
- Beijing University of Chemical Technology, China
- Guangdong University of Technology, China
- University of California, USA

## **IP DEVELOPMENT**

- ▹ Knowledge Transfer Partnership Associate, University of Sheffield, UK
- Business Development Manager (Research and Strategy), Deakin University, Melbourne
- R&D Tax and Grants, Ernst and Young, Sydney

**PERSONNEL TO** 

Imagine Intelligent Materials Pty Ltd, Australia

 Patent Reviews, Therapeutic Goods Association

**TRAINED** 

**START UPS** 

Aquahydrex, Australia and USA

Inventia Life Science, Australia

## BUSINESS SERVICE PROVIDERS

- Senior Engineer, GHD
- Senior Manager, Shenzen Economic and Trade Office



## BUT WAIT, THERE'S MORE

- COSMOS Science Writer
- Journal Editor, Wiley, China
- Further academic study in medicine
- Parenthood





#### IN THE SPOTLIGHT ACES CI A/PROF JEREMY CROOK

"The Future of: Regenerative Medicine" was an article which featured CI Crook illuminating how stem cells and materials science are being used to solve some of the biggest health challenges facing the world. The article was one in a series produced by UOW "the Future of" where UOW experts and researchers were asked the same five questions, to provide insight into the potential future states of our lives, communities and world.

#### What are you researching or working on in 2018?

Broadly speaking, my lab is progressing a program of research that brings together stem cells with novel biomaterials to build living 3D synthetic tissues for a range of applications including studying tissue biology (healthy and diseased), for improvement or replacement of tissues of the human body, and building medical devices for regenerative medicine. We're particularly interested in generating neural tissues using 3D cell printing as well as self-organising systems called neural or brain organoids...

## In regards to your field of study or expertise what are some of the most innovative or exciting things emerging over the next few years?

I'm excited about emerging technologies for precision research and medicine, including wearable and implantable biosensors as measurement tools, which incorporate 'point of decision' technologies for fast (and where applicable, preventative) and targeted therapies. Combined with machine learning we can reasonably expect rapid advances in research as well as diagnostics and therapeutics.

A major ongoing concern for the regenerative medicine field relates to the availability of unproven and unauthorised stem cell treatments. In Australia, and many other countries, there are only a few approved stem cell related therapies, with the blood disorder leukemia being one example. Nonetheless, there are clinics around the world that offer stem cells to treat a variety of conditions including cancer, stroke, diabetes, and autism, as well as for cosmetics involving unapproved anti-aging treatments.

People need to be aware of the significant risk to their health and financially, with little if any evidence for the treatments being beneficial.

#### Where do you believe major opportunities lie for people thinking about future career options?

Many of the most pressing challenges facing Australia and the world - equity and equality in healthcare, food and water security, renewable energy, climate change, waste management and recycling, environment protection and biodiversity conservation, to name a few - are and will need to be addressed by innovators in science, technology, engineering, and mathematics - disciplines collectively known as STEM. It's imperative that quality STEM learning opportunities be developed, promoted and made accessible for young people to develop the knowledge base and meet the requirements for innovating and leading in a rapidly changing world.

#### In regards to your field of study or expertise, what is the best piece of advice you could offer to our readers?

My advice is to initially identify a big picture challenge that you'd like to address - be it in my chosen area of regenerative medicine, or tackling climate change, or solving the problems resulting from global waste (be inspired by Craig Reucassel on ABC TVs "War On Waste") just to name a few - and pursue expertise in one or two relevant STEM disciplines. In embarking on your STEM career, focus on the things that count but don't be blinkered, align yourself with a great mentor, recognise opportunities as they present and create opportunities where and when you can, push through the glass ceiling by hard work and having a can-do-it-attitude, and be sure to learn from both success and failure...

Read the entire interview with Jeremy on: https://www.uow.edu.au/research/newsletter/2018/UOW250285.html

news/swinburne-s-shaun-gietman-hopesto-make-a-difference/

Eliza Goddard ECR UNSW http://www.electromaterials.edu.au/ news/research-that-matters/

Lilith Caallero Aguilar PhD Swinburne working at UOM St Vincents Hospital and UOW

http://www.electromaterials.edu. au/news/collaboration-critical-tobreakthrough-3d-bioprinting/ http://www.electromaterials.edu.au/ news/interview-lilith-caballero-aguilar/

Manjunath Chatti and Sarah Mann PhD candidate Monash University http://www.electromaterials.edu.au/ news/introducing-sarah-manjunath/

Dr Fengwang Li recent PhD graduate from ACES at Monash University http://www.electromaterials.edu.au/ news/two-minute-taxi-ride-with-drfengwang-li/

ACES UOW PhD graduates Xiaoteng Jia and Qi Gu

http://www.electromaterials.edu.au/ news/two-aces-graduates-amongstrecipients-of-prestigious-chinesegovernment-award-for-studies-abroad/

ECR ANFF-ACES at UOW Dr Ashley Walker

http://www.electromaterials.edu.au/ news/farewell-interview-research-fellowdr-ashley-walker/

ECR Hearing CRC Associate Investigator Dr Erica Zeglio

http://www.electromaterials.edu.au/ news/farewell-interview-with-ericazeglio-ipri-associate-research-fellow/

University of Tasmania ECR Joan Marc Cabot Canyelles

http://www.electromaterials.edu.au/ news/farewell-joan-marc-aces-thanksyou-and-wishes-you-well-in-your-newventure/

Biofabrication Masters student Joanne Williams reflecting on her year since being awarded the Bill Wheeler Award http://www.electromaterials.edu.au/ news/joanne-williams-refelcts-onwinning-last-year-s-bill-wheeler-award/

Alumni PhD student Dr Bo Weng back at ACES

http://www.electromaterials.edu.au/ news/dr-bo-weng-visits-aces/

Around the World with A/Prof Patrick Howlett ACES CI at Deakin University http://www.electromaterials.edu.au/ news/aces-around-the-world-patrickhowlett/

PhD interview with Rebecca Hodgetts ACES PhD Monash University http://www.electromaterials.edu.au/ news/phd-interview-rebecca-hodgetts/

PhD Interview with Laura Garcia-Quintana ACES PhD Deakin University http://www.electromaterials.edu.au/ news/phd-interview-laura-garciaquintana/

ACES ECR Maxime Fournier from ACES Monash University node http://www.electromaterials.edu.au/ news/interview-with-research-fellowmaxime-fournier/

ACES UOW recent PhD graduate Syamak Farajikhah

http://www.electromaterials.edu.au/ news/farewell-interview-syamakfarajikhah/

ACES PhD Abuzar Taheri at Deakin University

http://www.electromaterials.edu.au/ news/phd-interview-abuzar-taheri/

## TRAINING OPPORTUNITIES

## CONTINUING PROFESSIONAL DEVELOPMENT

ACES members are encouraged to participate in continuing professional development (CPD) activities run by their host universities and others complete CPD activities run by external companies.

ACES CI Deakin Jennifer Pringle was accepted as one of 30 participants in the mid-career emerging leaders stream of the VESKI 2018 inspiring women STEM side-by-side program: Leading the Way. A series of workshops were run throughout 2018.

ACES CI Deakin Jennifer Pringle completed a one-day workshop on "Social Intelligence" and another on "Resilience" run by Deakin University (June).

ACES ECR UOW Shaikh Nayeem Faisal completed the ANN ECR Entrepreneurship workshop at RMIT (21-22 November).

ACES CI UOW Jeremy Crook and ACES RF UOW Eva Tomaskovic-Crook completed the UOW Research Impact workshop series (17, 24 and 31 August).

ACES communications officer Lauren Hood completed the interactive session titled 'How and Why to Write for The Conversation' at the University of Wollongong, hosted by The Conversation Deputy Editor Energy and Environment, Madeleine De Gabriele (17 October). In the session, Madeleine covered the benefits of writing for The Conversation, how academic staff should pitch an idea and write an article, in terms of demonstrating impact, readability and language, connecting to current trends/affairs, and appealing to a non-academic audience.

The ACES Communications Working Group wanted a better understanding of how to successfully pitch to The Conversation, and this session provided a range of tips. A fact sheet has since been developed on this topic and circulated to ACES members.

ACES RF Deakin Jian Fang completed a Nature Masterclass on Scientific Writing and Publishing, at Deakin University (30 November).

ACES CI Jie Zhang completed an "electrochemistry lecture course" run by Prof Stephen Fletcher, Loughborough University, UK.

#### **JOURNAL EDITORS**

ACES CI A/Prof Jenny Pringle from Deakin University was appointed Associate Editor for the Australian Journal of Chemistry.

ACES CI UOW Marc in het Panhuis is Associate Editor for the Journal of Materials Chemistry B.

ACES CI and most highly cited Clarivate researcher Jun Chen and ACES AI Zhilian Yue, from University of Wollongong node, were chosen as Guest Editors for a special issue of Conducting Polymers, which will provide valuable guidelines for the fabrication and application of conducting polymers that can be made flexible, bendable and wearable with highly active interfaces.

ACES CI UOW A/Prof Jeremy Crook Editorial Board Member: Bioprinting, Dataset Papers in Medicine, Journal of Cellular Biochemistry, World Journal of Stem Cells, The Open Medicine Journal.

## ACES MEMBERS MENTORING AND TRAINING OTHERS

#### **ACES MENTORING**

As a result of the multidisciplinary nature of the research carried out at ACES, the leadership team has taken a nontraditional approach to supervision and mentoring; encouraging researchers to work together in teams, and across traditional boundaries, with access to collaborators' laboratories across the globe. This extends to implementing innovative programs to facilitate researchers in acquiring skills in technology transfer and the commercial development of research.

ACES continue to offer a range of technical and transferable skills training to all HDR students and ECRs. For example, a positive psychology coach provided a very motivational session during the February full centre meeting. Other activities for 2018, included science communication training (with a panel of professional science journalists) and small group scientific graphics workshops.

Beyond dedicated mentoring workshops or webinars, ACES exemplifies a culture of innovation, translation and just having a go. Specifically:

ACES appoints junior CIs and ECRs to the ACES Executive Committee for 12 months; ECR Binbin Zhang and CI Jeremy Crook (2015-16), and ECR Justin Bourke, RF Natalie Ralph and CI Marc in het Panhuis (2016-17) and CI Jun Chen, RF Lijuan Yu and Lauren Hood communications officer (2018 -19).

Deputy leaders for ACES research themes have transitioned to take up the reigns for driving the majority of the research activities.

- RF Cristina Pozo-Gonzales, CI A/Prof Patrick Howlett and SRF Caiyun Wang co-ordinate the SES theme meetings, research group discussions and specialised workshops.
- Prof Robert Kapsa and A/Prof Jeremy Crook drive the SBS research activities.
- ► A/Prof Jennifer Pringle assists in the coordination of the EM theme activities.

CI A/Prof Jennifer Pringle is Chair of the Research Training Group (RTG). CIs Pringle, Innis and Mozer have designed, co-ordinated and run the Electromaterials Masters program.

CIs Moulton and Pringle mentored the ACES student committee to organise and run the student led session at the ACES Full Centre meeting (20 July).

#### OTHER MENTORING ACTIVITIES

ACES CI ANU Prof Michelle Coote led discussion and workshops at the Australian Academy of Science (AAS) 2018 Mentoring and Guidance in Careers (MAGIC) workshop, Canberra (29 October-2 November). MAGIC 2018 welcomed 34 early career female or gender diverse researchers in mathematics and physics based in Australia. The event allowed the participants to explore the many facets of forging a career in academic, government or industry settings, and encouraged discussions on how to create building blocks for success and resilience in your career.

ACES CI UOW Prof Marc in het Panhuis was a mentor in UOW Early Career Researcher Development Program in 2018. He mentored Dr Kelly, UOW School of Biological Sciences, on development of cohesive track record and work/life balance. Marc also did a podcast, entitled "Why do children need fathers?", which was on pioneering parental leave (11 August). (https://stand. uow.edu.au/podcasts/do-children-needfathers/ or https://player.whooshkaa.com/ episode?id=258546).

ACES CI Monash Prof Robert Sparrow was an invited speaker at 'Brains of the Future': 2018 Students of Brain Research Professional Development Dinner, The Arts Centre, Melbourne (20 June).

ACES RF UOW Anita Quigley at St Vincents Melbourne gave a masterclass on "Bioprinting" to International Advanced Medical Science students from University of Melbourne/University of Indonesia (17 April).

ACES UOW CI Robert Kapsa, at St Vincents Melbourne, gave a masterclass on "Gene Editing in the mdx Mouse Model of Duchenne Muscular Dystrophy" to International Advanced Medical Science students from University of Melbourne/ University of Indonesia (24 April).

ACES UOW RF Anita Quigley and ACES CI UOW Robert Kapsa mentored 11 attendees, from national and international laboratories, at the University of Melbourne, Stem Cell Technologies-BioFab3D Joint Workshop on Differentiation of hPSCs to neural progenitors (24 June).

The ACES members at St Vincents Hospital Bionics laboratory conducted a training course, for 16 second year Medical Students, from Universitas Indonesia, as part of their Advanced Medical Science (AMS) year (21 October-2 November). The 'Laboratory Techniques' course introduced the students to the theory and practice of conducting medical research.

ACES RF UOW Anita Quigley is mentoring a second year medical student from Monash University, at St Vincents Hospital Melbourne, over the summer 2018-2019, on optimisation of muscle cell printing protocols.





# KNOWLEDGE TRANSLATION



## ACES STRATEGIC PLAN GOAL 3: TRANSLATION

Our goals are to:

- To implement strategies for effective industry engagement and knowledge transfer to industry partners.
- To utilise appropriate business tools to identify and select commercial opportunities in the early stages of ACES.
- To implement effective knowledge transfer strategies that facilitate the development of new business opportunities.

Our target audience is primarily investors. ACES can facilitate the development of technologies to create new disruptive business opportunities and to augment existing businesses.

## TOWARDS OUR GOALS

ACES research has been generating options for the future. Even where explicit beneficial outcomes may not yet be evident, there is value added in the options created through outcomes such as:

- enhanced capabilities
- improved research infrastructure to accelerate progress of research outcomes
- improved or new knowledge creation to disseminate
- a clearer understanding of the most prospective areas for future research opportunities
- information on what areas of research might best be scaled back or abandoned until further information comes to hand or circumstances change.

ACES researchers are creating new knowledge to deal with some of the great challenges of the 21st century. They are searching for material breakthroughs that will not only improve the productivity of existing industries and help create new ones, but will also provide energy solutions and improve health and lifestyle. ACES research has also been used to develop and implement better informed policy. Our innovative training programs are creating, nurturing and preparing next generation of gifted, driven, well-rounded researchers to ensure effective knowledge dissemination.

Worldwide, materials are seen as a priority for innovation, but also as a source of competition and advantage. Advanced materials and additive manufacturing are two connected technologies within the Fourth Industrial Revolution that we are in the midst of. Industry 4.0 is the new wave of innovation which brings with it incredible new opportunities.

New facilities and equipment provide ACES researchers with the means to design innovative methods to produce new advanced materials. While facilities certainly help our researchers deliver materials into applications as soon as possible, the most vital ingredient for rapid innovation is partnerships.

ACES are working together with the brightest minds in the world. ACES partners with communities, industry, business and all levels of government to help drive innovation.

## TURNING KNOWLEDGE AND IDEAS INTO ACTION

As ACES creates new knowledge it is channelled into existing commercialisation networks (through Cooperative Research Centres (CRCs)); helps build new activities with existing companies (through ARC Linkage Hubs, other grant proposals and direct funding of commercial projects) and in collaborations with other end-users, such as clinicians (through NHMRC grants and Garnett Passe funding).

We have embarked on the journey to identify ACES activities that could result in new commercial ventures, through both investment and partnerships. Local industry can also realise global opportunities by tapping into internationally recognised and networked research organisations. We at ACES are keen to take world class science and turn that into next generation manufacturing in partnership with local industries.

## COOPERATIVE RESEARCH CENTRES

#### CELL THERAPY MANUFACTURING (CTM) COOPERATIVE RESEARCH CENTRE (CRC)

This ACES collaborative effort was established in 2015 with the University of Adelaide and the CTM CRC for printing cells in scaffolds in partnership with clinical collaborator Prof Toby Coates. ACES AI Dr Zhilian Yue provided further training, in September 2018, for the customised 3D printer delivered to Adelaide in 2017.

#### **CRC FOR POLYMERS**

ACES UOW involvement in the CRC for Polymers has resulted in new solar cell technologies. The CRC for Polymers officially finished in June 2017, however commercial support for the technology developed continued to be pursued throughout 2018.

#### **FUTURE FUELS CRC**

ACES are in discussion with Future Fuels CRC.

#### **HEARING CRC**

ACES involvement with HEARing CRC has produced new electrode, controlled delivery technologies and work towards developing transistor devices relevant to the Cochlear implant, in partnership with clinical collaborator Prof Stephen O'Leary.

#### AUSTRALIAN RESEARCH COUNCIL (ARC) INDUSTRIAL TRANSFORMATION RESEARCH PROGRAM

#### ARC TRAINING CENTRE FOR FUTURE ENERGY STORAGE TECHNOLOGIES

This new Training Centre based at Deakin University has been funded to equip the next generation of researchers and the energy technology workforce with the skills needed to drive innovation, exploration and investigation to safeguard Australian workers and industries.

Led by ACES Associate Director Prof

Maria Forsyth, the ARC Industrial Transformation Training Centre for Future Energy Storage Technologies aims to challenge existing thinking and expand Australia's capacity in energy storage and production.

Working with fourteen organisations across government and industry, and four other Australian universities, researchers at the centre will facilitate small to medium-sized enterprises to take a global leadership role in advancing and producing new age storage technologies.

ACES involvement within the Centre will be to create new knowledge and intellectual property in advanced energy materials, batteries and batterycontrol systems for integration into end-user industries.

#### ARC TRAINING HUB IN COGNITIVE COMPUTING FOR MEDICAL TECHNOLOGIES

CI Prof Mark Cook from University of Melbourne leads ACES involvement. This training Centre's aim is to have individuals learn skills applicable across technologies and medical sectors and will focus its research on four high-value medical domains:

- epileptic seizure prediction based on real-time data analytics and online training using data streams from neurobionics devices; braincontrolled prostheses to improve the mobility
- function and quality of life of the disabled, based on machine learning using multimodal data streams from brain implants and video and speech inputs
- 3. predicting the Alzheimer's disease risk trajectory of an individual
- 4. real-time clinical decision support to improve the quality of clinical decisions

Also those individuals will be a new generation of entrepreneurial experts in cognitive computing for medical technologies, who will understand business drivers and opportunities for Australian industry. The experience of 12 months embedded in IBM will give the participants real industry experience and meet a key recommendation of the Australian Council of Learned Academies (ACOLA) Review of Australia's Research Training System. All this training closely aligns with ACES training.

#### ARC RESEARCH HUB FOR A WORLD CLASS FUTURE FIBRE INDUSTRY

ACES involvement, led by ACES CI Prof Xungai Wang at Deakin University, in the ARC Research Hub for a World Class Future Fibre Industry is seeing the translation of fundamental findings into developing novel fibre technologies to facilitate more sustainable, advanced manufacturing of fibre materials and products.

## ARC STEEL RESEARCH HUB

ACES involvement in the Steel Research Hub at the University of Wollongong, led by ACES CI Michael Higgins, is seeing the translation of fundamental findings into antimicrobial coatings.

# ARC TRAINING HUB FOR BIOFABRICATION

ACES recognises the major role 3D printing plays in Industry 4.0 – it is the fastest-growing sector of manufacturing globally. ACES at UOW, led by ACES Director Wallace, are partners in the ARC Training Centre in Additive Biomanufacturing that will help position Australia as a world leader in bioprinting for medical applications.

The research is structured around three synergistic and innovative programs – Technology, Materials and Clinical Translation. Industry partners include Osteopore, Anatomics and Cochlear. Surgeons from St Vincents Hospital Melbourne and the Peter MacCallum Cancer Centre drive the introduction of additive biomanufacturing into clinical applications.

## ENHANCED CAPABILITIES

Opportunities are being embraced at ACES, where research and outcomes since 2005 have steadily progressed materials science and next generation fabrication technology throughout Australia and the world.

Over the last three years ACES has been an integral component in the building of new facilities such as the Battery Technology Research and Innovation Hub (BatTRI-Hub) at Deakin and the Biofab3D@ACMD facility St Vincent's Hospital in Melbourne, with a view to attracting further end-user engagement. For example, through our ACES connection with Biofab3D@ACMD and AI Cathal O'Connell, ACES had the opportunity to test and evaluate the biopen in a simulated lunar base environment (the Lunares Simulated Space Base in Pila, Poland) in July.

Jaden Hastings, an artist in residence at BioFab3D, was invited by the European Space Agency to join the crew of a Moon Simulation Mission.

She spent two weeks exploring the use of the biopen for printing plant derived hydrogels for gestural (that is handheld) 3D printing for biomedical, food and artistic applications. The biopen could be successfully used in the field, and was deemed a potentially useful device for these applications - with the simplicity and lightweight nature of the design being especially beneficial towards meeting launch 'ruggadisation' requirements, and for practicality of set-up in orbit/off-world. Further work in low and/or microgravity are needed. These applications of the 'biopen in space uses' have attracted the attention of potential collaborators at the MIT Media Lab.

In 2018 ACES in partnership with UOW, MTPConnect and ANFF launched The Translational Reseach Initiative for Cell Engineering and Printing (TRICEP) in Wollongong. This is discussed in more depth later in this chapter.

## PARTNERSHIPS

#### ACES - AUSTRALIAN NATIONAL FABRICATION FACILITY (ANFF) PARTNERSHIP

ACES is funded to translate materials science knowledge into practical, game-changing devices that will have a significant impact in the areas of diagnostics, energy, health and soft robotics.

Rapid advances have been made possible through the integration of fundamental materials science research with cutting edge approaches to fabrication, including 3D printing. Our continued partnership with ANFF is critical to translating our research into real world devices.

The ANFF Materials Node is headquartered alongside ACES at the UOW Innovation campus and offers services to ACES researchers, external collaborators, publicly funded



researchers and end users. The Materials Node brings together specific strengths in the fabrication of emerging materials such as organic conducting polymers, graphene and new biomaterials. It provides expertise and facilities to scale processing methods to multi-gram to sub-kilogram scale to help bridge the laboratory to industry divide. The node also provides capabilities in the development customised formulations and associated hardware to produce 2D and 3D fabricated devices and structures via supported advanced printing and coating technologies as well as additive (bio)fabrication techniques.

#### ACES – BATTERY TECHNOLOGY RESEARCH AND INNOVATION HUB PARTNERSHIP

The BatTRI-Hub located in Melbourne, is a unique, world class research and innovation hub focused on advanced battery prototyping and the commercialisation of energy storage technologies. It has been operational since 2016.

The synergy of ACES research areas in key energy technologies and advanced polymer materials makes this an ideal partnership. The partnership with the BatTRI-Hub is critical for ACES as researchers have access to both facilities and expertise to assist in creating optimum design and enabling translation into real world devices.

For example, the BatTRI-Hub has enabled scale up of ACES electrochemical devices such as battery pouch cells and 'beyond lithium ion' battery technologies. The facilities and expertise within the hub have also allowed ACES researchers to customise batteries to fit into the prosthetic hand.

The team has established relationships with a range of domestic and international companies including LG Chem (largest manufacturer of batteries in the world), Toyota, HydroQuebec, Cytec, Ausnet, SEA Automotive and Avass to advance research into battery solutions for these industries.

## **BUILDING FACILITIES**

#### **BIOPRINTING FACILITY AT WOLLONGONG**

The worlds of medicine and biomaterials have collided with advances in 3D printing and bioprinting. The global 3D bioprinting market is forecast to reach US\$1.8 billion by 2027.

No Australian manufacturers produce bioinks or bioprinters – yet Australia leads the world in research and education in this area.

The field of tissue engineering has matured to the extent that new clinical treatments are possible. The development of stem cell technologies in parallel with advances in biomaterials has resulted in exciting new possibilities. The advent of 3D bioprinting, allowing cells, materials and other bioactives to be spatially distributed to ensure appropriate cellular development has had a further impact on the field. Current application areas include: cartilage regeneration, islet cell transplantation and corneal regeneration.

The enhanced interactions of medical and biomedical capabilities with the materials and advanced fabrication domains will be critical into the future. In order to achieve these goals a number of critical additive fabrication tools are required to enable the development of not only three dimensional structures such as bioscaffolds but also to use these tools to develop the next generation of biofabrication hardware for use in laboratories and clinical settings.

The Translational Reseach Initiative for Cell Engineering and Printing (TRICEP™) was launched November 2018. TRICEP works with research institutions and industry to develop innovative technologies using 3D Bioprinting. TRICEP is a 100% owned initiative of the University of Wollongong.

The state-of-the-art facility features a broad range of additive manufacturing technologies to process a range of commercially available polymer and metal materials, including carbon fibre nylon composites, titanium alloys, nickel and stainless steel.

TRICEP hardware inventory includes:

- the highest resolution metal additive fabrication system in Australia
- fused deposition modelling systems with capability in polymer and composites
- multiple inkjet technology systems allowing full colour 3D printing and biocompatible materials printing
- Australia's leading biofabrication/ biomaterials capability to develop



Translational Research Initiative for Cellular Engineering and Printing

"The establishment of TRICEP strengthens the Illawarra region's identity as a place of innovation and technology, and signifies a boost for our local skills base, the economy, and our local and national industry".

Member for Kiama and Parliamentary Secretary of the Illawarra and South Coast, Gareth Ward

and synthesise novel biofabrication platforms (such as bioinks) with materials including hydrogels and melt polymers

This world leading research infrastructure means TRICEP can bring to life novel technology from concept stage through to prototyping and manufacture of hardware and the formulation of customised bioinks, giving customers the advantage of accelerated product development and rapidly decreased time to market.

In 2019, TRICEP will have on board an end-user Entrepreneur in Residence, Dr Tillmann Boehme, to develop and implement strategies to promote and facilitate end-user engagement in TRICEP with a particular focus on local SME engagement and to apply for grant projects and grant applications.

Andrew Batty, from Lincoln Consulting, has been tasked to oversee implementation of the total quality management system for TRICEP in 2019.

## TRANSLATIONAL ACTIVITIES

ACES has taken steps towards translation of ACES fundamental research.

## CUSTOM 3D PRINTING SOLUTIONS INTO CLINICAL ENVIRONMENTS

Clinical connections have advanced in 2018 with funding secured to develop the fundamental research activities undertaken in ACES.

A grant to UOW from the Medical Technologies and Pharmaceuticals Industry Growth Centre (MTPConnect) with matching funds (\$800,000), additional funding for equipment in 2019 through ANFF-Materials node, an ARC Linkage Infrastructure, Equipment and Facilities (LIEF) grant alongside a substantial investment by UOW enabled the establishment of TRICEP.

The MTPConnect funding is being used specifically to engage with SME's to develop projects such as 'bioinks' from seaweed extracts, customised delivery systems - the 'iFixPen'- to treat conditions of the eye and the 'biopen' for cartilage regeneration.

#### BIOPEN BECOMES AXCELDA PEN

In late 2016 a patent "Apparatus and method for handheld free-form Biofabrication" (PCT/AU2016/050886) was lodged. ACES AI Prof Peter Choong, Director of Orthopaedics at St Vincent's Hospital Melbourne, developed the concept with the ACES team with support of the ANFF materials node. The idea behind the biopen was to give surgeons greater control over where materials are deposited. The approach involved designing a delivery system to enable delivery of live cells and growth factors directly to the site of injury, thus allowing accelerated regeneration of functional bone and cartilage, in this example.

By 2017 this was further refined through a landmark proof-of-concept study, where ACES researchers used a handheld 3D printing pen to 'draw' human stem cells in freeform patterns with extremely high cell survival rates, in excess of 97% (supported by Arthritis Australia; St Vincent's Research Endowment Fund).

Three exemplar projects, supported by MTP in 2018-19, will showcase the potential biofabrication has to offer a swathe of new clinical strategies.

In Australia, joint injuries are common, crippling and costly. Around 80 percent of Australians over 65 years old live with osteoarthritis, a debilitating condition which occurs when there is damage to joint cartilage. and deterioration of ligaments and tendons, causing painful inflammation of the tissue around the joint. Currently there is no cure for osteoarthritis. In addition to the individual's pain and reduced mobility, osteoarthritis costs our Australian economy over \$2 billion per year (Arthritis Australia).

While joint replacement—a major surgical procedure—remains a viable option for some patients, limited preventative treatments are available. To date, no clinical strategies are capable of consistently reproducing normal hyaline cartilage, which has the cellular and mechanical characteristics to sustain the everyday demands of shear and compression.

Engineering the biopen further, the focus of this particular MTP funded project, involves optimising the design for development of an ergonomic handheld device capable of being sterilised and of depositing living cells at high viability with minimal cell loss.

In parallel, a commercial engagement plan is under development as part of the same MTPConnect funding.

#### SEAWEED BASED BIOINKS - 'PHYCOINKS'

In 2015, ACES forged a partnership with seaweed biomass producer Venus Shell Systems (VSS). VSS's expertise lies in the production of seaweed biomass and extracts for use in biomaterials, cosmetics, dermatological care, food, nutraceuticals and pharmaceuticals.

In 2016, ACES and VSS extended these interactions through a collaborative research project, a PhD student project, to fast-track the development of seaweed wound healing materials.

In partnership with VSS and combining the high-tech processing and fabrication techniques at ACES-ANFF materials node, the project idea expanded to use the biomass for medical treatments, with artificial skin a potential end product to treat burns. In collaboration with Prof Chris Baker, St Vincents Hospital, and a Bauer grant to engage a PhD student, ACES are working towards developing 3D printed scaffolds and inks for wound healing.

In 2018 courtesy of the MTPConnect funding a new range of bioinks are to be produced, based on biomolecules extracted from seaweed. The production of this range of bioinks will showcase transforming local (Illawarra) manufacturing in seaweed biomass producer (Venus Shell Systems) through molecular extraction, into formulations and ultimately into high tech products.

This venture project gives ACES the opportunity to reinvigorate an industry, through science.

TRICEP can commercialise opportunities in 3D bioprinting including printer manufacturing, biomaterials, bioinks, and materialcellular combinations to address significant industry challenges that require an exclusive, tailored solution. For example, the University of Melbourne via another MTPConnect grant, have partnered now with TRICEP to develop specific bioink formulations for use with the biopen - for in-situ bioprinting treatment for cartilage injuries. Specifically TRICEP has been engaged to upscale synthesis of crosslinkable methacrylated gelatin (GelMA) with

the required rheological properties for printing and capable of sustaining living cells during the printing process.

#### **IFIX SYSTEM**

\$1.15million in funding from the NSW Government Medical Devices Fund (MDF) was received to further develop the iFix system – a system set to make a significant impact on reducing corneal blindness in Australia and around the world.

The MDF is a competitive technology, development and commercialisation program that encourages the development of and investment in new medical devices that will improve our health and wellbeing.

The support provided by the MDF will facilitate the translation of the iFix system into a commercial product. ACES have partnered with the NSW Lions Eye Bank led by Prof Gerard Sutton and the University of Sydney's Corneal Bioengineering Group to bring together the variety of skills needed to tackle this challenging area practically and successfully.

Corneal ulceration is extremely painful and accounts for 55,000 presentations to hospital each year across Australia. Corneal trauma and ulceration accounts for 1.5 to 2 cases of corneal blindness worldwide each vear (Bulletin of the World Health Organization, 2001, 79: 214–221). This is particularly problematic in developing countries such as Myanmar, Bangladesh and Cambodia where corneal trauma and acquired corneal disease accounts for between 55 to 75% of cases. These primary care injuries often go untreated and lead to infection and corneal scarring (Clin Ophthalmol. 2009; 3: 413–421; Br J Ophthalmol. 1997 Aug;81(8):622-3).

The iFix system is a medical treatment technology that incorporates 3D printing to repair corneal ulcerations. It comprises two components: a regenerative ink iFixInk<sup>™</sup> and its delivery device a handheld 3D printing device, the iFixPen<sup>®</sup>.

The iFixPen, developed by ACES researchers within the MTPConnect project, delivers a specialised bioink formulation to the eye defect with high accuracy in a smooth and effective manner. The delivery process takes less than 2 minutes.

Now the research is poised to transform the treatment of corneal diseases and



injuries. The iFixInk development, filling and manufacture, can be progressed courtesy of the MDF. The ink seals the wound and prevents pathogen infiltration. It relieves pain, accelerates healing and is biodegradable. The ink formulation can be tailored to clinical need and can contain antibiotics and or other active regenerative agents.

#### 3D PICT (PRINTER FOR ISLET CELL TRANSPLANTATION)

Researchers from ACES, at the University of Wollongong, in conjunction with Royal Adelaide Hospital (RAH) have demonstrated a breakthrough in 3D bioprinting insulin-producing islet cells to overcome some of the critical limitations in current cell transplantation (Advanced Health Materials, https://onlinelibrary. wiley.com/doi/full/10.1002/ adhm.201801181). Central to this work are the cutting-edge biomedical printing device, 3D PICT, and customised bioink formulation both designed and built by ACES researchers to support the study. The customised 3D bioprinter and bioink has allowed the team at RAH, under the guidance of Prof Toby Coates, to fabricate with precise control 3D islet-containing structures with a unique shell layer. This 'Trojan horse' style printing process allows the islets to be delivered into the body in a way that protects and maintains the viability of the cells.

RAH Director of Kidney and Islet Transplantation, Prof Toby Coates, said this breakthrough research could revolutionise treatment for people living with Type 1 Diabetes.

"The novel bioprinting process offered with the 3D PICT and designer bioink formulation allows us to use the patient's own cells to create the 3D printed islet structure, meaning we are minimising the distance between each islet to ensure better circulation of nutrients and oxygen, and ultimately reducing the likelihood of rejection in the person's body."

"The next step is to conduct in-depth animal trials, as well as further optimise the bioink formulation to ensure the islets are preserved after encapsulation and transplantation."

#### **THE SUTRODE**

The scene is set to revolutionise the field of electroceuticals.

With graphene as the material building block, ACES researchers have used the traditional method of fibre spinning to produce fibres of unprecedented performance. The fibres have the mechanical property of a suture in addition to amazing electrical properties.

In collaboration with researchers at the University of Texas Dallas, these fibre

#### TABLE 2: ACES PATENT FILINGS 2014-2018

Patent Description		Lead for Submission	Year filed	
1.	Thermo-Electrochemical Cell and Method of Use	PCT/AU2015/901513	Deakin & Monash Universities	2015
2.	Functionalised Photo-Electrocatalyst and Method for Chemical Conversion	PCT/AU2015/000248	Monash University	2015
3.	Chemical Gradients	PCT/US/14/768,820	University of Texas Dallas	Aug 2015
4.	Nanostructured electrode for CO <sub>2</sub>	2016/903555	Monash University	2016
5.	High-efficiency electrochemical conversion of nitrogen into ammonia	2016/900354	Monash University	2016
6.	High-efficiency electrochemical conversion of nitrogen into ammonia	2016/900613	Monash University	2016
7.	Sodium-ion Electrolyte Composition	PCT/AU2016/051172	Monash University	2016
8.	Appartus and method for handheld free-form Biofabrication	PCT/AU2016/050886	St Vincents Hospital Melb	Sept 2016
9.	Method and Cell for Conversion of Dinitrogen into Ammonia	PCT/AU2017/000036	Monash University	3 Feb 2017
9.	Method and Cell for Conversion of Dinitrogen into Ammonia	AU2018900370	Monash University	7 Feb 2018
10.	Method and Cell for Conversion of Dinitrogen into Ammonia	AU2017902960	Monash University	27 Jul 2018
11.	Method and Cell for Conversion of Dinitrogen into Ammonia	PCT/AU2018/000122	Monash University	26 Jul 2018
12.	Drug Delivery Device	AU Prov Patent No. 2018903570	University of Wollongong	23 Sept 2018
13.	Edge Functionalised Graphene	AU Prov Patent No. 2018903793	University of Wollongong	8 Oct 2018

structures have enabled recording of electrical impulses from nerves with extraordinary sensitivity in addition to enabling electrical stimulation of nerves with a high degree of spatial resolution. Sutrodes will be produced at TRICEP for use in applications such as electrical stimulation to treat diseases such as diabetes.

### OTHER COLLABORATIONS IN HEALTH AREA

Material scientists and engineers from ACES are also collaborating on new multidisciplinary projects with neuroscientists and cell biologists via the Illawarra Health and Medical Research Institute (IHMRI) to deliver next generation medical devices and therapies. New additive fabrication techniques for customised prostheses are being explored, with a multidisciplinary team recently developing the 'Lymph Sleeve' for controlling lymphoedema in breast cancer patients. This team draws research expertise from UOW's **Biomechanics Research Laboratory** and ACES, along with medical oncology expertise from the Local Health District. IHMRI and ACES have jointly funded three PhD scholarships (2017-2019) to work on the use of novel electromaterials in reversing cellular phenomenon associated with schizophrenia (with ACES AI Prof X-F Huang); developing controlled delivery strategies for oncology, and new materials for wound healing.

## CTECHBA OPPORTUNITY REPORT

A feature of our Centre of Excellence proposal was our commitment to

identify new commercial opportunities. ACES completed a two stage technology audit with CtechBA in 2016.

In stage one all planned research under the 2014-2017 program was examined from which a number of commercially significant projects (opportunities) were identified and recommendations put forward on how ACES can more effectively facilitate technology transfer through those opportunities. CtechBA absorbed lessons from the experiences of executives of spinout companies that are currently commercialising the IP that was developed under the 2005-2013 ACES program.

The initial project list identified 19 commercial opportunities by loosely grouping activities undertaken by each ACES supported research project. Of the 19 opportunities, 16 were considered applied R&D. After further internal deliberations three areas were identified as areas presenting the most immediate commercial engagement opportunities for ACES.

To date 13 patents have been filed, arising from research activities within the Centre, see Table 2.

Progress on opportunities identified in the report and since the report was completed and that have not been discussed earlier in this chapter are as follows:

Thermocells: Two patents were filed in 2015 'Thermo-Electrochemical Cell and Method of Use (PCT/ AU2015/901513) and Functionalised Photo-Electrocatalyst and Method for Chemical Conversion (PCT/ AU2015/000248)'.

In 2018 ACES CI A/Prof Jenny Pringle and ACES MPhil Electromaterials masters student Matthew Russo won a booth at the iMatSci innovation showcase as part of the Materials Research Society meeting in Boston (27-28 November). The iMatSci Innovation Showcase is designed for exhibitors to display technologies that have not yet been 'productised' but where there is a working prototype or evidence of a repeatable process.

In collaboration with ANFFmaterials node and TRICEP, ACES designed and printed a functioning protoype thermocell filled with ACES electrolyte to demonstrate our thermocell technology to potential investors. ACES also produced a video demonstrating the materials used and device assembly (see ACES youtube channel; https://www.youtube.com/ watch?v=HuiWfjojPTk).

**Tough Hydrogels** for a wide variety of applications ranging from 3D scaffolds to condoms. Activity in 2018 has included fundamental studies on the nature of toughening in solvent processable hydrogels that has supported the continued development of medical device prototypes with financial contributions from the Gates Foundation and Cook Medical.

**Carbon Dioxide reduction**: Discussions with True North Venture Partners (TNVP) revealed that CO<sub>2</sub> reduction to useful products (e.g. ethanol) would provide commercial opportunity. A provisional patent (2016903555) "Nanostructured electrode for CO<sub>2</sub> reduction" was lodged. Ongoing discussions have continued throughout 2018.

**Nitrogen reduction**: Commercial opportunity in the reduction of  $N_2$  to  $NH_3$ 

saw a suite of patents lodged by ACES Monash University "Method and Cell for Conversion of Dinitrogen into Ammonia".

In 2018, ACES through Monash University has formed an Ammonia Project Advisory Group involving Siemens, Yarra International, Renewable Hydrogen P/L and ETR Solar to provide input to the commercialisation process for ACES ammonia intellectual property.

With the support of ETR Solar the ACES Monash and Wollongong teams were successful in a \$2.5 million ARENA project bid to further develop the ammonia technology. The provisional patents lodged in 2017 have proceeded to PCT filings.

The Monash group hosts the Ammonia Energy Association - Australian Chapter. Online meetings were held 30 August and 6 December.

**Soft Robotics**: Moving forward there are clear avenues for further development of the soft robotic hand. We have developed a range of wirelessly controlled prosthetic hands with specific gestures. We plan to incorporate the wireless control and noninvasive sensory feedback features into these hands and test them with real users in 2019.

During 2018 the ACES soft robotics team has been working with endusers from Southern Prosthetics and Orthotics located in Unanderra, Port Kembla Amputation Clinic and Prince of Wales Hospital, Department of Rehabilitation Medicine to inform clinic practioners about the ACES prosthetic hand research, and explore the possibility of accessing their clients to receive feedback on the hand. ACES are now in the process of finalising ethics approval to test the ACES prosthetic hand with clients, and get client involvement in the ACES project on 'noninvasive sensory feedback techniques for prosthetic hand users'.

After initial collaboration visits in 2018 between ACES soft robotic team and CSIRO Data64 team, three jointly supervised PhD topics have been identified in order to progress the research in 2019.

A commercial engagement plan is to be completed in 2019. After completing that plan and successfully testing the hands, ACES will need further funding to take the project to the next level for commercialisation.

## FUNDING AWARDED TO PROGRESS TRANSLATION

ACES researchers welcomed a range of funding, outside of ARC grants in 2018, leveraged from the fundamental research undertaken in ACES, to assist in expanding research activities for specified applications- see listings in Table 3.

## BUILDING END-USER NETWORKS

## **RESEARCH IN ACTION**

ACES members worked with end-users to identify opportunities for translation of our research activities. Some of those activities are included below.

#### **ALLEGRA ORTHOPEDICS**

In 2018 ACES-ANFF materials node partnership continued working towards the production of bone scaffold structures for Allegra through an Innovations Connection Grant.

#### APPLIED NANO TECHNOLOGIES

Applied Nano Technologies is an Australian start-up that firmly believes in collaboration and utilisation of fundamental research to drive products and services. Applied Nano Technologies Pty Ltd actively interacts with ACES which allows ANT to interact with the ACES network. ACES has helped ANT build relationships in Japan, USA, Canada and the UK through their international links and events that have attracted leading researchers from these countries or held co-hosted events both in Australia and internationally. The ACES team at Monash has established during 2018 a CRC project to develop high pressure hydrogen generating devices for static solar energy storage.

#### AQUAHYDREX PTY LTD

Through building on fundamental discoveries on nanostructured catalysts, coupled with our ability to create translational devices, AquaHydrex was born. A reactor platform for low cost, high efficiency water electrolysis technology was spun-off as the new technology company, AquaHydrex Pty Ltd., that received substantial funding from True North Venture Partners (Chicago, USA), the Clean Technology Fund, ARENA and Australian Commonwealth and State bodies (NSW) (> \$25 million since 2012). The technology has recently been developed into a class of highly efficient fuel cells.

The ACES team has proven the science behind the new process, and efforts to scale up and prototype devices for use across a range of applications are in progress. The establishment of AquaHydrex created new positions and opportunities for 10 PhD graduates of UOW and ACES training programs, with over 20 jobs created in Wollongong by the end of 2016. The emergence of these new opportunities in engineering and manufacturing was particularly significant, since it coincided with decline in the Illawarra's steel manufacturing capabilities. The AquaHydrex venture was facilitated not only through ACES partnerships but was also strongly supported by the ANFF Materials Node, funded under the Commonwealth Government's National Collaborative Research Infrastructure Strategy (NCRIS).

In 2018, Aquahydrex relocated to Louisville, Colarado, USA. The AquaHydrex vision is to enable a cleaner, carbon-neutral world by accelerating the adoption of renewable energy. To support this vision, they are developing disruptive products and services that convert excess renewable energy into hydrogen, using alkaline water electrolysis, and thereby help decarbonise and reinvent energy, industrial, heating and transportation sectors of our global economy.

ACES is excited to be a world-class commercial research partner with AquaHydrex, and believe that the quality of the ACES facilities, equipment and people help to accelerate end-user research and ideas.

New research courtesy of an ARENA grant 'Bio Inspired Hydrogen Generation by novel Bubble Free Electro-Catalytic Systems' (\$2 million project), involving ACES and ANU researchers begins in 2019. Electrolysis uses electrical energy to convert water into the clean fuel, hydrogen, with pure oxygen as a bi-product. This project, using inspiration from nature, will develop a new electrolysis technology, more simple and efficient than any known to operate from pure water and renewably generated electricity. They will be using graphene materials developed within ACES, 'bubble free'

electrode systems for hydrogen generation optimised and utilised in Aquahydrex as well as ACES capabilities, researcher knowledge and the facilities for the larger scale electrode assembly/testing.

#### BILL & MELINDA GATES FOUNDATION

ACES' ultra tough hydrogel materials continue to be developed for use as a condom in a Bill & Melinda Gates Foundation grant project. The hydrogel condom that the 'Geldom' team have spent the past five years creating aims to mimic the feel of skin. The result is a soft, squishy condom that is nonallergenic, for those who are allergic to latex, and blocks viral molecules, bacteria, and sperm. In 2018 the project was granted \$1 million from the NSW Government's Medical Devices Fund.

#### CEREBRAL THERAPEUTICS

ACES CI collaborates with cerebral therapeutics a clinical stage pharmaceutical company treating patients with refractory CNS Diseases by utilising reformulated off-patent drugs delivered to the ventricles of the brain (targeted Central Nervous System Drug Delivery) in order to bypass the Blood Brain Barrier.

#### **COOK MEDICAL**

ACES are undertaking a feasibility study for coatings on stents.

#### **DST GROUP**

ACES researchers at Monash, UOW and Deakin have undertaken several projects on energy storage and electrochemical sensing technologies.

ACES UOW researchers are also working with DSTG in developing a new type of soft body armour with multiple functions – on one project researchers are working towards creating a flexible and durable solid electrolyte for energy storage devices. The collaborators have also discovered that creating body armour from magnetorheological (MR) fluids with an embedded battery both improves the protection level and flexibility function of the smart material.

#### **ENWARE**

ACES members are involved in contract research activities for the development of material technologies and properties related to tapware and plumbing systems.

#### **GELNOMICS**

A new startup company aimed at supplying high quality bioinks for the use in bioassays. ACES is working with Gelnomics with a view towards bioink supply.

#### **INVENTIA LIFE SCIENCE**

A startup company (https://inventia. life/) built on a foundation of deep science established through industryuniversity partnerships and driven by the needs of biomedical researchers and tissue engineers. ACES is working with Inventia Life Science, based in Sydney, on the supply of bioinks aimed at developing drug testing assays for the pharma industry. The Co-Founder & COO, Dr Cameron Ferris is an alumnus of ACES at UOW.

#### IMAGINE INTELLIGENT MATERIALS

ACES CIs continue to work closely with IMAGINE IM. Based on patented ACES graphene processing technology, the start-up IMAGINE IM was born. In 2015-16, ACES provided interactions with IMAGINE ranging from know-how process information transfer through to materials supply and materials coating via research collaboration and a materials transfer agreement. In a commercial deal in 2018, the University of Wollongong assigned patents to Imagine Intelligent Material Pty Ltd.

#### **MEDTRONIC**

ACES CI Cook has a project in collaboration with Medtronic (MN, USA), where they are conducting a first-inman feasibility study of a novel deep brain stimulator for the treatment of epilepsy seizures.

#### **ONESTEEL**

ACES members work on the development of improved coatings. In 2018 this project has been ongoing and expanded to include new test methods and metallographic studies. The research team, led by ACES CI Howlett recently submitted with partner Liberty Steel (Onesteel) as part of the ARC Research Hub for Australian Steel Innovation.

#### RESERVE BANK OF AUSTRALIA

ACES members collaborate on electromaterial research.

#### TABLE 3: FUNDING LEVERAGED FROM ACES RESEARCH ACTIVITIES

Funding leveraged from ACES research activities	Team and project Description
National Health and Medical Research Council (NHMRC) Grant (1148005: \$883,464, 2018-2021)	ACES CI Cook and team for 'Control of Prosthetic Limbs from Decoded Brain Signal'.
Australian Renewable Energy Agency (ARENA) Project (\$915,848, 2018-2021)	ACES CI MacFarlane, AI Sweigers, ACES SRF Simonov and team for project 'Ammonia Production from Renewables at Ambient Temperature and Pressue. Developing a Process for Reduction of Nitrogen to Ammonia'
Australian Renewable Energy Agency (ARENA) Project (\$615,682, 2018-2021)	ACES CI Pawel Wagner, AI Sweigers and team from ANU 'Bio- inspired hydrogen generation by novel bubble free electro- catalytic systems'.
CRC Project Grant	The ACES team at Monash University has established during 2018 a CRC Project to develop high pressure hydrogen generating devices for static solar energy storage.
NSW Medical Devices Fund (\$1.15million, 2018-19)	A collaboration between ACES, through Prof Gordon Wallace and the Lions NSW Eye Bank and Sydney University's Corneal Bioengineering Group, through Prof Gerard Sutton, for 'Development of the iFix System to treat corneal diseases and injuries'.
MedTech Pharma Growth Centre - Biomedical Horizons Project grant (\$958k, 2018-2020)	ACES AI Choong, CI Wallace and CI Moulton for the project 'Biopen: Advanced Limb Reconstruction Program'.
MedTech Pharma Growth Centre - Biomedical Horizons Project grant (\$400k, 2018-19)	ACES CI Wallace, AI Choong, AI Sutton, AI Winberg for the project 'The Bioprint Facility for Translational Science and Medicine in the MTP Sector'.
2018 Victorian Medical Research Acceleration fund (\$118k, 2018-2020)	ACES CI Moulton team in collaboration with Prof Gilda Tachedjian at the Burnet Institute for 'Development of hydrogel based intravaginal drug delivery device'.
2018 Australian Centre for HIV and Hepatitis Virology Research (\$88k, 2018-2020)	ACES CI Moulton and Geldom team for 'Tough hydrogel materials for drug delivery vehicles for prevention and treatment for HIV and other sexually transmitted diseases'.
2018 Cancer Australia, Priority-driven Collaborative Cancer Research Scheme (\$554,920, 2019-2021)	ACES CI Moulton, IHMRI-UOW researchers and Wollongong clinician for 'Implantable drug-eluting device: localised drug delivery for non-resectable pancreatic cancer'.
Arthritis Australia (\$20k, 2018)	ACES AI Choong and CI Wallace '3D Bioprinting of bio-adhesive scaffold for cartilage regeneration'.
Reserve Bank of Australia (\$50k, 2018)	ACES CI Wallace
Honda Research Institute of Japan (\$6k, 2018)	ACES CI Spinks
Contract research with Enware (\$25k, 2018) AIIM Industry Partnership Grant (\$50k, 2018) Contract research with Enware (\$58k, 2018)	ACES AI Paul Molino and CI Higgins 'for the development of antibacterial thermoplastic materials for water tap inserts' and 'development of a turbidity sensor and flow system for detecting bacteria/biofilms in water plumbing systems'.
Contract research with Greening Investments, including Tech Voucher through Advantage SME (\$30,000, 2018)	ACES CI Geoffrey Spinks
Contract research Toyota (\$85,400, 2018)	ACES Deakin University researchers for 'Research of all-solid- state batteries using plastic crystals as solid electrolytes'.
St Vincent's Hospital Research Endowment (REF) Grant (\$20k, 2018 for 2019)	ACES RF Quigley with associate researchers ACES AI Ngan, AI Choong and CI Kapsa for '3D printing human iPSC derived skeletal muscle and implantation of constructs for innervation and vascularisation'.
St Vincent's Hospital Research Endowment (REF) Grant (\$20k, 2018 for 2019)	ACES PhD Lilith Caballero Aguilar for 'Fabrication of a chondrogenic hydrogel for in situ 3D bioprinting'.

Funding leveraged from ACES research activities	Team and project Description
ANSTO-UOW Joint Project Seed Funding Award (\$18k, 2018)	ACES CI Crook for 'Testing in vivo biocompatibility and osteoinductivity of a 3D graphene scaffold for bone regeneration'.
Technologies R&D International Collaboration Program of Shaanxi Province grant (AUD30k)	ACES SRF Caiyun Wang for 'Development of environmentally benign high performance polyaniline anticorrosion coating'.
Australia-Germany Joint Research Co-operation Scheme Funding (\$8,272)	ACES CI Officer and ACES SRF Kaludia Wagner for 'Photoactive droplet swimmers - concepts for chemical driving and quantification'.
UOW Global Challenges Project (\$15k, 2018)	ACES CI Higgins for 'Protective Wear Resistant and Antibacterial Coating for Teeth'.
AIIM for Gold Grants Scheme (\$10k, 2018)	ACES SRF Pawel Wagner for 'Plantronic: in-situ electropolymerisation of monomers for wiring of brown algae'.
AIIM for Gold Grants Scheme (\$14,980, 2018 for 2019)	ACES SRF Caiyun Wang for 'Copper-based catalysts for selective electroreduction of carbon dioxide to multi-carbon products'.
AIIM for Gold Grants Scheme (\$14k, 2018 for 2019)	ACES AIs and ANFF members Chung and Sayyar for 'Fabrication of hig-resolution, flexible graphene/ polycaprolactone scaffolds using melt-electro writing technique'.
AIIM for Gold Grants Scheme (\$12,516, 2018 for 2019)	ACES AI - ANFF Fay for 'Practical in situ ammonia sensors facilitating fundamental and proof-of-concept research into nitrogen reduction reactions'.
UOW Major Equipment Grant (MEG) grant (\$250k, 2018)	ACES CI Chen to purchase a new TGA/DSC/DMA system for UOW.
UOW equipment replacement fund (\$512k, 2018)	ACES CI Innis to replace the RAMAN spectrophotometer.

#### ROMAR

ACES and the ANFF materials node work on 3D printing of biocompatible flexible materials and looking at opportunities for manufacturing hardware for bioprinting e.g. combining robotics and 3D printing.

#### **SMR AUTOMOTIVE**

SMR are moving from automotive component manufacture into the biomedical area through manufacturing 3D bioprinting devices.

#### TOYOTA MOTOR ENGINEERING AND MANUFACTURING

ACES through Monash University has been collaborating with the Toyota Research Institute of North America (TRINA) to make batteries better by eliminating flammability and increasing stability. Basically, the industry focused project, subsequent to our fundamental ACES work on ionic liquids for metal batteries, will be developing non-volatile, non-flammable and electrochemically stable electrolytes, based on liquid salts, that could be applied to batteries. ACES Deakin hosted intern Naoto Sato from Toyota in Japan for 12 months (2018) to undertake research on new solid-state composites for high energy batteries.

#### TRAJAN SCIENTIFIC AUSTRALIA PTY LTD

ACES members are involved in developing microfluidic devices for use within portable separation and detection technologies.

## END USER BRIEFINGS

ACES disseminates knowledge to existing industry partners through information sessions, workshops and web-portal sessions. ACES works hard to raise the Centre's visibility outside the academic sector. The aim is to: (a) showcase ACES research skills, technologies and facilities as well as to (b) understand how ACES can better facilitate pathways and connections to maximise their research impact. To this end over 58 business briefings took place via visits or teleconferences to ACES (appendix 3); 24 interactions with government or non-government organisations (appendix 4) and a further 45 briefings by ACES members visiting personnel within the government, industry or part of the business community (appendix 5).

#### 'A VOICE' AMONGST INDUSTRY PROFESSIONALS

During 2018 ACES has been given a voice on panels and at symposiums discussing new technologies on the horizon and how they may impact future directions. Through this avenue ACES has been given the opportunity to share our extensive knowledge and engage in networking that is vital to further translational activities.

ACES also hosted or showcased 21 events (appendix 6) in the 'bio-space'; 'energy space' and 'materials/facilities space', to raise awareness of the facilities and research activities amongst end-users.

## **SOCIAL IMPACT**

Indicators of the social impact of ACES can be measured through public outreach programs, contribution to policy development and influence on the national research strategy. Our ACES ethics, public policy and engagement team as well as ACES researchers throughout 2018 engaged and interacted with various stakeholders with this in mind. Research activities involving engagement have been reported under the research chapter. Further to those activities, we can report that:

#### **IN THE BIO SPACE**

ACES CI at Monash University, Prof Rob Sparrow works on ethical issues raised by new technologies. He has published on topics as diverse as the ethics of robotics, the moral status of Als, human enhancement, stem cells, preimplantation genetic diagnosis, xenotransplantation, and migration. He is a co-chair of the IEEE Technical Committee on Robot Ethics and was one of the founding members of the International Committee for Robot Arms Control.

CI Susan Dodds, from UNSW ACES node, is a member (2018-2019) of the Advisory Group for the Australian Academy of the Humanities' Future Humanities Workforce project, funded through the Australian Research Council Learned Academies Special Projects (LASP) scheme in 2017.

ACES Director Gordon Wallace and ACES AI Payal Mukherjee published a dicusssion paper in the ANZ Journal of Surgery on the 'proposed new regulatory changes on 3D technology: a surgical perspective'. The journal is the leading surgical journal published in Australia, New Zealand and the South-East Asian region and is dedicated to the promotion of outstanding surgical practice and research of contemporary and international interest. The paper discusses the need for new regulatory change, what those changes may entail, risk categorisation and some proposed new definitions. This paper was generated from discussion of the TGA consulting paper at RACS NSW office held by RACS and ACI NSW, in collaboration with the TGA and specialist stakeholders in June 2018.

Gordon and Payal also presented on 'Printing and replacing a new body part' in the Leaders in Healthcare session of the Sydney Innovation and Research Symposium (June) with approximately 1000 people in attendance. The presentation can be watched on YouTube. (https://www.youtube.com/ watch?v=YiLSmyTf3cs&feature=youtu. be)

Further to this both Gordon and Payal visited collaborators within the Korean Society of 3D Printing in Medicine (November) where discussions took place on how Korea was tackling the regulatory issues surrounding 3D bioprinting. Gordon was also an invited speaker at the 9th Korea Healthcare Congress 2018 (April). Topics discussed included: 3D Printing in Healthcare; 3D Bioprinting – should it be in every hospital?; Health insurance review; Medical Innovation with 3D Printing; and 3D Printing Technique as the 4th Industrial Revolution.

Director Wallace along with the Director Medical Device branch of TGA, Tracey Duffy, and Director of Conformity Assessment in the Medical Device Branch of TGA, Dr Elizabeth McGrath, were invited guests of Ramsay Health Care for a special meeting specifically discussing 3D Printing in Ramsay Health Care, Sydney (13 March).

ACES members and affiliates, including students and fabrication technicians, have been working within the Corneal Bioengineering working group of Save the Sight Institute, a research and teaching centre of the University of Sydney who are focused on patient care and improved outcomes. Several meetings and visits occurred throughout the year.

#### **IN THE ENERGY SPACE**

Members from our Ethics, Policy and Public Engagement theme were very active in this space throughout 2018. Joining working groups and engaging with a variety of stakeholders ensures ACES has effective engagement; so critical to ensuring that the knowledge and technological breakthroughs provide better social outcomes for communities.

For example, Dr Natalie Ralph, ACES Research Fellow Deakin University, was invited to present at Arena Magazine and Project Space, Melbourne, on 1 May on 'Exporting Renewable Energy?', an area of research carried out in collaboration with ACES CIs Hancock and MacFarlane. For more than 4 decades Arena has through its publications been engaged in a process of political and cultural interpretation. To be critically engaged necessarily today means to be concerned with not only politics but with science, the environment, indigenous communities, militarisation, the circulation of money and peoples, the centrality of images, information, and so on. The arena project space is a dynamic place where different aspects of discussion, thought, art and community can all connect. (Ralph, N., Hancock, L. Exporting Renewable Energy? ARENA Magazine, No.153, 1 May 2018, pp.33-36).

CI Hancock and Ralph co-authored the online article 'Ensuring Renewable Energy Doesn't Fuel Conflict' published in Australian Outlook, a publication of the Australian Institute for International Affairs (www.internationalaffairs. org.au/australianoutlook/potentialrenewable-energy-fuel-conflict/).

Then along with CI MacFarlane they published an article 'In the Lab: New Ethical and Supply Chain Protocols for Battery and Solar Alternative Energy Laboratory Research Policy and Practice' (Journal of Cleaner Production 187, June, 485-495). An online video, produced by Science and Society Network (SSN) at Deakin University and Deakin Invenio, was based on this last article and is hosted on the ACES website.

RF Ralph in 2018 also was:

- an invited member on the Steering Committee of the United Nations Global Compact/PRME (Principles for Responsible Management Education) Working Group on Business for Peace (September).
- a member of the United Nations Global Compact/PRME (Principles for Responsible Management Education) Working Group on Business for Peace, and then participated in the (online) conference meeting with a presentation by IFC (International Finance Corporation) representatives as well as US based academics/ industry representatives (March).
- presented a paper 'Renewable Energy Companies, Technologies and 'Business for Peace'' at the United Nations Global Compact/PRME Business for Peace Working Group and Network (23 August).
- joined as a member the ELSIET Network (Ethical, Legal and Social Implications of Emerging Technologies), organised under Science and Society Network, Deakin University, to explore opportunities in this area (15 November).
- participated in the event 'Repower Australia: Road to a Clean Energy



Future', organised by Australian Conservation Centre, Environment Victoria, Clean Energy Finance Corporation, Repower, held in Melbourne (22 February).

- met with Rob Rouwette, organiser of the Melbourne Energy Network, to discuss Renewable Energy technologies, and social Lifecycle Assessment methodologies (27 February).
- invited participant and recipient of a travel award to the US Stanley Foundation's roundtable discussion, "The Business Case for Building Resilience and Pursuing Peace", at the Stanley Foundation's 59th Strategy for Peace Conference Warrenton, US (17-19 October).
- a member of the Research Committee on Politics and Business, International Political Science Association.
- a member of the Environmental Politics and Policy Research Group, Australian Political Studies Association.
- a member of International Political Science Association (IPSA) to whom she presented the papers 'What is the Impact of Renewable Energy-related Businesses in Fragile and Conflictaffected States?' and 'How Can Business Help Prevent and Counter Violent Extremism?' at the IPSA Congress in Brisbane.

 participant in the Melbourne Energy Institute Energy Hack weekend (October).

CI Hancock in 2018 was:

- a board member of Hepburn Wind Farm; member of Hepburn Wind Finance and Risk Committee and on the Hepburn Wind Future Generation Working Group.
- participant in the webinar by the Energy Security Board – a public forum discussing the draft 'Detailed Design of the National Energy Guarantee' (2 July); the Energy Council webinar 'Future of the National Energy Guarantee' (17 July) and the Melbourne Energy Network's event 'The Democratisation of Energy' (20 July).
- participant at the AEMO Quarterly Energy Dynamics forum, Melbourne Energy Institute (2 September); University Industry Innovation Network – Perceptions of Capacity, Deakin Melbourne (31 August); Grattan Institute Forum 'Energy Policy – Where to from here?' University of Melbourne (13 September); Clean Energy Council: All-energy conference for policymakers (3-4 October); Australia Institute forum 'Targeting fossil fuels: The political and economic case' Melbourne University (24 October).
- Hancock and Ralph presented their invited paper 'Clean energy or Coal, jobs and displaced carbon emissions

at any cost? On assessing Australia's brown coal vs solar-produced liquid hydrogen exports to Japan' at the 7th International Workshop on Advances in Cleaner Production 'Cleaner Production for Achieving the Sustainable Development Goals' at the International Workshop in Colombia (21 June 2018.

ACES Deakin PhD candidate Matthew Cherian was appointed on a high level committee at CSR by the Government of India, October 2018.

Other papers written and presented for discussion at various events on research around renewable energy in 2018 included:

- Theorising Energy Security: How Will Australian Renewable Energy Exports to Indonesia Impact Energy Security and Technology Choices? (February)
- What is the Impact of Renewable Energy-related Businesses in Fragile and Conflict-affected States? (July)
- Renewable Energy Companies, Technologies and 'Business for Peace' (August)

ACES CI Patrick Howlett, from the ACES Deakin node, has engaged with the government on issues dealing with energy storage. In 2018, Pat attended Senate Select Committee on Electric Vehicles (31 August) and held discussions with Sustainability Victoria Melbourne.

# GLOBAL ENGAGEMENT



## ACES COLLABORATING ORGANISATIONS

- University of Wollongong (NSW)
- University of New South Wales (NSW)
- Australian National University (ACT)
- Deakin University (VIC)
- Monash University (VIC)
- University of Melbourne (VIC)
- Swinburne University of Technology (VIC)
- University of Tasmania (TAS)



#### ACES INTERNATIONAL PARTNER ORGANISATIONS

- Dublin City University (IRELAND)
- University of Warwick (ENGLAND)
- Friedrich Alexander University (GERMANY)
- Hanyang University (SOUTH KOREA)
- Yokohama University (JAPAN)



#### ACES STRATEGIC PARTNER ORGANISATIONS

- Korean Society of 3D Printing in Medicine (KS3DPM) (SOUTH KOREA)
- Institute of Electronics (BETRC) at the National Chiao-Tung University (NCTU) (TAIWAN)
- CIC Energigune (The Energy Cooperative Research Centre) (SPAIN)
- Istituto Ortopedico Rizzoli, Bologna (ITALY)
- The Institute of Materials Jean Rouxel: The French National Centre for Scientific Research (CNRS) and the University of Nantes (FRANCE)
- Nanotechnology and Integrated BioEngineering Centre (NIBEC), Ulster University (IRELAND)
- Sunchon University (SOUTH KOREA)

## ACES STRATEGIC PLAN GOAL 4: GLOBAL ENGAGEMENT

We are committed to connecting with the international research and enduser communities and strategically expanding our global sphere of influence by investing in partnerships, which add value to ACES.

## TOWARDS OUR GOALS

## STRATEGIC INTERNATIONAL PARTNERSHIPS

The Global Engagement Group determined that the most effective way to add significantly to the ACES international linkages program was to identify and pursue strategic alliances with appropriately aligned Centres overseas.

Two collaboration agreements with new strategic partners were negotiated in 2018, following on from the six signed in 2017.

#### KOREAN SOCIETY OF 3D PRINTING IN MEDICINE (KS3DPM)

ACES and KS3DPM signed a Memorandum of Understanding (MOU) at the Korea•Australia Bio-Medical Forum in 3D Printing held 7 November 2018 in Korea. The technical symposium featured talks from our partners and collaborators, covering 3D bioprinting and sensors.

Preceeding the technical symposium, on November 6, was the ACES-KS3DPM Innovation Showcase held at the Australian Embassy in Republic of Korea. The Australian Ambassador to the Republic of Korea, His Excellency Mr James Choi, hosted the event. Showcased were the significant collaborative relationships between ACES, KS3DPM and other members of the Korean clinical community interested in Bioprinting. Opportunities for future work were highlighted and a 3D printing demonstration by ACES and the Australian National Fabrication Facility (ANFF) followed presentations. ACES AI A/Prof Payal Mukherjee, ENT Surgeon at Royal Prince Alfred Hospital

in Sydney, was ACES's featured speaker along with Director Wallace.

#### INSTITUTE OF ELECTRONICS (BETRC) AT THE NATIONAL CHAIO-TUNG UNIVERSITY (NCTU) IN TAIWAN

ACES UOW hosted a delegation (five professors) from Institute of Electronics (BETRC) at the National Chaio-Tung University (NCTU) in Taiwan in March for a collaborative workshop and to formally sign the collaborative project agreement '3D retinal cell printing on retinal chips and multi-channel electrical stimulation and recording system'.

Two students, Mr Kun-Lin Tsou and Mr Yu-Wei Lin, were hosted by ACES UOW from 2-29 July 2018 to progress development of a microvalve printing system for retinal chips. Profs Chen and Ker visited 2-5 July and 8-10 July respectively to discuss the project requirements and to understand the required parameters for building a customised electrical stimulation and recording system for ACES.

ACES AI Johnson Chung travelled to NCTU in Taiwan 19-25 November to deliver, setup and provide training of an ANFF-ACES customised microvalve printer, as well as to progress the 3D printing on retinal chips project. He delivered cell chambers and electrodes to enable De Ker's group in Taiwan to make a customised stimulator for delivery to UOW.

Prof Ker returned to ACES on 11 December to deliver, setup and provide training of the electrical stimulation and recording system for ACES. Project details for two visiting students from NCTU, who will be at ACES for 3 months from early February 2019 were discussed. The students will further characterise and develop the microvalve printing system as well as conduct cell related assays.

Progress on other strategic alliances, where MOUs with ACES were signed in 2017, are as follows:

#### CIC ENERGIGUNE (THE ENERGY COOPERATIVE RESEARCH CENTRE IN THE BASQUE AREA), SPAIN

ACES signed an MOU with CIC Energigune in 2017 to facilitate further staff and student exchanges from 2018 in the area of energy storage. In 2018, ACES worked with CIC and Polymat on iongels based on ionic liquid electrolytes for use sodium batteries. Collaborative work involved studying the cathode and anode electrode/electrolyte interfaces. Asier Fernandez, Nagore Ortiz and David Mecerreyes (POLYMAT/UPV) and Montserrat Galceran (CIC) teamed with ACES members from Deakin University, CIS Forsyth and Howlett and ACES RF Cristina Pozo-Gonzalo, to progress the research and three papers/ communications are either in preparation or have been accepted.

CI Forsyth visited Tecnalia, CIC Energigune and Basque Country within POLYMAT as an Ikerbasque Professor (January).

CIC Energigune Professor, Michel Armand accepted ACES's invitation to sit on the ACES International Advisory Committee from 2018.

ACES Deakin hosted Dr Nagore Ortiz Vitoriano from CIC Energigune in their laboratories (20 October to 4 November).

ACES, through Deakin University, are involved in a European Masters course 'Materials for Energy Storage and Conversion' that involves 8 universities from 6 countries (France, Poland, Slovenia, Spain, US and Australia). Expanded research links to European universities are expected, with ACES Deakin hosting up to five interns each year as part of this two-year Master program in Materials Science and Chemical Engineering.

In 2018, ACES hosted two students, Karolina Biernacka and Aleksandra Grzelak, for 6 months (January to August). ACES CI Maria Forsyth, an examiner for the 2018 group, attended the MESC13 defence and graduation ceremony in Amein France (September).

#### THE INSTITUTE OF MATERIALS JEAN ROUXEL: THE FRENCH NATIONAL CENTRE FOR SCIENTIFIC RESEARCH AND THE UNIVERSITY OF NANTES, FRANCE.

ACES signed an MOU with The Institute of Materials Jean Rouxel (IMN) in 2017. The IMN team of Prof Dominique Guyomard, Prof Jean Le Bideau and Dr Nicholas Dupre have been working with ACES team at Deakin on novel solid state iongels for use in supercapacitors and lithium batteries.

ACES CI Prof Patrick Howlett was

appointed as a visiting fellowship at IMN. He delivered the IMN 2018 seminar 'Novel salt based electrolyte materials enabling safe and stable high energy density' and spent 3 weeks at Nantes working on collaborative research and discussing future research directions. In October 2018, Howlett participated in the CNRS network workshop on Ionic Liquids and Polymers held in Lyon France. He and CI Forsyth also visited the laboratories of Dominique Guyomard at University of Nantes to progress research collaborations.

Prof Forsyth was hosted by Prof Agilio Padua at the the École Normale Supérieure de Lyon, Laboratoire de Chimie, France (25 October). This Chemistry Laboratory is a joint unit operated by the CNRS, the École Normale Supérieure of Lyon and Université Lyon and spans a range of specialities in chemistry and physical chemistry, together with characterisation and modelling.

Three exchange students, Tony Pointu, Barthélémy Hugon and Florentin Guilbault, were hosted at ACES Deakin for their internships (January to June).

ACES CI Forsyth and ACES AI Rob Kerr co-supervise cotutelle student Khryslyn Arano (ADEME scholarship). Khryslyn is investigating novel electrolytes and silicone anodes for use in lithium rechargeable batteries and will visit ACES Deakin from March 2019.

#### NANOTECHNOLOGY & INTEGRATED BIOENGINEERING CENTRE (NIBEC), ULSTER UNIVERSITY, IRELAND.

The focus for this collaboration has been on developing 3D contactless characterisation techniques, to be used for monitoring biosystems. For example, using the RAMAN to characterise cell growth and development on 3D structures. Since 2015, ACES have been developing contactless characterisation techniques using ultrasound.

A collaborative workshop is planned for early 2019, with visits to ACES UOW from NIBEC members. Material transfer and collaboration agreements, including project details are currently under negotiation.

## SUNCHON UNIVERSITY, SOUTH KOREA

ACES AI Byul Chul Kim, in late 2018, was appointed as an International Professor

at Sunchon. Collaborative projects with ACES in the area of printed electronics and wireless electrochemistry projects have been initiated.

#### ISTITUTO ORTOPEDICO RIZZOLI, BOLOGNA, ITALY

ACES AI Dr Zhilian Yue travelled to Bologna (9-14 July) to check correct installation and test the customised 3D printer, produced and delivered to Rizzoli by ACES UOW. AI Yue and collaborator Dr Enrico Lucarelli conducted pilot studies to ensure progress towards the development of in vitro 3D chondrosarcoma models.

#### ACES EXPANDING GLOBAL COLLABORATIONS

#### CENTRE OF EXCELLENCE SHOWCASE AT ICONN2018

The 2018 International Conference of Nanoscience and Nanotechnology (ICONN), organised by ACES UOW, incorporated a showcase of six Australian Research Council funded Centres of Excellence with an interest in advancing nanoscience and nanotechnology, end-user engagement, industry partnerships and collaboration. ICONN participants were able to experience first hand the innovative research resulting from these collaborative centres with a view to building future global partnerships. The dedicated showcase, held 29 January, included introductions and presentations on breakthrough science from the following ARC Centres of Excellence:

- ARC Centre of Excellence for Electromaterials science (ACES)
- ARC Centre of Excellence in Convergent Bio-Nano Science and Technology
- ARC Centre of Excellence for Nanoscale BioPhotonics
- ARC Centre of Excellence in Exciton Science
- ♦ ARC Centre of Excellence in Future Low-Energy Electronics Technologies
- ARC Centre of Excellence for Ultrahigh bandwidth Devices for Optical Systems

Each presentation highlighted the innovative research resulting from the Centres of Excellence, from their collaborative environments, forward-



thinking research visions to ensuring that all the fundamental knowledge accrued is available to end-users and our community. Where appropriate the Centres outlined how commercial opportunities are supported – this done to ensure maximum impact of the research activities being translated to our communities.

The showcase also provided the opportunity for ICONN participants to meet the researchers, discuss collaborative opportunities and gain insight into capabilities throughout the day with a special posters session held.

#### HELMHOTZ ZENTRUM BERLIN, GERMANY

ACES researchers Dr Alexandr Simonov and Cls Profs David Officer and Douglas MacFarlane visited Helmholtz Zentrum Berlin (HZB) in 2018 to build on the alliance between ACES and the German specialists in advanced spectroscopic analysis.

This ACES-Germany link would provide researchers with the opportunity

to include high end *ex-situ* and unique *in-situ* electrochemical X-ray absorption spectroscopy, EPR and X-ray photoelectron spectroscopy. *In-situ* spectroscopic analysis of electromaterials under real operating conditions provides unprecedented insights into material performance.

In May, Simonov (ACES SRF Monash) undertook experiments at BESSYII and met with ACES AI Klaus Lips to discuss the possibility for setting up an Australia-Germany graduate school. He also visited the group of Dr K Lang to discuss further collaborative projects.

Officer (ACES CI UOW) also met with ACES AI Klaus Lips in May to discuss the possibility of future research collaborations and frameworks.

In June, MacFarlane (ACES CI Monash) followed up on progress in formalisation of the collaboration and presented a lecture "Direct Electrochemical Production of Ammonia" to the group. During the second half of 2018 changes to the HZB board of directors has slowed progress towards formalising collaborations.

#### ÅBO AKADEMI UNIVERSITY, FINLAND

Work continued to progress in 2018 on the collaboration formed in 2017, for 3D printing of nanocellulose hydrogel scaffolds for biomedical applications. A joint publication (*J. Mater. Chem. B*, **2018**, *6*, 7066-7075) resulted, with a further two papers currently under review. The formal research collaboration agreement is still being negotiated.

A UOW biofabrication masters student project for 2018 has focused on progressing research activities into the development of ink and printing protocols for wood biopolymers containing 3D structures.

ACES Director Wallace visited in April. ACES AI Dr Paul Molino also travelled to Åbo Akademi University (October)to discuss with Prof Johan Bobacka potential applications of their Åbo Akademi sensor technology for use in ACES industry partner Enware projects. Discussions also continued with Dr Xiaoju Wang on the potential of using their wood derived materials for ACES collaborative projects on antimicrobial surfaces.

#### TABLE 4: PUBLICATION AND CITATION ACTIVITY FOR ACES AFFILIATED PUBLICATIONS 2014-2018 (SOURCE, SCIVAL BASED ON SCOPUS DATA 4.1.19)

	2018	2014-2018
Number ACES publications (SCOPUS)	224	961
Number of ACES publications (SciVal)	206	943
Number of citations	362	13,653
Number of citing countries	52	101
Outputs in top 25% most cited	98 (47.6%)	605 (64.2%)
Field Weighted Citation Impact (#FWCI – for articles and reviews)	1.71	1.92
International collaboration	122 (59.2%)	525 (55.7%)
International Field Weighted Collaboration	1.42	1.39
National Collaboration	65 (31.6%)	333 (35.3%)
National Field Weighted Collaboration	1.35	1.39
**Collaboration Impact – International	1.9	15.7
**Collaboration Impact – National	1.6	13.8
**Collaboration Impact – Institutional	1.3	10.7

## ACES INTERNATIONAL LINKAGES

ACES international linkages through researcher-to-researcher collaborations are illustrated through ACES having published 122 (59.2%) journal articles with international co-authors, from 33 countries (160 research institutions), in 2018 and 525 articles (55.7%) since 2014. The articles published in 2018 have been cited 362 times (52 citing countries). ACES articles published 2014-2018 have received 13,652 cites from 101 citing countries (SCIVAL, Scopus data 4.1.19).

The average number of citations received by publications that have international co-authorship, and by inference the collaboration impact of that research, is greater (impact 15.7; ACES 2014-18) when compared to publishing with national (impact 13.8; ACES 2014-18) or institutional (impact 10.7; ACES 2014-18) co-authors (Table 4).

## PARTNER INVESTIGATORS

ACES has five partner investigators; Dublin City University, University of Warwick, Friedrich Alexander University, Hanyang University and Yokohama National University. Our partner universities enhance the specialist expertise available to our researchers and allow ACES access to world class facilities. Our partner investigators have also been engaged with ACES through joint international workshops and embassy events, as well as exchange visits.

#### ACES YOKOHAMA UNIVERSITY

PI Watanabe and ACES work together on the development and use of a new range of ionic liquid electrolytes and their application in various electrochemical devices focusing on synthetic energy systems. PI Watanabe was the plenary speaker at the 8th Australasian Symposium on Ionic Liquids (ASIL8) hosted by ACES at Deakin University (21-23 May).

Al Junii Fukuda from YNU and Al Binbin Zhang, an ACES alumna currently on a two year fellowship at YNU, visited ACES UOW (July and December). AI Fukuda's research at YNU focuses on developing a cellular monitoring system for stable cell preparation, direct selection and isolation of specific cells, cell sheet and spheroid engineering, and engineering vascularised threedimensional tissues. He presented his ideas on engineering three-dimensional tissues using microfabrication approaches at the ACES Full Centre meeting at Swinburne in July, then spent a week at our ACES UOW node collaborating with our researchers, with a particular focus on cell detachment using electrochemical reactions.

In December, ACES UOW welcomed back Als Fukuda and Zhang and three YNU students. Lei Yan, a masters student was working on the electrical stimulation of hair follicle cells with a polypyrrole platform. Sena Ozawa is doing her PhD on tissue origami so was interested in ACES cell printing techniques. Yoshili Tate doing his PhD on electrical cell detachment and hair regeneration, was at ACES to use the QCM to monitor the detachment process.

#### ACES DUBLIN CITY UNIVERSITY

Through ACES, the long established DCU-UOW collaboration has broadened to involve additional faculty members and collaborating organisations in Australia, Ireland and across Europe. Each year, researchers from ACES and their European collaborators meet in Dublin. In 2018, the symposium 'Bioinspired 3D Structures' was held at DCU (31 May), to explore converging technologies and emerging opportunities. Collaborators from Portugal, UK, Ireland, Finland, Sweden, Spain and France attended.

The symposium was followed by a showcase "Global Challenges need Global Collaborations" at the Australian embassy in Dublin, hosted by the Australian Ambassador to Ireland, Ambassador Richard Andrews. Drawing on examples from within the ACES research network, we demonstrated how advances at the frontiers of human health and energy benefit from interdisciplinary and global collaborations. Questions discussed were:



- Progress in 3D printing has had a dramatic impact on health options. Where is this all leading to?
- Can the energy from Australian sunshine be packaged and transported around the globe?

A public lecture, featuring David Hoey from the Amber centre and ACES speakers CIs Susan Dodds and Gordon Wallace, was held at the Dublin Science Gallery (1 June). David Hoey spoke on ethics issues around stem cell research and our ACES speakers highlighted the impact of the Ethics and Public Engagement activities within ACES, which included discussion on the broader issues around bionics and human augmentation.

**'Nanotech and nana's knee'** - whilst in Dublin Prof Gordon Wallace was interviewed by Irish podcaster Luke Clancy (Soundsdoable/Culture File) on how 3D printing might offer treatments for everything from bad knees to schizophrenia.

Researcher exchanges between our partner node at DCU were again positive. Dr Joan Marc Cabot Canyelles, an early career researcher from our University of Tasmania node, spent June at our partner Dublin City University to work with ACES PI Dermot Diamond to progress research on self-propelled ionic liquid droplets that may be useful in sensing systems. Joan Marc has developed diagnostic platforms for applications in bioactive molecule delivery into soft tissue models, the determination of bacteria and metabolites in urine and bacterial DNA in whole blood, and protein

separation whilst working in ACES.

DCU, equipped with advanced facilities and instrumentation to support cutting edge sensor research, is world-class in terms of photo-controllable sensors and actuators. Joan Marc was able to study and discuss possibilities on how to use electric fields to move droplets, like our body does, during his time at DCU.

ACES AI at DCU Prof Robert Forster continues to collaborate with ACES researchers on the development of characterisation tools as well as wireless bipolar electrochemistry.

ACES AI at DCU Aoffie Morrin and her group collaborate on sensing technologies for incorporation into wound healing systems.

ACES members who visited DCU in 2018 were:

- CI Officer and affiliate PhD candidate Sara Zarghami (April-June)
- CI MacFarlane (May-June)
- CI Higgins (a week late May)
- SRF Wagner (a week late June)

Visits from DCU to Australia in 2018 included:

- PI Diamond to progress collaborative projects and attend the ACES Full Centre meeting (February)
- PhD student Danielle Bruen at ACES UOW to develop 3D printed glucose sensors (March-May)
- Dr Margaret McCaul to review facilities and discuss collaborative research with ACES UOW and industry partners (June)
- Eimer Duffy to ACES UTAS for ink

tattoos to monitor air pollution (June)

Ivan Maguire to give a seminar and review the facilities at ACES UOW (August).

DCU has been able to build stronger global networks, raising their international profile and potential socio-economic impact. As a consequence of the ACES-DCU partnership, researchers at DCU-INSIGHT have assisted Australian companies including Enware and Scintilla MicroSampler Pumps. On the flip side ACES researchers have been able to interact with local Irish companies such as Shimmer (wearable sensors for personal health and activity tracking) and Tellabs (environmental sensing).

ACES at University of Tasmania hosted Eoin Murray a PhD student from T.E. Laboratories Ltd, Ireland for 4 months (2 March- 2 June 2018). The collaboration was focused on opportunities for commercialisation of newly developed 3D printed passive sampling devices. A joint 'Global Network' grant was submitted.

#### ACES HANYANG UNIVERSITY

Australia, through ACES, has built strong research collaborations with the Republic of South Korea.

There has been many excellent research outcomes arising from the collaboration with PI Kim and ACES researchers, including 14 journal articles since 2014. However, the initial intent of the collaboration going forward has subsequently changed as the research



direction of the ACES Soft Robotics group has changed, limiting the scope of the anticipated interaction between the groups. As a result, the two-way student exchanges have not eventuated as originally planned.

Hanyang University's growing awareness of ACES activities, since joining as a partner organisation, has identified new opportunities within the ACES Synthetic Energy Systems and Synthetic Biosystems themes for them to begin to engage. These areas have significant overlap with Prof Kim's interest in self-powered artificial muscles, biofuel cells and stretchable energy storage textiles. However, collaboration in these areas are still in their infancy therefore not many research exchanges in 2018.

PI Kim travelled to ACES UOW for a

week to discuss collaborative research and attend the ACES Full Centre meeting and Clinical Connections workshop (February). ACES UOW CI Spinks visited PI Prof Kim at Hanyang University, Seoul, South Korea, and gave a seminar on artificial muscles and soft robotics (29-31 October).

Hanyang University takes pride in its strong industry connections, and they value the new opportunities to build new partnerships with Korean companies through the ACES connection. In particular, ACES' strong international profile in 3D printing, especially bioprinting, has received significant attention.

In September an ACES-Korea Society of 3D Printing in Medicine (KS3DPM) event the 'Korea-Australia Medical-Bio 3D Printing Forum' was held. This was part of "NaNO Korea" an event with more than 1500 participants and 100 companies in attendance. An MOU between the two hosts was signed then research applications for medical innovation in 3D printing showcased.

An ACES-KS3DPM Innovation Showcase was held at the Australian Embassy Republic of Korea (6 November). Our partners at Hanyang University supported the showcase with Prof Seon Jeong Kim, Hak-Sung Kim, Seungjoon Jung attending. The event itself was hosted by the Australian Ambassador to the Republic of Korea, His Excellency Mr James Choi, and showcased the significant collaborative relationship between ACES, KS3DPM and other members of the Korean clinical community interested in Bioprinting.

#### ACES FRIEDRICH ALEXANDER UNIVERSITY

One of the key research priorities at FAU is Future Energy Materials that includes the Cluster of Excellence Engineering of Advanced Materials (EAM). It is this synergy of developing advanced materials for the creation of future energy systems that has established ACES as an important partner in helping develop FAU's research aspirations.

A major thrust of the FAU-ACES collaboration addresses the expanding global need for energy by developing a groundbreaking platform to produce chemical fuels using solar energy.

To advance to such a level of sophistication, we have focused on future generation photovoltaics and on artificial photosynthesis to demonstrate both, very high conversion efficiencies and environmental sustainability, in producing fuels and electricity with energy costs comparable to current energy production from fossil fuels. This approach utilises the strengths of each institution, the world class materials development and processing at ACES and the outstanding materials characterisation and fabrication at FAU. In 2018, two joint publications came from this work.

In 2018, ACES hosted the first joint FAU/UOW PhD candidate, Mr Markus Pfau, supervised by PI Guldi and Cl Officer, whilst he completed his thesis writeup. PI Dirk Guldi briefly visited the University of Wollongong (10-13 October).

ACES researchers CI David Officer and senior researcher Dr Pawel Wagner from ACES UOW met with PI Guldi, his associates and students from FAU, in Munich (1- 6 July), whilst they were presenting their research at the International Conference on Porphyrins and Phthalocyanines (ICPP18).

#### ACES WARWICK UNIVERSITY

Warwick Electrochemistry and Interfaces Group's (WEIG's) involvement in ACES is based around batteries and energy materials.

In 2018, ACES through Monash Unversity received substantial financial support from the Monash Warwick Alliance Accelerator Fund for a joint project to hire two postdoctoral researchers, one each at Monash and Warwick, for a total of 1.5 years. The aim of this project is to use the highresolution electrochemical imaging techniques, developed by WEIG, for mechanistic studies in order to guide the development of advanced energy electromaterials.

The participation in the Centre has been flagged in grant applications from WEIG, including the successful EU Marie Curie Fellowship Application made by Dr Cameron Bentley, a Monash graduate, who held a fellowship at Warwick through to November 2018. Dr Bentley is now working with our members at Monash Unversity to prepare a DECRA application with the aim to bring the advanced electrochemical imaging techniques to Australia. If successful, this will be highly beneficial to ACES.

Postdoctoral researcher Dr Minkyung Kang from Warwick worked with CIs MacFarlane and Zhang at Monash investigating the mechanisms associated with the catalytic reduction of carbon dioxide/nitrogen using the high resolution electrochemical imagining techniques developed at Warwick University.

ACES Monash hosted Ms Ellie Stepaniuk, a 3rd year exchange student from the Department of Chemistry Warwick University, in 2018 for research training in the area of electrochemical CO<sub>2</sub> reduction.

## PUTTING ACES ON THE GLOBAL STAGE

In the quest to consolidate existing collaborations and to initiate new ventures in research, ACES members were actively out and about speaking of ACES New Dimensions to existing and potential collaborators as demonstrated by the number of presentations and collaboration visits undertaken in 2018.

## PLENARY/KEYNOTE ADDRESSES

ACES members gave 32 Plenary or Keynote addresses in 2018 (appendix 7).

## INVITED TALKS AT INTERNATIONAL CONFERENCES

ACES members gave 72 invited talks at International Conferences in 2018 (appendix 8).

## INVITED PRESENTATIONS

#### DISTINGUISHED VISITOR LECTURES

ACES members gave eight invited 'distinguished visitor' lectures in 2018.

## INVITED COLLABORATION VISITS

ACES members gave 35 invited seminars at research institutions. In total, ACES members undertook 137 collaboration visits to research groups globally to discuss our research (appendix 9).

## CONFERENCE PRESENTATIONS BY ACES MEMBERS

90 conference presentations were given by ACES members in 2018 (appendix 10). Please note that presentations given by ACES members at ACES events are <u>not</u> included in any reported lists.

## ENCOURAGING RESEARCH COLLABORATION

## **WORKSHOPS**

The advancement of the scientific knowledge that ACES generates is an important component of Centre activities. ACES international conferences, symposia and events provide ACES students and ECRs the opportunity to communicate their research in ACES showcase sessions and poster sessions at ACES International events (9 events in 2018, appendix 11).

Networking by ECRs and students with international guests is encouraged. Over the years, ACES has developed a reputation for not only excellence in the educational quality of its conferences, but also the collegial atmosphere.

## **VISITING ACADEMICS**

91 International academics, interns, undergraduate or postgraduate students were welcomed to ACES in 2018. Activities include (i) working alongside ACES members to further collaborative research or (ii) for the opportunity to present a research seminar to ACES members and view ACES facilities as a first step towards engagement. See list in appendix 12.

62 national academic guests were also welcomed. See list in appendix 13.

# COMMUNICATIONS

## ACES **STRATEGIC PLAN** GOAL 5: **COMMUNICATIONS**

Our goals are to:

Develop communication skills and protocols that ensure awareness of and commitment to the ACES vision across the research, research training and commercialisation platforms within the Centre.

Create effective interfaces that disseminate the science and promote engagement effectively targeting the different stakeholders - in commercial sectors, healthcare, government and the community.

Our target audience is all ACES stakeholders - the global research community, students, investors, government and regulators and the community (Table 5).

## **TOWARDS OUR GOALS**

Effective communication is a critical component of all the strategic goals of ACES. Communication:

Enables ACES to transfer the continually growing body of

fundamental knowledge gained through undertaking our research to stakeholders and the broader community.

- Ensures an increased level of awareness, understanding and support among various stakeholders and the community.
- Enhances relationships between ACES and stakeholders: (i) raising the profile of ACES thereby assisting in identifying opportunities to progress the work and identify potential partners to translate the research as well as (ii) reducing the scope for 'misinformation' about the research and research outcomes.
- Assists ACES to attract quality student and staff to the Centre - our next generation research leaders!
- Raises the profile of ACES facilities and our members and their research which in turn helps the Centre to attract potential collaborators.

## SOME HIGHLIGHTS

#### **ICONN 2018**

In an exciting start to 2018, ACES in conjunction with the University of Wollongong hosted ICONN 2018 (International Conference on Nanoscience and Nanotechnology)

#### TABLE 5: ACES OUTREACH EFFORTS INVOLVE SIX KEY STAKEHOLDER AUDIENCES

Stakeholders	Key Messages
1. Global research community	ACES is a national resource in state-of-the-art electromaterials science and integrated device fabrication, with knowledge and facilities that are readily accessible for scientists, engineers, clinicians, regulators and policy makers.
2. Prospective students	ACES provides an inclusive and supportive global research training opportunity; giving access to the most innovative and dynamic research training programs and laboratories in Australia, also facilitated by global connections.
3. Investors	ACES facilitates the development of technologies to create new disruptive business opportunities and to augment existing businesses.
4. Government and Regulators	ACES provides information on the effectiveness of funding programs (for research training) and issues affecting policy and regulation in Energy and Health.
5. Community	ACES provides access to the exciting world of science through open engagement for the community to participate in the wonder of discovery and what can be achieved, using multidisciplinary research to address real community needs so that science can positively impact on people's daily life.
6. Internal	Together we have a common purpose - to build a sense of community for the communication of research progress.



in February. The conference which focused on the new and exciting advances in the field of nanoscience and technology, held a free public lecture featuring Nobel Prize Winner in Chemistry 2016, Sir Fraser Stoddart. Prof Stoddart's lecture featured in the *Illawarra Mercury*, *ABC Radio*, and Illawarra radio station *i98FM* covered the event.

#### BIOPEN RECEIVES BIOMEDTECH HORIZONS FUNDING

The biopen, a hand-held 3D printer developed by ACES in conjunction with St Vincent's Hospital to repair cartilage damage, received investment from the Australian Government's \$35 Million BioMedTech Horizons program in April. The grant has enabled the team, comprised of scientists, engineers and clinicians, to continue its work towards commercialisation of this innovative technology. This exciting multidisciplinary collaboration received media attention from 7 News in Brisbane and Melbourne; ABC Illawarra; WIN News Illawarra; 10 News Brisbane; Channel 9 News Illawarra; Illawarra Mercury; and St Vincent's Hospital Media.

#### ETHICS OF BRAIN ORGANOIDS

ACES CI and EPPE theme leader Prof Susan Dodds featured in an article in the *Sydney Morning Herald* titled 'Could lab-grown human minibrains help treat Alzheimer's and epilepsy', providing comment on the question of whether brain organoids developed for medical testing feel pain.

#### BRAIN IMPLANTS AID EPILEPSY TREATMENT

In May, ACES CI Mark Cook and his team at the University of Melbourne node commenced trials of a breakthrough device they developed to detect and prevent epileptic seizures. The device, which received coverage from Channel 7 News in Perth, Adelaide, Brisbane, Melbourne and Sydney, Channel 10's Eyewitness News in Sydney, The Scientist, Sun Herald, Sunday Mail Adelaide and Sunday Tasmanian, listens to the brain for specific electrical activity, which warns of a seizure. It is hoped the implant will eventually help gauge how well epilepsy medications are working, removing the need for trial and error treatment.


#### IFIX SYSTEM RECIPIENT OF MEDICAL DEVICES FUND

The ACES team behind the iFix Pen, developed in collaboration with the Lions NSW Eye Bank and the University of Sydney's Corneal Bioengineering Group, received \$1.15 Million through the NSW Government's Medical Devices Fund to further develop the iFix system. The iFix Pen is a hand-held printing device that delivers a specialised bioink formulation to repair corneal ulcerations with high accuracy. The funding received significant attention from ABC Illawarra's Mornings program, Sydney Morning Herald, University of Wollongong media, Mirage News, University of Sydney media, 3D Printing Industry, 3Ders, Clinical Innovation and Technology, and All3DP.

#### ABC'S CATALYST FEATURES ACES RESEARCH

In one of the most exciting media events for ACES in 2018, our researchers featured on *ABC's science program Catalyst* in an episode titled 'Bionic Revolution'. In the episode, Dr Nikki Stamp visited ACES headquarters in Wollongong to meet ACES Director Prof Gordon Wallace and ACES CI A/Prof Jeremy Crook and take a closer look at the 3D printing capabilities and devices being developed, including the Biopen and the iFix Pen, and to see first hand our research into cell regeneration.

#### THE ETHICS OF RENEWABLE ENERGY

ACES researchers Dr Natalie Ralph provided an analysis piece for the *Australian Institute of International Affairs' Australian Outlook* section that examined the risk and reward around renewable energy, highlighting the need for best practice to prevent destructive outcomes in emerging renewable energy systems in terms of protection of local environments and the rights of local communities.

#### BATTRI-HUB ADVANCES BEYOND LITHIUM-ION RESEARCH

The BatTRI-Hub at our Deakin University node is continuing to make breakthroughs in its research to develop cheaper, safer batteries using sodium-ion batteries as an alternative to lithium-ion. This sodium-ion research, which could allow batteries to be made without costly, environmentally harmful and ethically dubious mining for rare minerals such as cobalt, was featured by the *Geelong Indy*, the *Geelong Advertiser*, and *Deakin University* media. Instead, the key components of sodium-ion batteries are synthesised from low cost, abundant materials with secure supply chains.

#### ACES RESEARCHERS EUREKA FINALISTS

Two teams featuring ACES researchers were named as finalists at the 2018 Australian Museum Eureka Prizes, the 'Oscars' of Australian Science. The Invisible Catalyst Team, led by ACES CI Michelle Coote, was named as a finalist in the Eureka Prize *Excellence for Scientific Research* for their investigation into using electrical fields to catalyse chemical reactions to enable greener and safer methods for fabricating materials. The Biopen Team, including ACES CIs Gordon Wallace and ACES Als Stephen Beirne, Zhilian Yue, Claudia di Bella, Cathal O'Connell and Peter Choong, was nominated for *Excellence in Interdisciplinary Scientific Research* for their cutting-edge handheld 3D printing device to repair damaged cartilage. Our team nominations received coverage from a range of media outlets across Australia including *Australian National University media, Curtin University media, University of Wollongong media, Illawarra Mercury,* and the Royal Australian Chemical Institute.

## 3D PRINTED FINS AND VEGEMITE

ACES CI Marc in het Panhuis' work in 3D printing attracted significant media coverage in 2018. His work on 3D printed surfboard fins, including research fieldwork in Indonesia, was again popular with media outlets, including Channel 9 News Illawarra, Sydney Morning Herald, Canberra Times, Brisbane Times, University of Wollongong Media, Waxheads, and Swellnet. The team has also been investigating the creation of electronic components using edible materials with a focus on vegemite which drew attention from Linday McDougall on ABC Illawarra's Drive program, Channel 9 News Illawarra and Chemical and Engineering News.

#### **MEDIA SUMMARY**

During 2018, ACES members and their research activities were highlighted in 127 print and electronic articles and 48 radio and television stories in the Australian and international media (Table 6).

The number of radio interviews increased in 2018 starting in January when former federal politician Amanda Vanstone, who hosts ABC Radio National's Counterpoint program, chatted to ACES Director Gordon Wallace about research, collaborations and what inspired him to become a scientist. The interview titled 'Fusing human biology with engineering and robotics' can be found at http://www. abc.net.au/radionational/programs/ counterpoint/3d-printing-with-livingcells/9271318

For Christmas 2018 our communications team put together an ACES take on 'Listmas', with our favourite podcasts and videos featuring ACES researchers in 2018 for everyone to enjoy once again over their break. *http://www. electromaterials.edu.au/news/it-slistmas-aces-style/* 

#### **Beyond Human? (Shaping the Fourth Industrial Revolution)** – ACES CI Prof Rob Sparrow chatted with the team behind Shaping the Fourth Industrial Revolution podcast on the ethics around a 'post-human' era, given the advances in genetic engineering, neuroscience, pharmaceuticals and prosthetics.

Why Can't We Live Forever? (UOW's Can You Tell Me Why? Podcast) – ACES Director Prof Gordon Wallace offered his expertise on the reality of 3D printing bones, tissues and organs to potentially beat disease and death as part of a discussion on the idea of living forever.

Ammonia's big future in fuels and fertiliser (ABC Radio Science Show) – ACES CI Prof Doug MacFarlane spoke with ABC Radio's The Science Show on his team's discoveries in renewable energy conversion with the development of a new highly efficient way of producing ammonia using ionic liquids.

Thermal Energy Harvesting (ACES YouTube) – ACES has developed a range of redox active electrolytes for converting low grade waste heat directly into electricity. Thermocells incorporating these electrolytes are ideally suited for supplying continuous power for low voltage applications such as remote sensors, small wearable electronics or supporting the internet of things. A video featuring ACES CI A/Prof Jenny Pringle and ACES ECR Dr Danah Al-Masri allowed everyone to learn more about this exciting technology.

*Culture File: Nanotech and nana's knee (Soundsdoable/Culture File)* – ACES Director Prof Gordon Wallace was interviewed by Irish podcaster Luke Clancy on how 3D printing might offer treatments for everything from bad knees to schizophrenia.

#42Questions (The Science Talk) – ACES postdoctoral fellow at University of Melbourne, Dr Justin Bourke, appeared as a guest on The Science Talk's #42 Questions program. Justin chats about how he stays motivated, gender inequality in science, his involvement in Women in STEM Australia, what he would change in science and more.

Bespoke Bodies – the path to human regeneration (ABC Radio Science Show) – Listen to the panel discussion at the World Science Festival held in Brisbane in March featuring Prof Gordon Wallace on the ground-breaking science of selfrenewal and the promising benefits for human health and longevity.

**Robots that look like us** (ABC Radio Big Ideas) – As part of GOMA 2018

#### TABLE 6: MEDIA OUTREACH SUMMARY

Communications	KPI target 2018	Actual 2018
Online (web)	100	101
Print	20	26
Radio	10	28
TV	5	20

(Queensland Gallery of Modern Art), Prof Rob Sparrow spoke about the ethics behind 'The rise of the machines', considering whether robots can become so clever they blur the line between human and machine.

*Why Do Children Need Fathers?* (UOW's Can You Tell Me Why? Podcast) – ACES CI Prof Marc in het Panhuis gives us an insight into the influence fathers and father figures have on early childhood development with his experience in taking parental leave in the Can You Tell Me Why? podcast titled Why Do Children Need Fathers?

*iFix Pen receives 2018 Medical Devices Fund grant* (ABC Illawarra) – Listen to Dr Stephen Beirne explain the ins and outs of the iFix Pen, part of the iFix System that received \$1.15 Million in funding through the NSW Government's 2018 Medical Devices Fund to take the device to repair corneal damage towards commercialisation.

The Future of Sex? Bonking, bots, bits, babies, biology (ABC Radio National) – Science gets saucy in this discussion on the future of sex in the 21st Century featuring Prof Rob Sparrow as part of a Science Friction Live event recorded in front of a live audience at the Melbourne Museum in November.

#### ACES COMMUNICATION PLATFORMS

#### THE ACES WEBSITE -ELECTROMATERIALS. EDU.AU

The ACES website has many functions and serves as our main online platform. This year, we have built on the great work done in the past and have continued to share such content on our website. Moving forward in 2019, we will be redeveloping the website, giving it an updated design while making it more user-friendly to continue to showcase all the great work done at ACES.

## Showcases ACES research for our stakeholders

The research ACES does is truly groundbreaking. We want people to know about what we do and use our website to do just that – as well as distributing our content via our integrated social media channels.

For example, ACES CIs Prof Linda Hancock and A/Prof Patrick Howlett and ACES researcher Dr Natalie Ralph from our Deakin node highlighted the importance of an integrated approach to investigation and discovery in a video prepared for the Deakin University Science and Society Network. The team presented the importance of interdisciplinary research to understand and evaluate the ethical, policy and community concerns that arise from emerging technology to guide our research activities. http://www.electromaterials. edu.au/news/aces-shines-a-light-onsocially-conscious-research/

Our ACES research is often in the news and attracts international headlines, but not all ACES stories can be covered in the media. The ACES website provides another medium for us to showcase our work and to distribute it to a greater audience. We use the ACES website to publish news stories, interviews, events, interesting research and more.

Research can sometimes be hard to interpret, so an added benefit to showcasing ACES research on the website through stories, publications or through events is that the community can properly understand our amazing research findings in plain English.

Read our stories on at electromaterials. edu.au.

### Is there to attract our next generation researcher leaders

ACES is made up of researchers from all over the world and we can't achieve high quality research outputs without attracting and inspiring ambitious students to work with us and to allow them the opportunity to collaborate. To showcase our talented members and also to assist us in attracting



future research leaders to ACES, our website highlights events, opinions and information on what is on offer when joining our passionate team.

## Celebrates ACES successes and supports ACES members

ACES is proud of their members and make it a priority to support them in their endeavours and celebrate their achievements. The many awards won by ACES members would not have been possible without such an inspirational team that is dedicated and committed to hard work. We celebrate with everyone and share these accomplishments online.

#### **SOCIAL MEDIA**

We have continued to focus on utilising social media to share website content and to keep the community updated with what is happening at ACES. Facebook, Twitter and YouTube are the three main social media platforms we use to distribute this content. Followings have increased in 2018 on all platforms and have proven to be an excellent tool for engaging with our audience.

We use both Facebook and Twitter daily, sharing stories, images, event details, study and job opportunities and more. We also use these platforms for various campaigns, including:

Science Week: A number of our ACES team members shared quotes on what it takes to be a 'game changer' and 'change maker' in science, the theme for Science Week 2018. Accompanied by a photo, we distributed these quotes each day throughout Science Week, using the hashtag #ScienceWeek.

**PhD Interviews:** ACES has many PhD students based at our various nodes, who are working on fascinating research projects. We have conducted a number of interviews with these students and have published them on our website, providing them the opportunity to share their ACES experience and to give us some insight into what they are working on.

**Women in Science:** To celebrate International Woman's Day, some of the inspiring women that continue to drive ACES to be a world leader in electromaterials science spoke on being a women in science. We published what they had to say on social media throughout the day.

#### **FACEBOOK**

Facebook continued to be an effective platform to promote ACES work, linking back to both our website and to external media content. Our Facebook page (facebook.com/electromaterials) currently has over 1,231\* followers, compared to 1,140\* in 2017.

#### TWITTER

Our Twitter account (twitter.com/ ARC\_ACES) has over 1,011\* followers compared to 697\* in 2017. In addition to the ACES Twitter account, our team, including many of our Chief Investigators, are active on Twitter and frequently retweet what is posted. ACES Director Professor Gordon Wallace has 2,090\* followers compared to 1775 followers in 2017.

### **ACES COMMUNICATIONS: A SNAPSHOT**



COMMUNICATIONS

#### YOUTUBE

The ACES YouTube channel has over 571 subscribers, and our videos have gained thousands of views. Continuing to dominate in terms of views, the video 'Fishing line artificial muscles' is our most popular, with 77,311\* views up from 72,320 views last year.

\*statistics reported were as of December 18, 2018

#### ACES MAILING DATABASE

In 2018 ACES reviewed and restructured the email database according to stakeholder groups, to more actively engage subscribers. ACES had a database of 1,102 stakeholders in 2017. The database was not segmented and each subscriber received the same information, which may not be relevant to all the audience, resulting in lower engagement rates than a more targeted approach. With an opt in only system the 2018 ACES mailing list subscription numbers are as follows:

End User – 139 subscribers

Research – 378 subscribers

Community – 29 subscribers

Although the total subscribers to the database is less than 2017, with an opt in system ACES know these subscribers are actively engaged.

'The ACES Catchup' is our ACES fortnightly update for our internal audience. It features information under "What's new at our ACES nodes across Australia and the world"; "Latest News"; "ACES Good Reads"; "Social Media Snapshot"; "Learn with ACES" and "Upcoming events and meetings".

ACES first quarterly end-user engagement newsletter "Collaborations" was published in September 2018. This first edition was sent to 137 recipients, had 203 opens at an open rate of 39.8% (most within 8 hours of sending). ACES aims to continue to monitor engagement with our subscribers.

#### INSPIRING THE NEXT GENERATION OF SCIENTISTS AND THEIR TEACHERS

#### INSPIRING HIGH SCHOOL STUDENTS

ACES UOW hosted schools involved in the UOW Festival of STEM and

Entrepreneurship, on UOW Innovation Campus, daily for laboratory demonstrations on Artificial McKibben Muscles, drug release and 3D bioprinting activities (19-23 February).

Biofabrication masters student and ACES affiliate Joanne Williams, presented STEM Ability Resolvers project ideas to St Mary's High School in Wollongong (13 March).

Our ACES colleagues at University of Tasmania hosted visiting Indonesian high school students, conducting laboratory tours and holding a workshop on 3D printing capabilities with 3D printing spaces for the students (16 March and 27 April).

Jian Fang, ACES RF at Deakin, gave a talk about fibrous materials to primary school students attending Maker Faire at Deakin University (14 August 2018).

The ACES Deakin team hosted Ashwood High School year 12 Chemistry class students (13 in total). A number of staff and students presented theory sessions before their experiments started (31 May). For example, Danah Al-Masri, Danah ACES ECR conducted an electrochemistry laboratory practical for the students on 'plating metals from an electrolyte solution' (21-23 May).

Our ACES team at Deakin University also hosted high school student Tahlea Grant for a week as part of her Year 10 work experience program (6-10 August). During her time, Tahlea assisted in carrying out experiments and anaylsis, and had the chance to use a scanning electron microscope for the first time! Tahlea also assembled her first lithium battery, which is a significant achievement as it requires specific technique and precision.

ACES Director Prof Gordon Wallace chatted to Years 10, 11 and 12 students at Keira High School in the Illawarra region at a program run at the school titled Breakfast with a Scientist (15 August). Prof Wallace gave a talk followed by a Q and A session as part of National Science Week, to open students' eyes to the exciting world of medical bionics and future opportunities in biofabrication.

A number of these students then attended our Intelligent Polymer Research Institute Open Day to tour the labs located at ACES Headquarters at UOW and learn more about the groundbreaking research taking place in the Illawarra.

Prof Robert Sparrow, ACES CI at

Monash, gave a talk "Human and machine: the next creative partnership" at St Kevin's College Foundation Annual Business Breakfast (15 August).

Prof Michelle Coote, ACES CI at ANU, gave chemistry demonstrations at Gundaroo public school in Canberra (20 September and 9 November).

ACES Associate Director Prof Maria Forsyth addressed Years 9 and 10 girls from Clonard College, North Geelong Secondary College, Geelong High School, Grovedale College and Sacred Heart Girls College in Melbourne with a talk titled *Lead on Ladies* – Stories from women in STEMM in November. In a fascinating talk, Maria spoke on "What would you tell your 15 year old self what you know now about your career choices."

Prof Marc in het Panhuis, ACES CI at UOW, provided skills training in "Scientific literature: reading, processing and peer review", during HSC Science Extension Workshop at Ulladulla High School (26 November). The workshop was with 50 students and teachers from High Schools from Ulladulla, Nowra, Batemans Bay, Broulee and Pambula.

#### PROFESSIONAL LEARNING FOR STEM TEACHERS

Griffith University in Queensland hosted a professional learning day for teachers of STEM in December, where ACES Director Prof Gordon Wallace gave the keynote address on 3D Bioprinting: printing parts for bodies.

Marc in het Panhuis, ACES CI at UOW, was the STEM Professional in School for Ulladulla High School, Ulladulla, NSW, in 2018.

Prof Linda Hancock, ACES CI Deakin, gave her invited talk on "Safey and risk of nano materials and sustainable procurement"at the forum "Nano technology: The Scientist and the social implications" held at Deakin University and attended by 100 science teachers.

A/Prof Jenny Pringle, ACES CI at Deakin, participated in the Reconceptionalising Maths and Science Teacher Education Program (REMSTEP) preservice teacher educational activity (18 April).

#### ACES NANO-EXHIBIT AT THE WOLLONGONG SCIENCE CENTRE

Four display items from the original

ACES nano-exhibition are still on display at the Wollongong Science Centre. That exhibit has been seen by 14,827 school children, 31,967 members of the public and 2,005 groups in 2018.

#### PUBLIC ENGAGEMENT

ACES researchers continued to share their knowledge and expertise in advanced materials to educate, inspire and engage the broader community through a number of public lectures and other outreach events. Please refer to Appendix 14 for the list.

## THROWING OPEN THE DOORS TO IPRI LABS

ACES UOW threw open the doors to their labs as part of National Science Week, to give the community the opportunity to learn about the ground-breaking research being conducted in Wollongong.

City of Wollongong Lord Mayor Councillor Gordon Bradbery AM launched the ACES National Science Week on 13 August when he was presented with the Keys to the Labs – printed in 3D, as part of a tour of the IPRI facility to learn about the groundbreaking research being conducted in the region at the Innovation Campus.

Over 90 people from our community toured the labs to meet the researchers that are shaping the next generation of smart materials for health and energy solutions to improve people's lives. They openingly enjoyed visiting our world-class facilities and spoke with our researchers about their cutting-edge technologies including: human hair-size graphene fibre electrodes to provide recordings from brain cells; materials that can electrically stimulate brain cells to potentially reverse schizophrenia; and the amazing properties of bioinks to assist in wound healing, the regrowing of ears, and treating diabetics.

ACES Open Days are an important way for the local community to understand the pioneering research happening right on their doorstep.

Most exciting is the fact this research can directly translate into commercial enterprises, creating job opportunities for our next generation of scientists, engineers and entrepreneurs – so if anyone was considering a job in this field, they can come and check out our labs and see what their future could hold.

Potential PhD, Masters and Summer Scholarship students were invited to visit ACES labs to learn about future study opportunities, in September. They also heard from current students about their training as well as given the opportunity to meet potential supervisors.

Science week culminated with ACES hosting the 2018 Bill Wheeler Community Symposium. A/Prof Payal Mukherjee, an Ear, Nose and Throat Surgeon at the Royal Prince Alfred Hospital, gave the feature presentation for this public event, which attracted 87 attendees. Payal has been collaborating with ACES researchers, courtesy of funding from the Garnett Passe and Rodney Williams Memorial Foundation, to investigate the ability to regenerate cartilage for use in reconstructive ear surgery, with the hope of translating this research on a global scale.

2018 marked the tenth annual public talk, where a high achieving University of Wollongong Bionics student is awarded \$2,000 of community raised funds to assist with travel to share their cutting-edge research and build new collaborative relationships. The Symposium and Award honours the life of Bill Wheeler, an active member of the Illawarra community who took a keen interest in new bionics research at the University of Wollongong.

Luciana Yumiko Daikuara, an affiliate ACES UOW PhD student in Biofabrication, was presented with the 2018 Bill Wheeler Prize for her research into using bioprinting as a manufacturing approach to offer customisable biosynthetic skin grafts for patients with complex open wounds. The prize is for travel to an international conference or institution to further develop the student's research and community our research message to a larger audience.

### OUT AND ABOUT

#### DODDS GIVES FOOD FOR THOUGHT ON ETHICS OF VULNERABILITY

Our Ethics, Policy and Public Engagement theme leader Prof Susan Dodds spoke at the Festival of Dangerous Ideas in Sydney on the ethics of vulnerability and the importance of supporting the most vulnerable people in our society. The workshop explored how to better understand vulnerability and its effects on people, especially in areas such as health care, disability and climate change.

#### SCIENCE MEETS ART IN SPINNING WORLD

ACES AI and ANFF scientist, Dr

## BIOFABRICA



Sepidar Sayyar, teamed up with UOW Art research fellows, Drs Agnieszka Golda and Jo Law, and Earth and Environmental Sciences A/Prof Helen McGregor to produce an art installation titled *Spinning World*, showcased at the Powerhouse Museum in Sydney.

The exhibit was designed to illustrate through art how new strategies can be used to reduce energy consumption in the current environmental crisis, and features energy efficient elements as well as methods used to display the art.



Dr Sayyar integrated new advanced smart materials developed within the ACES-ANFF partnership, to enable sound, light and movement in the artwork, mostly achieved using screen printed graphene.

#### CHATTING BESPOKE BODIES AT WORLD SCIENCE FESTIVAL

ACES Director Prof Gordon Wallace featured on a panel at the World Science Festival in Brisbane in March to discuss the ground breaking science of self-renewal, and the promising benefits for human health and longevity. This important discussion, which was recorded by ABC Radio for *The Science Show*, examined the scientific discoveries to improve human performance.

#### INVISIBLE FORCES: CHANGING THE WORLD

ACES Director Gordon Wallace featured as a speaker on a panel as part of

the Sydney Science Festival at the Powerhouse Museum that discussed the invisible forces that underpin our greatest technology. In a talk titled *Invisible Forces: Changing the World*, audiences were treated to a discussion with leading physicists and scientists working in nanoscience and engineering, space engineering, biomaterials and vacuum science where they shared their expertise on how physics has been applied to create new technologies that solve diverse problems.







ACES members have been recognised for their outstanding contribution to science and research through a number of honours, prizes and awards.

#### PROF DOUG MACFARLANE AWARDED VICTORIA PRIZE FOR SCIENCE AND INNOVATION

ACES CI Prof Doug MacFarlane was the recipient of one of Victoria's most prestigious science awards the 2018 Victoria Prize for Science and Innovation (VESKI) in Physical Sciences.

Prof MacFarlane, from our Monash University node, has been working on revolutionising renewable energy conversion in Australia, based on his pioneering development of a class of new materials, 'ionic liquids'.

The Victoria Prize celebrates leadership, determination and creativity and is awarded only to outstanding science leaders.

This is the second consecutive year that an ACES researcher has received this VESKI award, with ACES Associate Director Prof Maria Forsyth a recipient in 2017.

"My parents gave me a chemistry kit for Christmas one year...several fires, floods in my room...l've never lost the interest in chemistry since." Prof Douglas MacFarlane FAA FTSE

#### FELLOWSHIP HONOUR FOR PROF MARK COOK

ACES CI and Synthetic Biosystems theme leader Prof Mark Cook was honoured with induction into the Australian Academy of Health and Medical Sciences (AAHMS) in January 2018.

Along with his role at ACES, Prof Cook is Director of Neurology at St Vincent's Hospital, Melbourne, Sir John Eccles Chair of Medicine at the University of Melbourne and Director of the Graeme Clark Institute and is recognised internationally for his expertise in epilepsy management, particularly imaging and surgical planning. In recent years his interests have included experimental models of epilepsy and seizure prediction and novel drug delivery systems.

He said his scientific and and clinical expertise created an opportunity for him to take a lead role in developing translational research for the treatment of uncontrolled epilepsy with the aim of developing a basic research program focused on epilepsy and other neurological diseases and drive collaborative clinical research across disciplines.

Prof Cook said that over the past five years, his team had made significant progress in developing therapeutic electrical stimulation strategies for the treatment of epilepsy and following on from success with animal models, treatment in humans was now being explored. All thanks to funding from the Australian Research Council (ARC) and National and Health Medical Research Council (NHMRC) that had enabled important collaborations with scientists from other research groups to explore human and animal research.

Prof Cook wanted to acknowledge all the engineers involved at the University of Melbourne and the team at UOW – especially from the Intelligent Polymer Research Institute and ACES collaborators.

#### PROF DOUGLAS MACFARLANE AWARDED 2018 DAVID CRAIG MEDAL

Prof Doug MacFarlane was awarded the prestigious Australian Academy of Science (AAS) 2018 David Craig Medal in a ceremony in May.

As the AAS tweet stated "Major advances in solar cell and battery storage couldn't have been achieved without @ DRMacFarlane's pioneering research into ionic liquids #Honorifics2018".

#### PROF MICHELLE COOTE 2019 SCHLEYER LECTURER AND 2019 ROYAL AUSTRALIAN CHEMICAL INSTITUTE MEDALLIST

ACES CI and Laureate Fellow Prof Michelle Coote, from our Australian National University (ANU) node, was named as the 2019 Schleyer Lecturer. The Schleyer Lecture, held annually at the University of Georgia, is from a guest lecturer nominated to present their research in the field of organic chemistry. Michelle is the first female Schleyer Lecturer in its 18-year history, and only the second Australian selected, following Leo Radom's talk in 2008.

Prof Coote was also named the 2019 Royal Australian Chemical Institute (RACI) Physical Chemistry Division Medallist, the premier award of the Physical Division of RACI. The medal is awarded in recognition of outstanding contributions, by an individual, to the field of Physical Chemistry in Australia.

#### ACES RESEARCHERS NAMED AMONG THE WORLD'S MOST INFLUENTIAL

Three ACES Chief Investigators, Prof Gordon Wallace, Prof Jun Chen and Prof Leone Spiccia were named among the world's most influential scientists in the Clarivate Analytics 2018 Highly Cited Researchers report. The report recognises world class researchers who are having the greatest impact on the research community, demonstrated by the publication of multiple papers over the previous decade that rank in the top one per cent of most cited for their field and year.

The three CIs were part of the 76 researchers from Australia listed in the cross-field category. Wallace and Chen are based at our lead node at the University of Wollongong.

The report also acknowledged the work of the late Prof Leone Spiccia, our ACES Chief Investigator who passed away in 2016. Leone was a tremendous member of the team since the beginning of ACES, and his inclusion on the Highly Cited Researchers list is an impressive tribute to Leone's legacy across many areas of science.

#### MOLLIE HOLMAN AWARD FOR BEST THESIS

ACES PhD Graduate, Dr Fengwang Li, was the recipient of Monash University Science Faculty's Mollie Holman award for the best thesis in the Faculty. His thesis "Two-Dimensional Catalysts for Electrocatalytic  $CO_2$  Reduction" was written under the supervision of ACES Cls Jie Zhang and Douglas MacFarlane.

This very distinguished Medal was established in 1998 and is named after the late pioneering physiologist, Emeritus Professor Mollie Holman AO, in honour of her significant contributions to science and education. A pioneer in her field, Prof Holman's memory is preserved in these medals struck in her honour. They are among the highest academic honours Monash University bestows, and mark the recipients as researchers of the highest order.

Fengwang is currently working as part

of the Sargent Group at the University of Toronto, focusing on converting  $CO_2$ to value-added hydrocarbons, especially ethylene with high activity, selectivity and durability using renewable electricity as energy input.

"Being a member of ACES since 2014, I have had many opportunities to understand what the leading scientists, in a quite a range of disciplines, are interested in and putting their efforts to. I also have had many chances to communicate with the electrocatalysis guys, to learn from each other and work together to make fancy ideas come true. Recalling this experience in ACES, I feel lucky to be part of it and grow with it."

#### ACES GRADUATES RECIPIENTS OF CHINESE GOVERNMENT AWARD

ACES affiliate students and UOW graduates, Xiaoteng Jia and Qi Gu were recipients of the Chinese Government "2017 Outstanding Self-Financed Students Abroad Award". Granted annually to the top 500 nationals studying outside of their home country, the accolade is considered a high honour.

Approved by and published on the Ministry of Education's website early 2018, finalists were selected via a process of peer review. The number of Chinese students leaving China to study abroad is more than half a million each year, making the award highly competitive.

The presentation ceremony for recipients having studied in NSW was hosted by the Consulate-General of China, H.E. Consul-General Gu Xiaojie in Sydney in June. Both men received certificates and a cash prize of USD6000.

When asked what receiving this award meant for them, Qi Gu replied, "*Receiving the award is both a great honour and strong motivator moving forward in my research.*"

"To win this prestigious award is high recognition of my research. The biodegradable implantable battery I have developed received high praise from the judging panel" replied Xiaoteng Jia.

### So what are the next steps for these inspired researchers?

Xiaoteng spent 2018 as an early career research fellow in the ARC Centre of Excellence for Nanoscale BioPhotonics at Macquarie University. His project focused on a biocompatible electrochemical biosensor for the detection of biomarkers. Given the conductive materials research developed whilst at ACES and its applicability for the development of biocompatible bioelectrodes, Xiaoteng is keen to bridge and further nurture collaborations between both ARC Centres.

For Qi, the future is about progressing the work of the Intelligent Biomaterials and Biomedical Engineering lab within the Chinese Academy of Sciences in collaboration with ACES researchers. Qi established the lab as a Principal Investigator, after having successfully completed the Academy's, 'Hundred Talents Program'. Development of novel biomaterials, advanced technologies and novel therapeutic methods are the lab's key objectives.

ACES CIs Jeremy Crook, Gordon Wallace and Michael Higgins received acknowledgement letters from the China Scholarship Council for their outstanding performance as Qi Gu's and Xiaoteng Jia's student supervisors.

#### AWARD: NONCONVENTIONAL TRANSDISCIPLINARY RESEARCH

ACES CI Simon Moulton at Swinbure University is part of 'Team Geldom' who were awarded the Swinburne University of Technology, Faculty of Science, Engineering and Technology Award for Nonconventional Transdisciplinary Research.

ACES' ultra tough hydrogel materials continue to be developed for use as a condom – the Geldom – in a Bill and Melinda Gates grant project. The project involves the disciplines of Biomedical Engineering, Health & Social Psychology, Polymer Science, Microbiology and Manufacturing. In 2018, the team received a further investment of \$1million from the NSW Government's Medical Devices Fund. They are preparing to begin clinical trials in 2018/2019.

#### HIGHLY COMMENDED 2018 VICE-CHANCELLOR AWARD

ACES CI Gursel Alici received a Highly Commended nod at the 2018 Vice-Chancellor's Awards at the University of Wollongong in August.

Gursel received his Highly Commended Award for Higher Degree Research Supervision for the School of Mechanical, Materials, Mechatronic and Biomedical Engineering, where he has taught since 2004. Gursel is a popular supervisor choice for many students for his expertise in a range of areas, including robotics and intelligent mechatronic systems, medical devices, system dynamics and control, smart actuators and sensors for use in macro/micro/nano robotic manipulation systems, and bio-inspired devices.

Gursel said it was nice to be recognised for supervision and mentoring, which is an important aspect in training the next generation of researchers.

"I try to mentor my students to become independent and confident learners and researchers, how not only see an enjoyable and positive point in their study, but also realise that 'A smooth sea never made a skilful sailor'," Gursel said.

#### SOFT ROBOTICS TEAM, DOUBLE WINNERS AT ICRA 2018

In May, a team from the ACES Soft Robotics group headed up to Brisbane to compete in the 2018 International Conference on Robotics and Automation's (ICRA) 'Soft Material Robot Challenge'. We were thrilled the team came away winners, not in one but in both of the competition's challenge categories. Congratulations to Gursel Alici, Charbel Tawk and Andrew Gillett!

The Soft Material Robot Challenge invites participants from across the world to demonstrate their robots actuated using soft materials. This challenge provides an international platform to showcase soft robotics research and aims to promote research in the field of soft robotics and applicability to on-field competence. The challenge includes two categories: (A) Soft Component Technologies challenge and (B) Soft Robots Grip competition.

For the soft component technology challenge, Charbel delivered a demonstration of his hopping robot called "Gongaroo" and spoke to the application of soft actuation concepts currently being researched as part of his ACES PhD to be awarded equal first in the category. The entries were judged for significance, originality, functionality and quality of documentation and all applicants were required to demonstrate their prototype.

In the gripping challenge, the omnipurpose soft gripper (OPSOG) was put through its paces. The robot carrying the gripper was controlled by one of UOW's undergraduate students, Andrew Gillett, wirelessly through his PlayStation game controller. Under significant pressure Andrew did a fantastic job - successfully picking up, on the first attempt, 10 out of 10 'odd' objects. The objects included a bar of soap, 500 grams of grapes, a USB stick, a pair of scissors, a banana, a pack of tissues and a small notebook.

#### ACES RESEARCHERS EUREKA FINALISTS

Two ACES research teams were finalists for the prestigious Australian Museum Eureka Prizes, held in August. The team behind the Biopen, made up of researchers from ACES at the University of Wollongong, St Vincent's Hospital Melbourne and the University of Melbourne Department of Surgery was named as a finalist for Excellence in Interdisciplinary Scientific Research for their breakthrough handheld 3D printing device to repair cartilage damage. The Invisible Catalyst Team, led by ACES CI Michelle Coote from ANU was named as a finalist in the Eureka Prize for Scientific Research for their investigation into using electricial fields to catalyse chemical reactions.

#### EUROPEAN MATERIALS RESEARCH SOCIETY: YOUNG SCIENTIST AWARD

ACES PhD candidate Sidra Waheed, from University of Tasmania, received the European Materials Research Society (E-MRS) Young Scientist Award at the E-MRS Spring meeting in Strasbourg, France. Sidra presented her paper 'Breaking barriers within 3D printing technology: Development of low cost 3D printable diamond composite'.

#### DR ALEXANDR SIMONOV RECEIVES RICHARD A. GLENN AWARD

ACES researcher Dr Alexandr Simonov received the Richard A. Glenn Award for having the most outstanding paper at the 256th ACS National Meeting held in Boston in August.

Dr Simonov's paper on electrochemical nitrogen reduction to ammonia highlighted the most recent developments in engineering a system for efficient electroreduction at ambient temperature, provided by the design of unique electrolytic mediums and catalysts. Dr Simonov is a senior researcher at Monash University's ACES node and part of the 'Ammonia Team', spearheaded by ACES CI Douglas MacFarlane.

#### BIOFABRICATION STUDENT FIRST PRIZE AT ISBF 2018

University of Wollongong Master of Biofabrication and ACES affiliate Joanne Williams, was awarded first prize by the Biofabrication journal for her poster presentation '3D printing drug-loaded PDMS' at the 2018 International Society for Biofabrication (ISBF) conference held in Wurzburg, Germany in October.

Joanne has been studying her Masters with ACES in 3D fabrication of dualdrug delivery components, with a keen interest in cochlear implants and more generally bionic hearing, inspired by her son Felix who was born profoundly deaf.

#### ACES STUDENT WINS VIDEO CHALLENGE

ACES and UOW Soft Robotics PhD candidate, Charbel Tawk, was named a winner for UOW's Global Travel Scholarship Challenge in 2018 for his video, 3D Printable Soft Actuators and Sensors.

In his video, Charbel describes how soft robotics will have a major impact on state-of-the-art products and technologies, with reference to his PhD project on developing 3D printable soft actuators and soft sensors for use in soft robots and soft prosthetic hands. https://globalchallenges.uow.edu.au/ UOW206310.html

The scholarship challenge encourages students to submit a short two minute clip that defines a 'big picture' issue relating to their area of research. Charbel received \$2,000 to support travel to a destination of his choice.

#### OTHER ACCOLADES AND AWARDS

Scientific journal ChemPlusChem paid tribute to the late Prof Leone Spiccia, our ACES CI who passed away in 2016, in an issue dedicated to showcasing developments in a number of his research interest areas.

Dr Mary Walker, ACES research fellow at Monash University, named as a Brocher Foundation visiting researcher. Mary will do a two month residency at their Centre in Switzerland in 2019 on "Altering human embodiment: Phenomenology and artificial organs".

ACES CI Robert Sparrow from Monash University received a visiting fellowship (for one month) to the Department of Philosophy, Carnegie Mellon University where he gave a lecture and undertook collaborative research in January.

ACES Associate Director Prof Maria Forsyth was appointed as one of the committee members in charge of awarding the International Society of Electrochemistry Prize for Electrochemical Materials Science.

Luciana Yumiko Daikaura, an affiliate ACES UOW PhD student in Biofabrication, was presented with the 2018 Bill Wheeler Award (\$2,000) for her research into using bioprinting as a manufacturing approach to offer customisable biosynthetic skin grafts for patients with complex open wounds.

ACES Director Prof Gordon Wallace won a research pitch award for his presentation on 3D bioprinting at the Annual Joint Academic Meeting of the Royal Australasian College of Surgeons (RACS) in November, judged by NSW Minister for Health Brad Hazzard and RACS CEO Mary Harney.

Daniela Duc, ACES PhD candidate Swinburne University, won Best Poster Award Prize at International Conference on Nanoscience and Nanotechnology (ICONN) in January. Her poster was titled "Fabrication of Biocompatible Interface for Electrical and Optical Cell Co-Stimulation". She also received a 2nd Prize Poster Award at the Swinburne Research Conference in May.

Dr Caiyun Wang, ACES senior research fellow at UOW, received the International Conference of Young Researchers on Advanced Materials (ICYRAM) 2018 Emerging Researchers Mobility Grant to attend ICYRAM2018 in Adelaide. Over 140 EMCRs and industry representatives attended the event, and had the opportunity to share ideas and discuss potential collaborations in the field of advanced materials.

Ms Ying Zhang, ACES PhD candidate from Monash University, received a travel grant from the International Society of Electrochemistry (ISE) to attend the 69th Annual ISE Meeting in Bologna, Italy in September.

ACES affiliate, UOW Biofabrication Masters graduate and joint ACES-CSIRO PhD candidate Malachy Maher received a travel grant from European Molecular Biology Laboratory's (EMBL) Australia to attend the EMBL 20th Annual PhD Symposium in Germany, where he presented a poster and gave an oral presentation on his area of research in biofabrication.

Shaikh Nayeem Faisal, an early career researcher from ACES UOW, received a travel grant to attend the ANN ECR Entrepreneurship workshop at RMIT in Melbourne, 21-22 November. Eva Tomaskovic-Crook, an ACES research fellow at UOW, received an Australasian Society for Stem Cell Research Travel Award to attend and present at the International Society for Stem Cell Research 6th Annual Meeting, Melbourne, 20-23 June. Her presentation was "NextGen" human brain organoids using 3D printed gelatin methacrylate'.

ACES CI A/Prof Jeremy Crook received funding (USD8000)

from the International Society for Neurochemistry to hold a symposium titled 'Molecular insights on organoid and 3D models to study brain diseases and development' at the 6th Annual Molecular Psychiatry Meeting in Hawaii in September.

Umme Kalsoom, ACES ECR UTAS, was awarded a 2018 Business Development & Technology Transfer (BD&TT) Travel Award of \$5000 in December.













## PERFORMANCE INDICATORS



Key Performance Indicators (KPI)	Target 2018	Actual 2018
Number of research outputs		
Journal publications	120	224
Book chapters	2	5
Conference publications/abstracts	50	207 – 11 refereed papers – 2 non-refereed papers – 194 abstracts non-ACES conferences
Patents (filed)	2	5
Quality of research outputs		
Quality of research outputs	50% with impact factor >3.15	67% (150 publications)
Cumulative Citation data Average cumulative citation per publication	16 Av cumulative citation per publication	14.5 (778 cited publications from 961 published 2014-2018)
Overall publication and citation activity of ACES publications	Overall Field weighted citation impact: 1.7 Outputs in top 10% most cited: 25% Views in top 10% world % views: 30%	1.71 30.1% 35.4%
Number of invited talks/papers/keynote lectures given at major international meetings	30	104 32 plenary/keynote 72 invited talks
Student prizes and awards	1	12
Training and Professional Educat	ion	
Number of training courses held/ offered by the Centre Annually	Total = 17 Thematic workshops: 5 Summer scholarships: 2 Researcher exchanges: 10	Total = 70 Thematic workshops: 15 Summer scholarships: 8 Researcher exchanges: 47 - 39 international students hosted by ACES (>5 days) - 8 ACES crossnodal student exchanges (>3 days)
Number of workshops/conferences held/offered by the Centre	Total = 6 Full Centre Meeting: 1 International Symposium/Event : 1 International or National Joint workshops: 2 End-User sessions: 2	Total = 42 Full Centre Meeting: 2 International Symposium/Event: 9 International or National Joint workshops: 11 End-User sessions: 20
Number of additional researchers working on Centre research - Postdoctoral researchers - Honours students - PhD students - Masters by research students - Masters by coursework students - Associate Investigators	Associate Postdoctoral researchers: 15 Affiliate PhD students: 20 Masters by research students: 5 Associate Investigators: 15	Associate Postdoc researchers: 18 Affiliate PhD students: 39 Masters by research students: 20 Associate Investigators: 26

Key Performance Indicators (KPI)	Target 2018	Actual 2018
Number of mentoring programs offered by the Centre	5 Webinars: 2 Additional skill training activities: 2 Enduser mentoring program: 1	2 Webinars: 0 (webinar scheduled Dec 2018 postponed to 2019). Additional skill training activities: 2 Enduser mentoring program: 0 (EOI sent to ACES members - no additional end-user mentoring requested).
International, national and region	al links and networks	
Number of presentations/briefings To the public To government (parliamentarians and departments/agencies at both State and Federal level) To industry/business/end-users To non-government organisations To professional organisations and bodies Other (please specify)	To the public: - 100 web - 20 print - 10 radio - 5 television To government (parliamentarians and departments/agencies at both State and Federal level): 6 To industry/business/end-users: 30 To professional organisations and bodies: 10 Other (STEM education activities): 1	To the public: - 101 web - 26 print - 28 radio - 20 television To government: 13 (appendix 4) To industry/business/end-users: 103 (appendices 3 & 5) To professional organisations and bodies: 12 Other (STEM education activities): 16
Number of new organisations collaborating with, or involved in, the Centre since 2014	1	2 – Korean Society of 3D Printing in Medicine (KS3DPM) – Institute of Electronics (BETRC) at the National Chaio-Tung University (NCTU) in Taiwan
Centre-specific Key Performance	Indicators	
Commercial translation of Centre research	Ongoing through life of Centre	See Knowledge Translation chapter
Attraction of new funding from endusers and stakeholders in government, NGOs, industry and the private sector	Ongoing through life of Centre	See Knowledge Translation chapter
Specific training courses in entrepreneurial skills for Centre staff and students	Run a Certificate in Innovation and Entrepreneurship each year	1
Initiatives on gender equity and diversity for Centre staff and students	Establish an Equity and Diversity action committee to drive activities within ACES: (i) Review the 2017 ACES gender equity plan (ii) Review available ACES data to establish KPI targets. (iii) Organise one training activity on equity or diversity each year.	<ul> <li>Equity and Diversity committee formed July 2018, with terms of reference established.</li> <li>Reviewed CAASTRO (as recommended by the ARC) and Science in Australia Gender Equity Forum (SAGE) documents.</li> <li>First draft ACES code of conduct completed</li> <li>Statistical analysis: diversity and gender profiles for ACES members completed.</li> <li>Gender Equity session run at full centre meeting July.</li> </ul>

## GOVERNANCE

The Centre's governance structure aims to ensure the efficient operation of the Centre across multiple locations and is focused on achievement of Centre objectives through specialist committees and advisory groups informing the Centre Executive. The governance arrangements provide the appropriate mix of strategic planning and day to day management and ensure proper engagement with key stakeholders.

Highly effective engagement at many levels has underpinned the success of ACES in tackling the big multidisciplinary research challenges. None of this has been possible without the commitment of highly talented individuals to ACES research, administration, communication, and governance teams.

The ACES governance structure 2014-2016 (p 93, Annual Report 2016) enabled engagement of expertise from across the nodes in global strategy (by the Global Engagement Group (GEG)) and commercial developments (by the Commercialisation Development Group (CDG)). Having fulfilled their purpose these two governance groups ceased to be part of the Centre's formal governance structure in 2017.

The approaches refined by the groups are being utilised going forward through the Research Training and Communications groups. Chairs of the GEG and CDG, Profs Chicharo and Glynn, now sit on the International Advisory Committee with their expertise still available to implement previously agreed strategies across the nodes.

In 2018, ACES established an Equity and Diversity action committee to establish and drive these activities within ACES. The schematic reflects these changes to the governance structure.

#### ACES

Director Prof Gordon Wallace is passionately committed to fundamental research that can be translated into real outcomes for our community. Gordon is ably supported by Prof Maria Forsyth, as Deputy Director, and a strong research leadership team. Senior CIs in their role as research theme leaders on the ACES research strategy group, mentor other CIs as deputy theme leaders who now lead many of the activities within the ACES themes.

- RF Crisitina Pozo-Gonzales, CI A/Prof Patrick Howlett and SRF Caiyun Wang co-ordinate the SES theme meetings, research group discussions and specialised workshops.
- Prof Robert Kapsa and A/Prof Jeremy Crook drive the SBS research activities. Crook also co-heads the Equity and Diversity Committee.
- A/Prof Jennifer Pringle assists in the co-ordination of the EM theme activities.

As we transit to focus our research onto strategic applications, the relevant theme leaders (and deputies) are assuming greater responsibility for communication of findings and dissemination of knowledge accumulated.



#### ACES GOVERNANCE STRUCTURE

#### ACES OPERATIONAL ARRANGEMENTS

The Chief Operations Officer (COO) manages the Centre's day-to-day operations in consultation with the Centre Director and the Chairs from the ACES governance committees, where required. A part time operations manager (0.6FTE) joined the team in late 2017.

The Director and Operations team work daily with the ACES communications and media officers to ensure communication of key messages within the Centre as well as to stakeholders outside the Centre.

#### CENTRE EXECUTIVE COMMITTEE

The Centre Executive Committee oversees the Centre's operations and reviews performance against defined indicators. It is responsible for reporting outcomes to the ARC and other stakeholders and for setting strategic directions and broad budget allocations. The committee is advised by the International Advisory Committee.

ACES appoints CIs and ECRs to the ACES Executive Committee for 12 months as part of the mentoring arrangements within the Centre. ECR Binbin Zhang and CI Jeremy Crook (2015-16); ECR Justin Bourke, RF Natalie Ralph and CI Marc in het Panhuis (2016-17) CI Jun Chen, RF Lijuan Yu and Lauren Hood communications officer (2018-19).

The executive committee met four times in 2018 (February, June, September and December) as well as attended the IAC meeting (February). The committee reviewed and endorsed the activities of its sub-committees (Research Strategy Group, Research Training Group, Communications Group and Equity and Diversity Committee).

#### INTERNATIONAL ADVISORY COMMITTEE

The role of the International Advisory Committee (IAC) provides high level strategic advice to the Centre Director into the positioning of the Centre's activities to secure and retain a position of global leadership in electromaterials science as well as ongoing input into the Centre's research programs.

Members are appointed for an initial term of 2 years, taking into consideration

disciplinary balance, spread and continuity. As indicated in Table 7 the IAC membership group has changed in line with the Centre's transition from building the fundamental knowledge pool of science towards the use of this knowledge to create high impact outcomes in electrofluidics and diagnostics, soft robotics, synthetic energy systems and synthetic biosystems.

Profs Lee Won-Mook and Hans-Joachim Freund completed their terms on the IAC at the February 2018 meeting. ACES sincerely thank them for their valued inputs into the Centre as members of the ACES IAC.

Prof Michel Armand (a highly accomplished researcher in the energy space with extensive experience in translation), Dr Warren King (an independent adviser on the management of R&D and previously Group Executive for IT Manufacturing and Services at CSIRO) and Dr Buzz Palmer (Founder and CEO The Actuator (Australia's National MedTech Accelerator), former CEO of STC Australia, founding partner in Dialectica Group and entrepreneur) were welcomed onto the IAC in 2018.

#### **OPERATIONS GROUP**

The operations group comprises of the DVC (Research) or their appointed proxy from each of the collaborating organisations. The meetings chaired by Dame Bridget Ogilvie (IAC chair) address cross-institutional matters. The Operations Group met on 26 February in 2018 to be apprised of ACES activities.

#### RESEARCH STRATEGY GROUP

The key goal of the Research Strategy Group (RSG) in 2018 was to drive ACES interconnecting theme projects, as well as co-ordinate theme activities to maximise synergies that arise from the diverse skill-sets of the researchers. This group also discussed emerging research opportunities and submitted an expression of interest to the ARC for the establishment of a Centre of Excellence 2020-2027, which was unsuccessful. Chaired by the Centre Director Prof Gordon Wallace, the RSG met February and July in 2018. All current ACES CIs participated in these two meetings.

#### RESEARCH TRAINING GROUP

The ACES Research Training Group (RTG) is responsible for designing,

establishing and implementing an innovative research training and career development / mentoring program, including alerting our members to various industry and web-based programs.

Outside the research it was agreed that the most important contribution ACES could make is in delivering advanced teaching and learning practices; especially in post graduate training. The delivery of the two new Masters courses: Biofabrication and Electromaterials highlight these practices.

The Research Training Group (RTG) met four times in 2018 - April, June, September and December. In addition, the working group for the MPhil Electromaterials and Biofabrication masters had regular meetings throughout the year.

#### COMMUNICATIONS GROUP

The ACES Communication Strategy supports the broad ACES organisational goal of becoming the pre-eminent world centre for electromaterials science research. Awareness and perception play a key role in achieving this goal and as such, a dynamic and effective communications plan is vital to the Centre's success.

The Communications Group discusses issues and strategies around the goal of reaching ACES KPIs and achieving our overall mission as stated in the ACES strategic plan; that is to educate, inspire and engage stakeholders and the broader community, by effectively communicating our research messages.

ACES welcomed two new communications and media officers to the team in July. The communications group met four times in 2018 - February, July, September and December.

ACES outreach efforts involve six key stakeholder audiences (five external to ACES).

The ACES internal community (members and affiliates) is widespread, across 13 institutions worldwide. A 2016 survey found ACES members lack sufficient knowledge of the broader mission of the Centre and its activities. To address this issue ACES has since implemented:

- A monthly 'ACES all' virtual meeting covering the broader ACES researcher aims.
- The communication team runs

#### TABLE 7: ACES IAC MEMBERSHIP

Name	Expertise	Service Years
Dame Bridget Ogilvie (Chair)	CEO Wellcome Trust; Board Director pharmaceutical company AstraZeneca and Lloyds TSB Bank	2005 - ongoing
Prof Ric Kaner (Deputy Chair)	Distinguished Prof at the University of California, Los Angeles (UCLA). World authority on graphene.	2007 - 2013 2016 - ongoing
Prof Michel Armand	Directeur de Recherche at Centre National de la Recherche Scientifique (CNRS); co-leader at CIC energigune (energy co-operative research centre).	2018 - ongoing
Prof Ray Baughman	Director of the MacDiarmid Centre for Nanotechnology, USA. World authority on electromaterials, fibres and actuation.	2005 - ongoing
Prof Joe Chicharo	Deputy Vice-Chancellor (Academic) at UOW; formally DVC (Global Strategy).	2017- ongoing
Prof Robert Cowan	CEO of the HEARing Cooperative Research Centre and HEARworks, its commercial arm. Authority on bioengineering and biomedical research and translation activities.	2016 - ongoing
Prof John Glynn	Emeritus Prof, Sydney Business School, UOW; former Exec Dean, UOW Business Faculty.	2017 - ongoing
Dr Anita Hill	Executive Director, CSIRO Future Industries & Chief Scientist, CSIRO. Authority on electromaterials and nanotechnology and a very experienced board member.	2014 - ongoing
Dr Russell Jones	Bio-MPD Leader, Cell and Gene Therapy Platform, Biopharm R&D, GlaxoSmithKline. Electro- analytical chemistry, expertise in new biomedical venture commercialisation.	2014 - ongoing
Dr Warren King	Chair, Scientific Advisory Board, Cap-XX Ltd and independent adviser on management of R&D at CAP-XX. Previously Group Executive for IT Manufacturing and Services at CSIRO.	2018 - ongoing
Dr Buzz Palmer	Founder and CEO The Actuator (Australia's National MedTech Accelerator), former CEO of STC Australia, founding partner in Dialectica Group and entrepreneur	2018 - ongoing
Dr Jan Weber	Senior technical & management positions within Boston Scientific, a world leading medical company. Experience in development & application of medical devices.	2014 - ongoing
Prof Chung-Yu (Peter) Wu	Prof, National Chiao Tung University, Director Nanotechnology Program, Taiwan. Authority on biomedical and nano electronics with research collaborations with high-tech industries.	2014 - ongoing
Prof Hans- Joachim Freund	Director Fritz-Haber-Institut der Max-Planck-Gesellschaft, Germany. Authority on catalysis and nanostructures, vast experience on scientific and advisory boards.	2014 - 2018
Prof Lee Won- Mook	President Hanbat University, Korea. Authority on bioengineering and more recently involved in 3D printing technology.	2014 - 2018
Dr Ian Dagley	CEO CRC for Polymers, Australia. Authority on polymers and translation activities.	2014-2017
Prof Yoshihito Osada	Former Deputy Director RIKEN Advanced Science Institute, Japan. Expert polymer gels.	2014 - 2017
Prof Daoben Zhu	Former Director at Chinese Academy of Science. Molecular materials/devices expert.	2014 - 2017

targeted educational activities and training sessions at each full centre meeting, with the aim of producing a body of staff and students capable of effectively communicating their work in various contexts.

- A fortnightly internal email newsletter 'ACES news' for staff and students on publications, events and meetings.
- A quarterly end-user stakeholder newsletter. ACES monitors analytics to gauge reach and interest from mailing database.

ACES has been enjoying good media coverage across a number of research topics. Facebook, YouTube, Twitter and LinkedIn platforms all have an increased ACES presence.

#### EQUITY AND DIVERSITY COMMITTEE

This committee was formed in July 2018 to inform ACES Executive on Equity and Diversity issues. The terms of reference for this newly established ACES Governance Committee is "to be responsible for ACES initiatives including a review of ACES Gender Equity Plan and ACES policies including a Code of Conduct that embrace gender equity and diversity. The Committee will initiate training activities on equity or diversity, collect gender and diversity related metrics, and monitor progress on KPIs on an annual basis; reporting to ACES Executive on progress against targets".

The Committee will meet four times

a year and will be made up of an even distribution of gender and node participation where possible along with a student representative. The Committee is Chaired by CI Prof Linda Hancock of Deakin University and co-led by CI A/Prof Jeremy Crook of the University of Wollongong.

In 2018 the committee met six times: twice in July, twice in August, October and November. The major activities of the EDC were:

- Recruitment of ACES members to the committee: five members (Deakin (F), UOW (M), UNSW (F), UOM (M), Operations officer UOW (F) nodes) and a student member (Deakin node (F)).
- Reviewed both CAASTRO (as recommended by the ARC) and Science in Australia Gender Equity Forum (SAGE) documents.
- First draft of an ACES code of conduct to include guidelines for integrating and inclusive practices at conferences, appropriate communication practices, respectful interactions and family friendly options.
- Undertake retrospective statistical analysis on ACES recruitment to core positions.

Employment practices vary between institutions within ACES and position description wording driven by individual University policies and guidelines, which limits ACES ability to effect major changes. ACES will review position descriptions to ensure absence of unintentional bias.

Every ACES node institution has signed up to the SAGE initiative that was established to pilot the United Kingdom's Athena SWAN Charter in Australia. ACES lead node, UOW, was awarded the Athena SWAN Bronze Institution Award from Science in Australia Gender Equity (SAGE), which recognises the University's commitment to gender equality in science, technology, engineering, medicine and mathematics (STEMM) in December 2018.

In depth statistical analysis (for example how many females applied, shortlisted, interviewed and subsequently successful or how diverse were applicants attracted to apply for ACES positions) retrospectively for recruitment to core ACES positions has not been possible. Data available from node Human Resource units was limited, as neither gender nor country of origin are mandatory fields captured during the recruitment process.





## FINANCIAL STATEMENT

#### STATEMENT OF OPERATING INCOME AND EXPENDITURE FOR YEAR ENDED 31 DECEMBER 2018.

INCOME	2018 \$
ARC Centre Grant Funding	3,924,050
Institutional Cash Support	2,380,124
Total income	6,304,174

EXPENDITURE-ARC AND INSTITUTIONAL CASH	2018 \$
Personnel (salaries & stipends)	5,191,467
Equipment	55,483
Travel	493,895
Research maintenance & consumables	450,175
Marketing	56,765
Other (3rd party expert services, administration, outreach)	65,286
Total Expenditure	6,313,071
Net Position	8,897

## OTHER RESEARCH DEVELOPMENTS

ACES members are involved in other research initiatives. In some cases the ACES entity (facilities, personnel and market presence) has enabled the development of these research

initiatives that could not be funded by the Centre of Excellence core funding. A list of some of the other research initiatives is shown in Table 8.

TABLE 8: EXAMPLES OF OTHER FUNDAMENTAL RESEARCH INITIATIVES WHERE ACES MEMBERS ARE INVOLVED

ACES Research Area	Project	Researcher	Funding Body
Energy	2019-2021: Faster interfacial electron transfer: the effect of molecule shape and size.	A/Prof Attila Mozer (ACES); Dr Pawel Wagner (ACES); Dr Andrew Nattestad (ACES AI); A/Prof Shogo Mori; Prof Keith Gordon	ARC Discovery grant DP190100687
Bionics	2019-2021: Bioelectronics: addressing the biointerface challenge.	Dr Damia Mawad; Prof David Officer (ACES); Dr Antonio Lauto; Prof George Malliaras	ARC Discovery grant DP190102560
Energy	2018: ARC Training Centre for Future Energy Storage Technologies	Prof Maria Forsyth (ACES); Prof Dan Li; Prof Douglas MacFarlane (ACES); Prof Abbas Kouzani; Prof Peter Talbot; A/Prof Jennifer Pringle (ACES); A/Prof Patrick Howlett (ACES); Dr Robert Kerr (ACES AI); Prof Saeid Nahavandi; Dr Michael Fielding; et al	ARC Industrial Transformation Training Centre IC180100049
Materials/Energy	2018-2020: Self-powered Active Noise Control via a Nanofibre Acoustoelectric Converter	Tong Lin, Xu Wang (ACES), Jian Fang (ACES)	ARC Linkage
Medical Bionics	2018-2020: Control of Prosthetic Limbs from Decoded Brain Signals	D Freestone; D Grayden, S John; T Oxley; M Cook (ACES); D Ackland; Y Wong	NHMRC Project 1148005
Chemistry	2018-2020: A Universal Chiral Auxiliary for Controlled Radical Polymerisation.	Prof Michelle Coote (ACES)	ARC Discovery grant DP 180100139
Materials/ Bionics	2018-2020: Ultra-low fouling active surfaces.	Prof Simon Moulton (ACES); Prof Robert Kapsa (ACES); Prof Wren Greene (ACES AI); Dr Anita Quigley (ACES)	ARC Discovery grant DP 180102287
Materials	2018-2020: Multifunctional and environmentally friendly corrosion inhibitor systems	Prof Maria Forsyth (ACES); Dr Anthony Somers; Prof Margaret Ackland; Dr Laura Machuca Suarez; Prof Herman Terryn	ARC Discovery grant DP180101465
Medical Bionics	2018: ARC Training Centre in Cognitive Computing for Medical Technologies	T Baldwin; D Freestone; D Grayden; C Masters; K Verspoor; M Cook (ACES); A Burkitt; T Cohn; J Bailey; I Mareels; T Kalincik; A van Schaik; M McDonnell; L Cavedon; J Batstone; S Harrer; N Faux; A Jimeno Yepes; C Butler; B Goudey; U Asif ; J Tang; JH Lau; B Mashford; P Maruff	ARC Industrial Transformation Training Centre IC170100030
Biosynthetic Biosystems	Critical Slowing in Epilepsy	Prof Mark Cook (ACES); Grayden D; Kuhlmann L; Freestone DR; D'Souza W; Burkitt AN	NHMRC Project 1130468

ACES Research Area	Project	Researcher	Funding Body
Chemistry	2017-2021: Controlling chemical reactions via pH-switchable electrostatic catalysis.	Prof Michelle Coote (ACES)	ARC Laureate Fellowship FL170100041
EPPE	2017-2019: Legal and ethical issues in the inheritable genetic modification of humans.	A/Prof Catherine Mills; Dr Karinne Ludlow; Prof Robert Sparrow (ACES); Dr Narelle Warren	ARC Discovery grant DP 170100919
Materials/Fabrication	2017-2019: The true potential and limitations of fibres. This project aims to understand the fibre spinning process of nanomaterials to identify their true potential and limitations in wearable applications.	A/Prof Joselito Razal ; Prof Xungai Wang (ACES); Dr Maryam Naebe	ARC Discovery grant DP 170102859
Materials	2017-2019: Increasing solid electrolyte conductivity through defect design. This project aims to engineer electrolyte materials, based on organic ionic plastic crystals, and use isomeric doping to improve the ionic conductivity.	A/ Prof Jennifer Pringle (ACES); Prof Peter Bruce; Dr Anthony Hollenkamp	ARC Discovery grant DP 170101087
Materials	2017-2019: A project to develop and apply a highly advanced integrated research package in dynamic electrochemistry to molecules of biologically significance and ionic liquids of industrial importance.	Dr Jie Zhang (ACES); Prof Alan Bond (ACES AI); Prof David Gavaghan; Dr Alison Parkin	ARC Discovery grant DP 170101535
Ethics	2017-2019: A project to investigate the legal and ethical implications of technologies that allow inheritable modifications of the human genome	A/Prof Catherine Mills; Dr Karinne Ludlow; Prof Robert Sparrow (ACES); Dr Narelle Warren	ARC Discovery grant DP 170100919
Materials/Energy	2017-2019: Efficient ionic liquid-based reduction of nitrogen to ammonia. This project aims to develop a hybrid ionic liquid- nanostructured electrode platform to electrochemically convert nitrogen gas to ammonia.	Prof Douglas MacFarlane (ACES); Dr Xinyi Zhang; Prof Jun Chen (ACES); Dr Suojiang Zhang	ARC Discovery grant DP170102267
Materials/Energy	2017-2019: A project to synthesise flexible redox gel- electrolyte interpenetrated electrodes for an eco-friendly prototype wearable thermo- electrochemical cell that can power body-worn low-power wearable electronics.	A/Prof Jun Chen (ACES); Dr Leigh Aldous	ARC Discovery grant DP170102320

ACES Research Area	Project	Researcher	Funding Body
Materials/ Characterisation	2017-2019: On-fibre separation science with ambient ionisation mass spectrometry. This project aims to combine fibre-based electrofluidics and ambient ionisation mass spectrometry.	Prof Brett Paull (ACES); Prof Miroslav Macka; Prof Dr Wolfgang Buchberger; A/ Prof Peter Innis (ACES)	ARC Discovery grant DP 170102572
Materials/ Electrofluidics	2016-2019: A high speed, high fidelity 3D printer for fabricating microfluidic devices. This project aims to develop a novel 3D printer offering the highest resolution available and fastest printing speed for the single-step manufacturing of complex microfluidic devices.	Prof M. Breadmore (ACES AI); Dr Rosanne Guijt; Dr Stuart Thickett; Prof Brett Paull (ACES); Mrs Celia Lin	ARC Linkage grant LP160101247 with partner Young Optics Inc
Materials/Energy	2016-2019: Towards high stability, high energy density Na batteries for widespread energy storage	Prof Maria Forsyth (ACES); A/ Prof Patrick Howlett (ACES); Dr Alexey Glushenkov; Prof Michel Armand	ARC Discovery grant DP160101178
Materials	2014-2019: ARC Research Hub for a World-class Future Fibre Industry. This research hub aims to transform the Australian fibre industry into a dynamic sector focused on high-performance and high- value fibres and fibre-based products.	Prof Xungai Wang (ACES) et al	IH140100018
Materials/ Fluidics	2014: ARC Training Centre for Portable Analytical Separation Technologies. The aim is to discover and create new technologies to enable more portable separation science applications.	Prof EF Hilder; A/Prof RA Shellie; Prof PR Haddad; Prof MC Breadmore; Prof B Paull (ACES); Prof PN Nesterenko; Dr RM Guijt	IC140100022
Materials	2012–2017: Protonic materials for green chemical futures By emulating the structures that nature has evolved this project will create novel materials that will be used to develop new sustainable chemical technologies.	Prof DR MacFarlane (ACES)	ARC Laureate FL120100019

# MEMBERSHIP



Lists of ACES members indicating their involvement in the various ACES research themes are below in Tables 9-15.

#### TABLE 9: A LIST OF ACES CHIEF INVESTIGATORS AND PARTNER INVESTIGATORS

Name	Gender	Node	EM	SES	SBS	SR	E&D	EPE
Chief investigators								
Wallace, Gordon	Male	University of Wollongong	~	~	~	~	~	
Officer, David	Male	University of Wollongong	~	~				
Alici, Gursel	Male	University of Wollongong	~			~		
Chen, Jun	Male	University of Wollongong	~	~				
Crook, Jeremy	Male	University of Wollongong	~		~			
Higgins, Michael	Male	University of Wollongong	~		~			
in het Panhuis, Marc	Male	University of Wollongong	~		~	~		
Innis, Peter	Male	University of Wollongong	~				~	
Kapsa, Robert	Male	University of Wollongong	~		~			
Mozer, Attila	Male	University of Wollongong	~	~				
Spinks, Geoffrey	Male	University of Wollongong	$\checkmark$	~		$\checkmark$		
MacFarlane, Douglas	Male	Monash University	$\checkmark$	~				

Name	Gender	Node	EM	SES	SBS	SR	E&D	EPE
Zhang, Jie	Male	Monash University	~	~				
Sparrow, Robert	Male	Monash University						~
Forsyth, Maria	Female	Deakin University	~	~	~			
Howlett, Patrick	Male	Deakin University	$\checkmark$	~		~		
Pringle, Jennifer	Female	Deakin University	$\checkmark$	~				
Wang, Xungai	Male	Deakin University	$\checkmark$					
Hancock, Linda	Female	Deakin University						~
Paull, Brett	Male	University of Tasmania	$\checkmark$				~	
Dodds, Susan	Female	University of Tasmania						~
Cook, Mark	Male	University of Melbourne	$\checkmark$		$\checkmark$			
Coote, Michelle	Female	Australian National University	$\checkmark$	$\checkmark$	$\checkmark$			
Moulton, Simon	Male	Swinburne University of Technology	$\checkmark$		~		$\checkmark$	
Partner Investigators								
Kim, Seon Jeong	Male	Hanyang University, Korea	~			~		
Guldi, Dirk	Male	Friedrich Alexander University, Germany	~					
Watanabe, Masa	Male	Yokohama University, Japan	$\checkmark$	~				
Diamond, Dermot	Male	Dublin City University, Ireland	$\checkmark$				~	
Unwin, Patrick	Male	Warwick University, UK	$\checkmark$	~				

## TABLE 10: A LIST OF ACES RESEARCH FELLOWS, EARLY CAREER RESEARCHERS, ENGINEERS AND TECHNICIANS

Name	Gender	Node	EM	SES	SBS	SR	E&D	EPE
Research Fellows								
Kerry Gilmore	Female	University of Wollongong	~		~			
Paul Molino (0.1FTE)	Male	University of Wollongong			~			
Anita Quigley	Female	University of Wollongong	~		~			
Eva Tomaskovic-Crook	Female	University of Wollongong	~		~			
Pawel Wagner (0.8FTE)	Male	University of Wollongong	~					
Caiyun Wang	Female	University of Wollongong	~	~				
Klaudia Wagner (July-Dec)	Female	University of Wollongong	~		~			
Alexandr (Sasha) Simonov	Male	Monash University	~	~				
Si-Xuan Guo	Female	Monash University	~	~				
Mark Howard (casual)	Male	Monash University						~
Neil Graham McKinnon (casual)	Male	Monash University						~

Name	Gender	Node	EM	SES	SBS	SR	E&D	EPE
FangFang Chen	Female	Deakin University	~	~				
Jian Fang	Male	Deakin University	~					
Cristina Pozo-Gonzalo	Female	Deakin University	~	~				
Natalie Ralph	Female	Deakin University						$\checkmark$
Naomi Haworth (Jan-July)	Female	Australian National University	~					
Lijuan Yu (July-Dec)	Female	Australian National University	~					
Early Career Researchers								
Shaikh Nayeem Faisal	Male	University of Wollongong	~	~				
Chong Yong Lee (Sept-Dec)	Male	University of Wollongong		~				
Yuqing Liu (0.2FTE)	Female	University of Wollongong		~				
Andres Ruland	Male	University of Wollongong	~					
Holly Warren (maternity leave Aug-Dec)	Female	University of Wollongong	~		~	$\checkmark$		
Hao Zhou	Male	University of Wollongong				$\checkmark$		
Andrew Gillett (casual)	Male	University of Wollongong				$\checkmark$		
Yu Chen (casual)	Male	University of Wollongong			~			
Qingsheng Zhang (casual)	Male	University of Wollongong			~			
Jacinta Bakker	Female	Monash University		~				
Maxime Fournier (Max)	Male	Monash University	~	$\checkmark$				
Ciaran Mcdonnell-Worth (Jan-Aug)	Male	Monash University		~				
Tiago Mendes	Male	Monash University		~				
Tamas Oncsik (0.8FTE Nov-Dec)	Male	Monash University		~				
Federico Maria Ferrero Vallana (Oct-Dec)	Male	Monash University		~				
Mary Walker	Female	Monash University						~
Fengling Zhou (Jan-Feb)	Female	Monash University		~				
Diogo Luiz Moulin Cabral (casual)	Male	Monash University		~				
Casper Sean (casual)	Male	Monash University		$\checkmark$				
Yuping Liu (casual)	Female	Monash University		~				
John Taylor (casual)	Male	Monash University		~				
Danah Al-Masri (0.5FTE Jan-Oct)	Female	Deakin University		~				

Name	Gender	Node	EM	SES	SBS	SR	E&D	EPE
Madeleine Dupont (Jan-Feb) recruited to RF position at RMIT	Female	Deakin University		~				
Faezeh Makhlooghiazad (Nov-Dec)	Female	Deakin University		~				
Yafei Zhang (0.5FTE)	Female	Deakin University	~	~				
Joan-Marc Cabot Canyelles (Jan-Aug)	Male	University of Tasmania	~				~	
Umme Kalsomme (July-Dec)	Female	University of Tasmania	~				~	
Vipul Gupta (July-Dec)	Male	University of Tasmania	~				~	
Eliza Goddard (0.8FTE)	Female	University of NSW						~
Justin Bourke	Male	University of Melbourne			~			
Benjamin Noble	Male	Australian National University	~					
Technicians /Engineers/Res	search A	ssistants						
Adam Taylor Fabrication (Jan-June)	Male	Fabrication Engineer University of Wollongong	~	~	~	$\checkmark$	~	
Cathal O'Connell Fabrication (0.2FTE)	Male	University of Wollongong/ ACMD St Vincent's Hospital Melbourne	~		~			
Kalani Ruberu (0.6FTE Jan-Aug)	Female	Bionics technical officer University of Wollongong			~			
Zhigang (Armstrong) Xie (0.2FTE)	Male	Engineer Deakin University	~					
Richards, Laura (0.6FTE Aug-Dec)	Female	Bionics technical officer University of Wollongong			~			
Kita, Magda (0.4FTE April-Dec)	Female	Senior Research Assistant Bionics University of Wollongong at St Vincent's Hospital Melbourne			~			

#### TABLE 11: A LIST OF ACES NON-ACADEMIC POSITIONS

Name	Node	Position	Gender						
Non-Academic Positions									
Toni Campbell	University of Wollongong	Chief Operations Officer	Female						
Vanessa O'Brien (0.6FTE)	University of Wollongong	Operations Officer	Female						
Lisa Hutton (Jan)	University of Wollongong	Communications & Media Officer	Female						
Sian Wright (Jan-May)	University of Wollongong	Communications & Media Officer	Female						
Lauren Hood (July-Dec)	University of Wollongong	Communications & Media Officer	Female						

Name	Node	Position	Gender
Samuel Findlay (July-Dec)	University of Wollongong	Communications & Media Officer	Male
Delvene McKenzie (0.6FTE)	University of Wollongong	Administration	Female
Carin Cinnadaio (0.6FTE, April-Dec)	University of Wollongong	Administration	Female
Sona Shekibi (0.2FTE)	Deakin University	Administration	Female
Jacqui Sandilands (Jan-May)	Deakin University	Administration	Female
Helen Woodall (0.5FTE)	Deakin University	Administration	Female
Gary Annat (0.4FTE, Jan-July)	Monash University	Administration	Male
Aimee Scott (0.3FTE)	University of Tasmania	Administration	Female
Naomi Morter (0.4FTE)	University of Melbourne	Administration	Female

## TABLE 12: A LIST OF ACES POSTGRADUATE STUDENTS WORKING ON CORE CENTRE RESEARCH AND SUPERVISED BY CENTRE STAFF IN 2018

Name (Start Year)	Funding Source	Project Description	Node	Country of Origin	Program Theme	Gender		
Core Funded ACES projects								
Eli Abdell Massih (2017)	ACES	Control system for robotic hand	University of Wollongong	Lebanon	SR	Male		
Joshua Brooks (2016)	APA	Development of high aspect ratio ordered thermoplastic nano-materials as print media for 3D additive fabrication	University of Wollongong	Australia	EFD/EM/ SR	Male		
Zhi Chen (2015)	ACES	Bio inks for stem cells	University of Wollongong	China	EM/SB	Male		
Inseong Cho (2017)	ACES	Developing new asymmetric redox mediators with large difference in forward / backward electron transfer rates	University of Wollongong	Korea	EM/SES	Male		
Kyle Guerrieri-Cortesi (2018)	ACES	Modelling schizophrenia using 3D bioprinted neural tissues	University of Wollongong	Australia	SBS	Male		
Hadis Khakbaz (2016)	UPA	Development of high nanofilled (aspect ratio ordered) bio-thermoplastics as print media for 3D additive fabrication.	University of Wollongong	Iran	EM/EFD	Female		
Jianfeng Li (2015)	ACES	Electrical stimulation cell effects-molecular markers.	University of Wollongong	China	SB	Male		

Name (Start Year)	Funding Source	Project Description	Node	Country of Origin	Program Theme	Gender
Gerardo Montoya (June 2018)	ACES	Integration of sensing technology into soft robotic hand	University of Wollongong	Mexico	SR	Male
Alex Nagle (2015)	ACES	Nano-printing	University of Wollongong	Ireland	EM	Male
Aida Shoushtari Zadeh Naseri (2017)	UPA	3D electrical stimulation in hydrogels	University of Wollongong	Iran	EM/SBS	Femal
Bijan Shekibi (2017)	ACES	Design of an integrated multi-well cell culture system for functional tissue constructs	University of Wollongong St Vincent's Hospital Melbourne	Australia	SB	Male
Charbel Tawk (2016)	ACES	Actuators, sensors and support for robotic hand	University of Wollongong	Lebanon	SR	Male
Liang Wu (2015)	ACES	Detection systems for diagnostics	University of Wollongong	China	EFD	Male
Shuai Zhang (Feb 2018)	ACES	Flexible thermoelectrochemical cells	University of Wollongong	China	SES	Male
Thomas Blesch (2018)	ACES	Non aqueous flow batteries	Monash University	Germany	SES	Male
Manjunath Chatti (2015)	ACES	Photo-processes-MoS <sub>2</sub> nanosheets integrated into graphene matrix for enhanced hydrogen evolution	Monash University	India	EM/SES	Male
Shuo Dong (2017)	ACES	Redox couples for flow batteries	Monash University	China	SES	Male
Hoang Long Du (2017)	ACES	Nanostructured catalysts for electrochemical ammonia synthesis	Monash University	Malaysia	EM/SES	Male
Rebecca Hodgetts (2017)	АРА	Understanding the mechanism of electrocatalytic nitrogen reduction	Monash University	Australia	SES	Female
Cuong Ky Nguyen (Sept 2018)	ACES	Photoelectrocatalytic production of ammonia	Monash University	Vietnam	SES	Male
Mary Kalani Erangi Periyapperuma Achchige (2015)	ACES	Energy storage for soft robotics	Deakin University	Sri Lanka	SES/SR	Female
Srdjan Begic (2014)	ACES	Characterisation and modelling of 3D electrolytes & active metal interphases	Deakin University	Yugosalvia	EM/SES	Male
Mathew Cherian (2015- 2018 Part time)	ACES	Global development, community development and energy	Deakin University	India	EPPE	Male
Laura Garcia Quintana (2017)	ACES	Enhancement of oxygen reduction mechanism in sodium air batteries	Deakin University	Spain	SES	Female
Name (Start Year)	Funding Source	Project Description	Node	Country of Origin	Program Theme	Gender
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Dmitrii Rakov (2018)	ACES	Characterisation and modelling electrolytes and interface for Na-Oxygen batteries	Deakin University	Russia	SES	Male
Linda Wollersheim (2018)	ACES	Assessing policy and supply chain aspects of renewable energy	Deakin University	Germany	EPPE	Female
Sidra Waheed (2015)	ACES	3D fabricated micro-fluidic manifolds – design and characterisation	University of Tasmania	Pakistan	EFD	Female
Anna Blum (2016)	ACES	Ethical challenges for electromaterials and neuroscience: the benchtop brain	University of NSW	USA	EPPE	Female
Catherine Simpson (2016-Maternity leave Part time 2018)	ACES	Nitroxides for energy	Australian National University	Australia	EM/SES	Female
Nicholas Hill (2017)	ACES	Modelling 3D spatial effects on radical orbital switching and associated properties, and indeed electric field effects on chemical reactions in general	Australian National University	Australia	EM/SES	Male
Lilith Caballero Aguilar (2015)	ACES	3D printing of drug delivery structures	Swinburne University	Mexico	SBS	Female
Daniela Duc (2015)	ACES	Materials design and fabrication of effective optical and electrical co- stimulation of cells	Swinburne University	Mauritius	SBS	Female
Shaun Gietman (2015)	ACES	Synthesis of optically active drug delivery systems	Swinburne University	Australia	EFD/ SBS	Male
Masters students						
Karmjeet Kaur Buttar (2017)	IPTA	Electromaterials masters	Deakin University	India	SES	Female
Mehmood, Irfan (2018)	IPTA	MPhil Electromaterials - Photocatalytic water splitting using novel electromaterials	University of Wollongong	Pakistan	EM/SES	Male
Shahshahan, Sayedmohsen (2018)	IPTA	MPhil Electromaterials- Development of 2D Metal Organic Frame (MOF) for Photocatalytic CO <sub>2</sub> Reduction	University of Wollongong	Iran	EM/SES	Male
Affiliate ACES proje	ects					
Al-Ghazzawi, Fatimah (2016)	Iraqi Govt	New metal-organic interfaces- new photo-active interfaces for catalytical chemistry and/or energy harvesting/conversion applications	University of Wollongong	Iraq	EM	Female

Name (Start Year)	Funding Source	Project Description	Node	Country of Origin	Program Theme	Gender
Al-Graiti, Wed (2014)	Iraqi Govt	Development of functionalised nanoporous carbon fibre electrodes for probe-sensing technology	University of Wollongong	Iraq	EM	Female
Chao, Yunfeng (2015)	CSC	Fabrication of graphene- based composites for energy storage application	University of Wollongong	China	EM/SES	Male
Chen, Xifang (2016)	UOW-VSS matching	Ulvan fabrication for wound healing	University of Wollongong	China	EM/SBS	Female
Daikuara, Luciana Yumiko (2016)	UOW-IPRI- IHMRI matching	Fabricating delivery system for wound healing- thread based electrofluidics	University of Wollongong	Brazil	EM/SBS	Female
Fan, Yuchao (2017)	UOW-IPRI matching	Hybrid bioprinted cartilage scaffold based on cellulose nanocrystals reinforced GelMA/HAMA hydrogel	University of Wollongong	China	SBS	Female
Hou, Yu (2016 – withdrew Jan 2018)	UOW-IPRI matching	Develop printable delivery systems, bioinks and bioprinting protocols for islet transplantation	University of Wollongong	Mongolia	SBS	Female
Hai, Abdul Moqeet (2018)	HEC scholar- ship with ACES topup	Fabrication of silk-based structures for corneal application	University of Wollongong	Iraq	SBS	Male
Kang, Lingzhi (2016)	UOW- St Vincents Hospital Matching	Biofabricated platforms (based on collagen) for skin repair and regeneration	University of Wollongong	China	EM/SBS	Female
Khan, Jawairia Umar (2017)	Pakistan HEC & IPTA	Fibre electrofluidics for ambient ionisation mass spectrometry	University of Wollongong	Pakistan	EFD	Female
Kuppanacharry, Praneshwar Sethupathy (2017)	UPA	Developing new architectures for redox- based energy processes	University of Wollongong	India	EM	Male
Maher, Malachy (2018)	UOW- CSIRO scholar- ship	Development and evaluation of new biologically based materials for bioprinting cells	University of Wollongong	Australia	SBS	Male
Posniak, Stephen (2018)	Australian Govt Research Training Program (AGRTP)	Development of 3D printed hybrid structures for cartilage reconstruction	University of Wollongong	Australia	SBS	Male
Qin, Chunyan (2017)	UOW-IPRI- IHMRI matching	Injectable electrodes - bipolar electrochemical chips for wireless cell stimulation driven by electric field	University of Wollongong	China	EM/SBS	Female

Name (Start Year)	Funding Source	Project Description	Node	Country of Origin	Program Theme	Gender
Rahim, Siti Abdul (2014)	Malaysian Gov't & ACES	- Studying schizophrenia using induced pluripotent stem cells and conductive biomaterials	University of Wollongong	Malaysia	SBS	Female
Stephens-Fripp, Benajmin (2017)	RTP	A minimally invasive interface between a prosthetic hand and its user	University of Wollongong	Australia	SR	Male
Vijayakumar, Amruthalakshmi (2016)	IPTA	N-doped graphene for electrocatalytic reduction of CO <sub>2</sub>	University of Wollongong	India	EM/SES	Female
Wang, Kezhong (2018)	UOW-IPRI matching	Graphene-based soft electrodes	University of Wollongong	China	EM	Male
Xiao, Yang (2015)	ΙΡΤΑ	The synthesis and characterisation of photoactive materials and their use in the chemopropulsion-based fluidic transport systems.	University of Wollongong	China	EM	Male
Yu, Changchun (2014)	CSC/ACES	Functional batteries for cellular communications	University of Wollongong	China	SES/SBS	Female
Zarghami, Sara (2016)	ARC DP	Development and study of chemopropelled cargo- carrying vehicles in fluids.	University of Wollongong	Iran	EM	Female
Zhou, Ying (2017)	UPA	Development of multifunctional bioinks for 3D printing cellular constructs	University of Wollongong	China	SBS	Female
Zou, Jinshuo (Sept 2017)	UOW-IPRI matching	Electrocatalytic nitrogen reduction at ambient temperature and pressure	University of Wollongong	China	SES	Female
Kang, Colin (2016)	APA	Electrochemical reduction of nitrogen gas to ammonia	Monash University	Australia	SES	Male
Mudiyanselage, Isuru Eranda Gunathilaka Adikari (2018)	Deakin	Studying novel redox systems for electrochemical devices by magnetic resonance spectroscopy and imaging	Deakin University	Sri Lanka	SES	Male
Ha, The An (2017)	AISRF	Na-Air cells	Deakin University	Vietnam	SES	Male
Adesanya, Olumayowa (2017)	UTAS	The legal and ethical aspects of bioprinting	University of Tasmania	Nigeria	EPPE	Female
Mladenovska, Tajanka (2016)	UOM	Innovation, commercialisation and regulation of 3D-BioPrinted surgically implantable orthopaedic medical devices	University of Melbourne	Macedonia	SBS/EPE	Female
Ngan, Catherine (2015)	UOM	3D muscle constructs for ablated muscle injury and robotics tissue-electrode interfaces	University of Melbourne	Australia	SBS	Female

Name (Start Year)	Funding Source	Project Description	Node	Country of Origin	Program Theme	Gender
Affiilate Masters Pr	ojects					
Kuan Phang Chan	IPTA	MPhil Biofabrication - 3D Printing for Bone Regeneration	University of Wollongong	Malaysia	SBS	Male
Narangerel Gantumur	IPTA	MPhil Biofabrication- Encapsulation of VEGF for islet transplantation	University of Wollongong	Mongolia	SBS	Female
Sulokshana Marks	IPTA	MPhil Biofabrication- Development of nanostructured cellulosic inks for wound healing application	University of Wollongong	Sri Lanka	SBS	Female
Joanne Williams	IPTA	MPhil Biofabrication - 3D printing controlled drug delivery systems	University of Wollongong	Australia	EM/SBS	Female
Diego Castaneda Gray	EU-Biofab project	MPhil Biofabrication- 3D printed degradable stents with controlled drug delivery capabilities	Utrecht University / UOW	Mexico	SBS	Male
Laura Blanco Peña	EU-Biofab project	MPhil Biofabrication-3D printing flexible electrodes	Utrecht University / UOW	Spain	EM/SBS	Female
Max Renes	EU-Biofab project	MPhil Biofabrication- Towards the fabrication of pancreatic islet tissue constructs through co-axial bio-printing	Utrecht University / UOW	Nether- lands	EM/SBS	Male
Gilles van Tienderen	EU-Biofab project	MPhil Biofabrication- Towards an innervated in vitro 3D corneal tissue model	Utrecht University / UOW	Nether- lands	SBS	Male
Gregor Weisgrab	EU-Biofab project	MPhil Biofabrication- Novel fabrication methods for collagen-based implantables for the cornea	Utrecht University / UOW	Austria	EM/SBS	Male
Stefan Zaharievski	EU-Biofab project	MPhil Biofabrication- 3D printed drug delivery systems – towards a dual drug infused membrane for treatment of epilepsy	Utrecht University / UOW	Macadonia	SBS	Male
Marius Berthel	EU-Biofab project	MPhil Biofabrication- Dual drug-eluting collagen matrix for epilepsy treatment	Wurzburg University/ UOW	Germany	SBS	Male
Maxim Brodmerkel	EU-Biofab project	MPhil Biofabrication- 3D printed degradable stents with controlled drug delivery capabilities	Wurzburg University/ UOW	Germany	SBS	Male
Markus Ebert	EU-Biofab project	MPhil Biofabrication-3D printed graphene-flexible electrodes	Wurzburg University/ UOW	Germany	EM/SBS	Male

Name (Start Year)	Funding Source	Project Description	Node	Country of Origin	Program Theme	Gender
Anne Gruska	EU-Biofab project	MPhil Biofabrication- Parameter optimisation of co-axial melt extrusion writing.	Wurzburg University/ UOW	Germany	EM	Female
Hannah Haag	EU-Biofab project	MPhil Biofabrication- 3D printed structures for cartilage growth in predestined shape with high resolution.	Wurzburg University/ UOW	Germany	SBS	Female
Juliane Kade	EU-Biofab project	MPhil Biofabrication- 3D hybrid printed structures for auricular cartilage regeneration	Wurzburg University/ UOW	Germany	SBS	Female
Karolina Biernacka	ACES living allowance	European Materials for Energy Storage and Conversion Masters	Deakin University (6 month internship)	Poland	SES	Female
Aleksandra Grzelak	ACES living allowance	European Materials for Energy Storage and Conversion Masters	Deakin University (6 month internship)	Poland	SES	Male

#### TABLE 13: ACES WORK SUBMITTED FOR EXAMINATION 2018

Name	Project Description	Node	Country of Origin	Program Theme	Gender
Cody Wright ACES PhD	Electro-printing	University of Wollongong	USA	EM	Male
Tom Barsby ACES PhD	Electrical stimulation 3D structures – stem cell effects	University of Wollongong St Vincent's Hospital Melbourne	UK	SB	Male
Fahimeh Mehropouya ACES PhD	Polymeric nanodispersion and growth factors	University of Wollongong	Iran	EM/SB	Female
Jaecheol Choi ACES PhD	Electrocatalytic reduction of CO <sub>2</sub>	University of Wollongong	Korea	EM/SES	Male
Christina Puckert ACES PhD	Cell-material interac- tions using Bio-AFM	University of Wollongong	Germany	EM/SB	Female
Ying (Sherry) Zhang ACES PhD	Utilisation of CO <sub>2</sub> as C1 building block for elec- troorganic synthesis in ionic liquids	Monash University	China	SES	Female
Changlong Xiao ACES PhD	3D structural control of ionic conduction	Monash University	China	EM/SES	Male
Abuzar Taheri ACES PhD	Integrating 3D materials in thermoelectrics- new solid and liquid electrolytes and 3D electrocatalysts for thermal energy harvesting	Deakin University	Iran	SES	Male

Name	Project Description	Node	Country of Origin	Program Theme	Gender
Masters Studen	t				
Thomas Robinson MPhil Biofabrication	Corneal tissue engineer- ing with methacrylated gellan gum	University of Wollongong	Australia	EM/SBS	Male
Farzad Shahangi MPhil Biofabrication	3D printing polycapro- lactone structures and modelling and finite element analysis of the internal structure to predict properties of auricular structures	University of Wollongong	Iran	EM	Male
Affiliate Student	S		`		
Javadi, Seyed	Developing graphene oxide based composite materials capable of acting as a temperature sensor	University of Wollongong	Iran	EM	Male
Salahuddin, Bidita Binte	Hydrogel McKibben artificial muscles	University of Wollongong	Bangladesh	SR	Female
Zhang, Long	Electrostatic control over radical reactions at solid/liquid interfaces	University of Wollongong	China	EM	Male
Yong Zhao	CO2 reduction on Copper Metal or Copper Oxide electrodes	University of Wollongong	China	EM/SES	Male
Viana, John	Ethical issues involved in recruiting people with dementia for clinical trials	University of Tasmania	Philippines	EPPE	Male

#### TABLE 14: SUCCESSFUL COMPLETIONS ACES 2014-2018

Name	Degree	Project Description	Node	Program Theme	Gender	What was next?
2015						
Keira Grierson	Honours International Bachelor of Science		University of Wollongong	SBS	Female	
2016	2016					
Benjamin Noble	Affiliate PhD	Study stereoregulation in radical polymerization	ANU	EM	Male	ECR ACES
Richmond Lee	Affiliate PhD	Studying reactive oxygen chemistry and its role in oxidative degradation in materials and biology	ANU	EM	Male	Research Singapore
2017						
Ken Chun	Core PhD	Develop novel nanoporous metals for electrochemical applications	Monash University	SES	Male	

Name	Degree	Project Description	Node	Program Theme	Gender	What was next?
Danah Al- Masri	Core PhD	New redox couples and ionic liquid electrolytes for thermal energy harvesting	Deakin University	SES	Female	ECR Deakin University
Reece Gately	Affiliate PhD	3D printed robotic hand	University of Wollongong	SR	Male	
Xiaoteng Jia	Affiliate PhD *awarded 2017 outstanding self financed student abroad.	Biodegradable electrodes for energy storage applications in medical bionics	University of Wollongong	EM/SES	Male	ECR in Centre of Excellence for Nanoscale BioPhotonics Macquarie University
Qi Gu	Affiliate PhD *awarded 2017 outstanding self financed student abroad.	3D Bioprinting for neural tissue engineering	University of Wollongong	EM/SBS	Male	ECR at Chinese Academy of Sciences
Danial Sangian	Affiliate PhD	Developing a new type of McKibben artificial muscles	University of Wollongong	SR	Male	Alexander von Humboldt Postdoctoral Fellow, Technical University of Berlin, Germany
Shannon Bonke	Affiliate PhD	APA- Co-, Mn- and Ni-oxides from various preparation methods will be examined electrochemically for conversion of solar energy to drive the synthesis of solar fuels	Monash University	SES	Male	Post doctoral Hermholtz Zentrum Berlin
Simon Maksour	Awarded First Class Honours	Establishing a novel human neural stem cell model for DISC1 loss-of-function: a valuable tool in molecular studies of neurogenesis and psychiatric disorders	University of Wollongong	SBS	Male	
2018						
Fengwang Li	ACES PhD *Mollie Holman award best thesis	Photoelectrocatalytic and electrocatalytic reduction of CO <sub>2</sub> using novel 2D mate- rials	Monash University	SES	Male	Post Doc University of Toronto, Canada
Diogo Cabral	ACES PhD	Novel redox couples for redox flow batteries	Monash University	SES	Male	
Dijon Hoogeveen	ACES PhD	Dye-Sensitized photocathodes catalysing light driven reduction	Monash University	EM/SES	Male	
Jun (Rossie) Rao	ACES core PhD	3D nanostructured electrolytes	Deakin University	EM	Female	
Tian Zheng	UOW matching scholarship Affiliate PhD	Development of magnetoelectric polymer composites	University of Wollongong	EM/SBS	Female	ECR Melbourne University

Name	Degree	Project Description	Node	Program Theme	Gender	What was next?
Yan Zong	Self funded Affiliate PhD	Development of biocompatible and biodegradable magnetoelectric electrodes for remote and contactless electrical stimulation of neural tissue	University of Wollongong	EM/SBS	Male	Post doctoral China
Vipul Gupta	Affiliate PhD	New composite and micro/ nanostructured materials for chemical analysis	University of Tasmania	EFD	Male	ECR ACES
Feng Li	Affiliate PhD	Microfluidic devices with integrated nanochannels for sample-in/answer-out analysis of pharmaceuticals from body fluids.	University of Tasmania	EFD	Male	
Ahmed Halima	Monash Scholarship	Novel Si-based photocathode assemblies.	Monash University	SES	Male	
Zan Lu	CSC Scholarship	Carbon nanotube fiber and its application in garment and wearable sensors	University of Wollongong	EM/SES	Male	
Yu Ge	UPA Core funded project PhD	Graphene and its inorganic analogues based materials for energy storage device	University of Wollongong	EM/SES	Male	Postdoctoral China
Syamak Farajikhah	ACES core PhD	Sensor systems for fluidics	University of Wollongong	EM/EFD	Male	ECR University of Sydney
Shazed Md Aziz	Affiliate PhD	Polymer fibre artificial muscle	University of Wollongong	EM/SR	Male	
Yuqing Liu	Affiliate PhD	Flexible 3D electrodes via extrusion-printing for flexible and wearable device	University of Wollongong	EM	Female	ECR ACES UOW
Haitao Li	ALF	Develop several different kinds of photocatalysts with excellent properties to convert the CO <sub>2</sub> into fuel or other useful chemicals.	Monash University	SES	Male	
Charles Hamilton	ACES Masters Cored funded	Printable tough, thermally- active hydrogel actuators	University of Wollongong	SR	Male	Doing medical degree US
Mathew Russo	ACES MPhil Electromaterials	Development of quasi- solid state electrolytes for thermal energy harvesting	Deakin University	SES	Male	
Sarah-Sophia Carter	MPhil Biofabrication masters	Development of bioprinting platforms for bioartifical pancreas constructs	Utretch University / UOW	SBS	Female	Netherlands
Sylvia van Kogelenberg	MPhil Biofabrication masters	Fabrication of ulvan based structures for cell culture in wound healing	Utretch University / UOW	SBS	Female	Netherlands
Sam Rathbone	Honours Bachelor of Science	The stimulating application of nanoparticles in neural stem cells	University of Wollongong	SBS	Male	PhD ACES affiliate

TABLE 15: ASSOCIATE INVESTIGA	TORS 2018 WITH ACES	ACKNOWLEDGEMENT	OR DEEDS
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Name	ACES Node	AI affiliation	Program Theme	Al RF or Al
Beirne, Stephen	University of Wollongong	UOW, Australia	EM- fabrication	AI RF
Ciampi, Simone	University of Wollongong	UOW, Australia	EM	AI RF
Esrafilzadeh, Dorna	University of Wollongong	RMIT, Australia	EM/SBS	AI RF
Foroughi, Javad	University of Wollongong	UOW, Australia	EM	AI RF
Forster, Robert	University of Wollongong	Dublin City University, Ireland	EM/SBS	AI
Harris, Alex	University of Wollongong	UOW, Australia	EM/SBS	AI RF
Huang, Xu-Feng	University of Wollongong	UOW, Australia	SBS	AI
Jalili, Rouhollah (Ali)	University of Wollongong	RMIT, Australia	EM	AI RF
Kim, Byung Chul (Benny)	University of Wollongong	UOW, Australia	SES	AI RF
Liu , Xiao	University of Wollongong	UOW, Australia	EM/SBS	AI RF
Molino, Paul	University of Wollongong	UOW, Australia	EM	AI RF
Morrin, Aoife	University of Wollongong	Dublin City University, Ireland	EM/SBS/EFD	AI
Mukherjee, Payal	University of Wollongong	UOW, Australia	EM/SBS	AI
Mutlu, Rahim	University of Wollongong	UOW, Australia	SR	AI RF
Nattestad, Andrew	University of Wollongong	UOW, Australia	EM/SES	AI RF
Oetomo, Denny	University of Wollongong	University of Melbourne, Australia	SR	AI
Sencadas, Vitor	University of Wollongong	UOW, Australia	SR	AI RF
Sutton, Gerard	University of Wollongong	UOW, Australia	EM/SBS	AI
Yue, Zhilian	University of Wollongong	UOW, Australia	SBS	AI RF
Zhang , Binbin	University of Wollongong	Yokohama National University, Japan	EM/SBS	AI RF
Azofra, Luis	Monash University	Monash, Australia	SES	AI
Bond, Alan	Monash University	Monash, Australia	SES	AI
Sun, Chenghua	Monash University in 2018 moved to Swinburne University of Technology	Monash, Australia	SES	AI
Atobe, Mahito	Monash University	Yokohama National University, Japan	SES	AI
Fukuda, Junji	Monash University	Yokohama National University, Japan	SES	AI
Hutchison, Katrina	Monash University	Adjunct Monash & Macquarie University, Australia	EPPE	AI
Greene, Wren (George)	Deakin University	Deakin, Australia	SBS/EFD	AI
Kerr, Robert	Deakin University	Deakin, Australia	SES	AI RF
O'Dell, Luke	Deakin University	Deakin, Australia	EM	AI RF
Zhu, Haijin	Deakin University	Deakin, Australia	EM	AI
Mecerreyes, David	Deakin University	Polymat-University of the Basque Country, Spain	EM/SES	AI
Breadmore, Michael	University of Tasmania	UTAS, Australia	EFD	AI



Name	ACES Node	AI affiliation	Program Theme	Al RF or Al
Gilbert, Frederic (DECRA )	University of Tasmania	UTAS, Australia	EPPE	AI RF
Lewis, Trevor	University of Tasmania	UTAS, Australia	EFD	AI
Nesterenko, Pavel	University of Tasmania	UTAS, Australia	EFD	AI
Neilsen, Jan	University of Tasmania	UTAS, Australia	EPPE	AI
Thickett, Stuart	University of Tasmania	UTAS, Australia	EFD	AI
Thomson, Colin	University of Tasmania	UOW, Australia	EPPE	AI
Choong, Peter	University of Melbourne, Australia	University of Melbourne, Australia	SBS	AI



Name	ACES Node	Al affiliation	Program Theme	AI RF or Al
DiBella, Claudia	University of Melbourne	University of Melbourne, Australia	SBS	AI
Duchi, Serena	University of Melbourne	University of Melbourne, Australia	SBS	AI
Onofrillo, Carmine	University of Melbourne	St Vincents Hospital, Melbourne, Australia	SBS	AI RF
McArthur, Sally	Swinburne University of Technology	Swinburne University of Technology, Australia	EM/SBS	AI
Stoddard, Paul	Swinburne University of Technology	Swinburne University of Technology, Australia	EM/SBS	AI

# **2019 ACTIVITY PLAN**

### **GOAL 1: RESEARCH**

#### FROM 2019-2020 RESEARCH MILESTONES

Utilise the knowledge gained in fluidics and diagnostics, synthetic energy systems, synthetic biosystems and soft robotics – specifically to:

- Develop devices for CO<sub>2</sub>/N<sub>2</sub> reduction based on novel 3D electrode configurations
- Develop the 'brain on a bench' system specifically targeted at understanding development of schizophrenia and epilepsy
- Develop a soft robotic hand that integrates sensing components
- Develop strategies to address ethical, policy and regulatory issues that arise from technical advances in each of these areas

## THEMES

#### **ELECTROMATERIALS**

Milestone EM11: Provided optimised materials to the application theme projects.

Milestone EM12: Developed a functionalised biogel for 3D fabrication.

Milestone EM13: Understood the effects of electric fields and electrolyte composition on electrochemical processes. Case studies will have included  $O_2$  redox processes for Na-air batteries and the electrochemical generation of radicals and ions from alkoxyamines.

Milestone EM14: Evaluated the photochemistry of existing initiators for 3D-printing applications.

Milestone EM15: Provided optimised materials to the application theme projects.

Milestone EM16: Provided catalysts for CO<sub>2</sub> and N<sub>2</sub> reduction.

#### **ELECTROFLUIDICS AND DIAGNOSTICS**

Milestone EFD5: Delivered integrated 3D microfluidic platform for study and monitoring of electro, thermal and optical stimulated controlled delivery of drugs from hydrogels.

Milestone EFD6: Developed first generation integrated microfluidic/electrofluidic bench-top platform for culture and study (chemical stimulation and electrochemical observation) of neural cells, for application in the investigation and understanding of neural disorders, beginning with epilepsy.

#### SYNTHETIC ENERGY SYSTEMS

Milestone SES5: Finalised design for optimal performance of devices for:

- ightarrow A Solar driven CO<sub>2</sub> or N<sub>2</sub> Reduction Cell
- A Sodium-air Battery and
- A Thermoelectrochemical cell

Complete and characterise the first stage device prototypes.

#### SYNTHETIC BIOSYSTEMS

Milestone SBS5: Established Working 3D Neural Function Modelling Platform.

# SOFT ROBOTICS FOR PROSTHETIC DEVICES

Milestone SR4: Integrated pressure and other sensors into the multi-digit 3D robotic prosthetic hand.

#### ETHICS, POLICY AND PUBLIC ENGAGEMENT

Milestone EPPE4: Identified the epistemic and ethical limitations of randomised clinical trials for regulation and approval of personalised medicine.

#### **GOAL 2: RESEARCH TRAINING**

DURING 2019: Continue to refine training programs in end-user engagement and science communications. Engage researchers in building the engagement network through contributions to the end-user newsletter, events and translational projects.

# GOAL 3: TRANSLATION COMMERCIALISATION

END 2019: Implement commercial engagement plans for:

- Soft Robotics
- ► CO<sub>2</sub>/N<sub>2</sub> reduction
- 3D Bioprinting

## **GOAL 4: GLOBAL ENGAGEMENT**

2019-2020: Continue to develop international collaborative research opportunities with newly established international alliances.

#### **GOAL 5: COMMUNICATIONS**

END 2019: Implement plans for new Science Centre exhibits. ONGOING ANNUAL EVENTS:

- Host the annual Bill Wheeler Student Award for 'Bionics' research.
- Host a Science Week event.
- Host Leon-Kane Maguire public lecture

# SUPPLEMENTARY INFORMATION



#### APPENDIX 1: ACES RESEARCH TRAINING AND MENTORING EVENTS 2018

Rese	Research Training and Mentoring Events / Meetings 2018		Venue	Attendees
1.	<b>Centre of Excellence Showcase at ICONN2018.</b> The showcase provided the opportunity for ICONN participants to meet the researchers, discuss collaborative opportunities and gain insight into capabilities throughout the day. A special poster session was held to further encourage interactions- between COEs as well as international researchers.	29 Jan	UOW Northfields Ave Campus Wollongong	150
2.	ACES Networking event A social networking event talking all things ACES.	4 Feb	Novotel Wollongong	55 – All ACES members or affiliates
3.	ACES Full Centre Meeting. Included a two hour workshop run by Positive Psychology Coach, Jody Cooper, on "Presentation Skills".	5-6 Feb	iC campus UOW Wollongong	130 – All ACES members or affiliates
4.	<b>Clinical Connections workshop.</b> Biofabrication students had the opportunity to hear from and network with clinicians, as well as present their research for discussion.	7 Feb	iC campus UOW Wollongong	60 – 13 collaborators – 4 ACES CIs – 1 ACES RF – 2 ACES AI – 3 industry – 27 ACES PhD or masters or affiliated students – 10 clinicians
5.	ACES Electrofluidics and Diagnostics face-to-face meeting for researchers from UOW, Swinburne, University of Melbourne, St Vincents Hospital Melbourne and University of Tasmania.	1 Mar	University of Tasmania	16 - 4 ACES CI - 10 ACES PhD or affiliated PhD - 2 ACES AIs
6.	<b>Dementia Stem Cell Workshop.</b> In conjunction with IHMRI ACES hosted this workshop to start discussion about funding strategies and to plan for a larger meeting on dementia research. Tours were conducted by ACES staff to showcase: Biopolymers for Bioinks, Processing Cells for Bioinks, 3D printing ears, 3D printed structures containing islets and Customised printers - biopen and iFix system.	16 Mar	IHMRI and tours of iC campus UOW Wollongong.	22 – 15 ACES PhD, ECR, Cls – 4 IHMRI UOW PhD, SRF – 3 Finland 1 Prof, 2 Masters – New Zealand 1 PhD
7.	Antimicrobial and Biofouling Resistant Materials – Academic and Industry Engagement and Planning Workshop. This ACES event had speakers from Industry (included Enware, DSTG, Greencorp Marine), Academia and Government Agencies (ANFF, CSIRO).	7 Jun	iC campus UOW Wollongong	38
8.	-The <b>"Science" of Collaboration Workshop</b> where topics included: – Collaborating to Realise Commercial Opportunities – Collaborating with Schools to Develop STEM Skills – Ethicists Collaborating with Scientists – Collaborating Across the Globe to Realise Local Opportunities –Is There a Collaboration "Science"?	8 Jun	iC campus UOW Wollongong	94 - 7 ACES CIs - 4 ACES RFs - 2 ACES ECRs - 10 ACES AIs - 39 ACES PhD, masters or affiliated PhD - 10 students non- ACES - 19 academics non- ACES - 3 industry

Rese	arch Training and Mentoring Events / Meetings 2018	Date	Venue	Attendees
9.	<b>Entrepreneurship and Innovation Certificate Course.</b> This intensive week of lectures and coursework kicked off the 2018 program. Over the next nine months the teams refine their project and pitch culminating in a presentation to a panel of experts.	18-23 Jun	Sydney Business School Sydney	26 – 8 Masters – 7 PhD – 4 ECR – 7 Mentors
10.	ACES Science Communications Training. The training run by the professional company, Science in Public, was a half day workshop with press panel and make a pitch sessions. The panel of working journalists from print, TV, and radio told ACES about what they do, and what they look for in a story. The panel then introduced the needs and challenges of TV news, radio, and the daily press. Participants pitched their story to their colleagues and received expert feedback.	18 Jul	Swinburne, Melbourne	18 - 2 ACES CI - 12 ACES or affiliate PhD - 2 SRF ACES - 5 RF outside ACES - 2 PhD outside ACES
11.	SBS face to face planning meeting.	18 Jul	St Vincent's Hospital Melbourne	14
12.	ACES Full Centre Meeting. A student committee, comprising of 7 members from Swinburne, Deakin, Monash and UOW/St Vincent's nodes, led the planning and organisation of the meeting. The ACES student committee chaired all the mentoring sessions. Session topics including: 'PhD Strategies for Success', 'Networking', 'student-supervisor relationships', 'Careers after PhD' and 'Gender Equity'. 8 theme 'burster' talks were given with representation from across all the ACES Themes and Nodes.	19-20 Jul	Swinburne, Melbourne	90 – All ACES members or affiliates
13.	Editor of Wiley Visit to ACES. Former ACES UOW PhD student and now Editor of Wiley, Dr Bo Weng, returned to IPRI to give an invited seminar to pass on her experiences since her PhD and to explain to the current ACES PhD students/ECRs what they should be working towards in order to get published. After completing her thesis, 'Inkjet Printing of Conducting Polymers', in 2012, Dr Weng left UOW ACES in 2013 to work as Associate Professor at Southwest University for three years before joining Wiley in Beijing as Editor of Advanced Materials, Advanced Energy Materials, Macromolecular Journals and Journal of Applied Polymer Science. Dr Weng also visited Melbourne ACES nodes before heading back to Beijing.	3 Aug	iC campus UOW Wollongong	36 - 15 ACES or ACES affiliated PhD - 8 Biofab masters - 4 CIs - 3 RFs - 6 other students
14.	<b>Biologic electrical impedance spectroscopy (EIS) workshop.</b> Delivered by Bill Eggers, the founder and President of Biologic USA this workshop covered the use of biologic instruments and EC-lab software to collect and analyse electrical impedance spectroscopy data, instrumental capabilities as well as data analysis techniques.	15 Aug	Deakin University Burwood	17 – ACES PhD and ECRs in addition to academics outside ACES.
15.	ACES Electrofluidics and Diagnostics face-to-face meeting for researchers from UOW, Swinburne, University of Melbourne, St Vincents Hospital Melbourne and University of Tasmania.	12 Oct	University of Tasmania	14
16.	ACES Workshop 'Processing Cells for Bioprinting'	17 Oct	St Vincent's Hospital Melbourne	25 – 8 Als – 4 Cls – 2 ACES RF – 1 ACES ECR – 4 ACES PhD – 3 ACES affiliate PhD – 3 students

Rese	arch Training and Mentoring Events / Meetings 2018	Date	Venue	Attendees
17.	Advanced Drug Delivery Workshop	22 Oct	iC campus UOW Wollongong	41
18.	<b>Nitrogen Reduction Catalysis Workshop.</b> A face-to-face meeting to discuss the challenges and approaches for this research activity.	20 Nov	Monash University and virtual	23
19.	Advanced Electrochemical Methods Workshop. Young researchers who already have experience in electrochemical analysis and were keen to advance their experimental and modelling skills to the next level were targeted to participate in this course. Training over the two days was split 75:25 experimental:modelling. Topics included: - Forgotten electrochemical skills - Electrochemical Impedance Spectroscopy - Cyclic voltammetry and chronamperometry for electrocatalysts and other electomaterials - Demonstrating the power and limitations of FT ac voltammetry	20 & 21 Nov	Run concurrently at 2 ACES nodes Monash University Clayton and UOW Wollongong	10 – 8 ACES PhD and 2 ECR students
20.	Impedance and Related AC Methods in Electrochemistry Masterclass. The objective of the course was to provide advanced lectures, seminars and hands-on experiments for scientists who use or wish to use electrochemical AC & impedance methods for their academic research or industrial applications. A strong emphasis of the course was the small group teaching methods, supported by Cambridge and Monash University academics and invited experts in the area, to train participants in the use of 'state-of-the-art' electrochemical techniques. *Course was directed by ACES AI Prof Alan Bond and ACES CI Dr Jie Zhang, Monash University, Dr Adrian C Fisher, University of Cambridge and Dr Sivanesan Arumugam, Metrohm Australia.	5-6 Dec	Monash University	Limited to 20 people
21.	<b>Drug Delivery Mini symposium</b> with collaborators at IHMRI, Wollongong hospital and ACES members at UOW and Swinburne to discuss advanced drug delivery.	10 Dec	iC campus UOW Wollongong	10
22.	<b>ACES Collagen Workshop.</b> An ACES and affiliate brainstorm for researchers utilising collagen. From sources, processability, forward onto bioengineering using co-compaction, electro-compaction and electrochemical compaction.	13 Dec	iC campus UOW Wollongong + virtual	21 – 3 ACES CIs – 4 ACES RF/ECR – 5 ACES AIs – 7 ACES PhD or affiliate students
23.	<ul> <li>ACES Scientific Writing Workshop. This one on one workshop was designed for attendees to:</li> <li>gain information on the publication process, instructions to authors, reviewing, co-authoring</li> <li>learn how to plan papers in a coherent way</li> <li>understand the purpose of the various sections within a paper</li> <li>the appropriate language to be used when writing in each section</li> <li>present results clearly (both written and visually)</li> <li>acquire the language to be able to discuss the work of others critically including expressing clear comparisons to other published works in the field.</li> </ul>	17 Dec	Deakin University Burwood	9 - 3 ACES PhD - 6 other PhD
24.	ACES Printer Design and Fabrication Workshop. A workshop into new ACES-ANFF 3D bioprinting developments including the use of computational chemistry in designing new inks and printing strategies. Customised printer requirements for 2019 were dicussed.	18 Dec	iC campus UOW Wollongong and virtual	34

Rese	Research Training and Mentoring Events / Meetings 2018		Venue	Attendees
25.	Monthly ACES Theme meetings for the following themes: Electromaterials, Synthetic Energy Systems, Synthetic Biosystems, Electrofluidics and Diagnostics, Soft Robotics and Ethics, Public Policy and Engagement	Mar-Dec	Virtual – video link	
26.	<b>Monthly ACES All meetings</b> includes: hot 'research' topic presentation by an ACES senior researcher; Graphic of the month and researcher introductions.	Mar-Dec	Virtual – video link	

# APPENDIX 2: ACES CROSS-NODAL INTERACTIONS 2018

Cross-nodal visits/ interactions are reported for when members travel between ACES nodes to undertake multidisciplinary research, which includes brainstorming, project meetings, or access to laboratories to undertake research tasks. These visits are additional to ACES support provided to attend targeted workshops or ACES events/conferences.

ACES	6 Cross-nodal Interactions 2018
1.	Bourke, J (2018) ACES RF UOM visited Monash University for paper writing and experimental planning 2 days per week on average throughout January-March.
2.	Periyapperuma, K. (2018) ACES PhD Deakin 3D printing collaboration visit with ACES RF UTAS Niall MacDonald to finalise H-cell design, January.
3.	Kaur, Karmjeet (2018) EM masters student Deakin visited ACES UOW AI Lee to work on graphene composite materials, Wollongong, 7 January - 2nd March.
4.	Ms Ellie Stepaniuk, 3rd year exchange student from the Department of Chemistry, University of Warwick, was hosted by ACES Monash to work on research training in the area of electrochemical CO <sub>2</sub> reduction, 2018.
5.	Kim, Seong Jung (2018) ACES PI Hanyang University visited ACES UOW for a week to discuss collaborative research and attend the ACES Full Centre meeting and Clinical Connections workshop, 5-12 February.
6.	Pozo-Gonzalo, C (2018) ACES RF Deakin visited ACES RF UOW C Wang at UOW regarding free standing air cathodes based on conducting polymers, 4-6 February.
7.	Guo, S (2018) ACES RF Monash visited ACES AI UOW Alex Harris at UOW to undertake a laboratory visit and discuss research, 5 February.
8.	Blum, A (2018) ACES PhD UNSW visited ACES UOW RF Tomaskovic-Crook, to discuss brain organoids and 3D bioprinting of neural tissue, 6 February.
9.	Geitman, S (2018) ACES PhD Swinburne visited ACES UOW to network and collaborate with researchers and clinicians at the Clinical connections workshop, 7 February
10.	Garcia-Quintana, L (2018) ACES PhD Swinburne met with ACES AI Monash Prof A Bond regarding Chronoamperometry experiments and CVs of mixtures, 13 February.
11.	Pozo-Gonzalo, C (2018) ACES RF Deakin visited by ACES AI Monash Prof Alan Bond to discuss the mechanism for cathodic processes in oxygen reduction, 13 February.
12.	Diamond, D (2018) ACES PI DCU visited ACES UTAS to give a lecture on "biomimetic microfluidics", 15 February.
13.	Guo, S (2018) ACES RF Monash met with ACES CI Deakin Pringle to discuss application of POM thermocell and experiment on synthesis of reduced form of POM, 16 February.
14.	Gupta, V (2018) Affiliate PhD UTAS visited ACES CI UOW R Kapsa, ACES CI Swinburne S Moulton, ACES RF UOM J Bourke and ACES RF UOW A Quigley, at St Vincent's Hospital Melbourne to discuss 'Brain on a chip' project, 19 February.
15.	Shekibi, B (2018) ACES PhD UOW visited ACES CI Paull CI UTAS to modify the NeMo device to meet the design brief, 19 February.
16.	Officer, David (2018) ACES CI travelled to Deakin University Burwood to discuss ACES research activities and the ACES COE bid, 19 February.

ACES	Cross-nodal Interactions 2018
17.	Guo, S (2018) ACES RF Monash met with ACES ECRs Al-Masri to undertake the experimental synthesis of reduced form of POM, 20 February.
18.	Pozo-Gonzalo, C (2018) ACES RF Deakin visited by ACES CI UTAS Prof Brett Paull regarding 3D printing of H- cell for flow cell applications and high surface area metals, 27 February.
19.	Bourke, J (2018) ACES UOM RF was at ACES Monash writing collaboration papers, 1-15 March.
20.	Danielle Bruen (2018) PhD student Dublin City University PI Diamond's group studied at ACES UOW developing glucose sensors by 3D printing from 6 March- 16 May.
21.	Officer, David (2018) ACES CI travelled to Deakin University Burwood to discuss ACES research activities and the ACES COE bid, 7 March.
22.	Kalsoom, Umme (2018) ACES ECR travelled to Deakin University Burwood, with CI Brett Paull, to discuss ACES research activities, March.
23.	Si-Xuan Guo and Jie Zhang (2018) from Monash University continued visits and held ongoing collaboration meetings on the POM redox couple with ACES CI Deakin J Pringle, April.
24.	Mozer, A (2018), ACES CI UOW, and UOW EM masters students Mehmood Irfan and Mohsen Shahshahan, visited Deakin University to assist with the joint Deakin –UOW Electromaterials Master's laboratory practice and tutorials, 16-20 April.
25.	Officer, D (2018), ACES CI UOW, visited ACES PI Prof Dermot Diamond's laboratory to plan research project for visiting PhD student Sara Zarghami and attend joint ACES/DCU symposium, INSIGHT Centre, Dublin City University, Dublin, 25 April – 27 April.
26.	Pringle, J (2018) ACES CI Deakin visited ACES RF ANU Benjamin Noble to discuss modelling of thermocell systems, 26-27 April.
27.	Shekibi, B. (2018) ACES PhD UOW visited Melbourne University to work with ACES AI Denny Oetomo on collaborative efforts, 8 May.
28.	Zhao, Y (2018) Affiliate PhD UOW met with ACES CI Monash Doug MacFarlane and Dr Bryan Suryanto at Monash to work on nitrogen electroreduction performance of rGO-Au composites, 27 May to 1 June.
29.	Cabot, JM (2018), ACES RF at University of Tasmania, visited ACES partner Dublin City University (DCU), Ireland to undertake collaborative research on electrotactic droplets chemical reaction, microencapsulation, and sensing, 28 May - 26 July.
30.	Higgins, M (2018) ACES CI UOW visited Prof Dermot Diamond, Dublin City University, Ireland to present at the 'Bioinspired 3D Structures' symposium at Dublin City University and attend a networking event at the embassy. Whilst in Dublin, he visited research groups at Trinity College Dublin (CRANN) and University College Dublin (Conway Institute for Biomolecular and Biomedical Research), 30 May-3 June.
31.	Hancock, L (2018) ACES CI Deakin and Ralph, N. ACES RF Deakin attended ethical renewable energy and biomedical entrepreneurship workshop provided as part of the course, Certificate of Entrepreneurship and Innovation, ACES and Sydney Business School, University of Wollongong, Sydney, 21 June.
32.	Goddard, E (2018) ACES RF UNSW met with CI UNSW Susan Dodds, RF UOW Eva Tomaskovic-Crook and CI UOW Jeremy Crook at UOW to discuss development in argumentation technologies and to undertake revisions of paper on brain organoids, 12 June.
33.	Goddard, E (2018) ACES RF UNSW met at UOW with RF Monash M Walker, CI UOW G Alici and ACES affiliate PhD B Stephens-Fripp to discuss paper on ethical analysis of prosthetic hand users, 15 June.
34.	Williams, J (2018) ACES UOW Masters Biofabrication visited UOM CI Mark Cook and RF J Bourke, UOW CI Rob Kapsa, and ACES Als Cathal O'Connell and Serena Duchi, to tour the BioFab3D lab and discuss collaboration opportunities, 25 -27 June.
35.	Officer, D (2018), ACES UOW CI visited ACES PI Prof Dermot Diamond's laboratory to review research project of visiting ACES affiliate PhD student Sara Zarghami, INSIGHT Centre, Dublin City University, Dublin, 28 - 29 June.
36.	Wagner, P (2018) ACES UOW SRF visited ACES PI Prof Dermot Diamond INSIGHT Centre, Dublin City University and and Dr Florea Trinity College Dublin to work on advanced microfluidics, 28 June – 1 July.
37.	ACES AI Junji Fukuda and Binbin Zhang, from ACES partner university Yokohama National University, visited ACES UOW and ACES Swinburne, 15 – 27 July 2018.
38.	Gilmore, K (2018) ACES UOW RF visited ACES members at St Vincents Hospital Melbourne for collaborative discussions in the synthetic biosystems theme, 18 July.

E.

ACES	Cross-nodal Interactions 2018
39.	Gietman, S (2018) ACES PhD Swinburne visited ACES UOM at St Vincent's Hospital Melbourne for disucssions on biosystems research activities, 18 July.
40.	Pozo-Gonzalo, C (2018) ACES RF Deakin and ACES PhD Deakin K Periyapperuma met with B Paull CI UTAS on 3D printing of H cell for flow cell applications and high surface area metals, 19 July.
41.	Garcia-Qunitana, L (2018) ACES PhD Deakin visited ACES Monash to discuss chronoamperometry experiments with ACES AI Prof Alan Bond, 25 July.
42.	Pozo-Gonzalo, C (2018) ACES RF Deakin worked with A Bond (Monash) on mechanism for cathodic processes in oxygen reduction, 25 July.
43.	ACES Als Claudia Di Bella, Cathal O'Connell, Serena Duchi and Carmine Onofrillo, University of Melbourne, visited ACES- ANFF to update and progress the biopen project, 30 August 2018.
44.	Molino, P (2018) ACES AI UOW travelled to partner organisation DCU to discuss with ACES PI Dermot Diamond and Dr Margaret McCaul collaborative research with industry partner Enware on developing sensors, 3-5 September.
45.	Zou, Jinshou (2018) ACES affiliate PhD UOW visited and took material samples to test for nitrogen reduction with the ACES team at Monash University, Melbourne, 1-3 October.
46.	Gietman, S (2018) ACES PhD Swinburne visited ACES UTAS node and presented an update on his work towards the 'Brain- on-a-bench milestone project', 12 October.
47.	Goddard E, Dodds S (2018) ACES EPPE members UNSW held a meeting (video conference) to discuss ethical status of human brain organoids, 18 October.
48.	McCaul, M (2018) DCU academic visited ACES UOW to continue discussions with ACES and our industry partner Enware on developing sensors, 18 October.
49.	Pringle, J (2018) ACES CI Deakin visited ACES UOW to discuss the printing of thermocell device prototypes, 22 October.
50.	ACES CI UOM Mark Cook and ACES CI Swinburne Simon Moulton, visited ACES UOW for the controlled drug delivery workshop and get an updated lab tour of the new TRICEP facilities, 22 October 2018.
51.	Spinks, Geoff (2018) ACES CI UOW visited ACES PI Prof Kim at Hanyang University, Seoul, South Korea, and gave a seminar on artificial muscles and Soft Robotics, 29-31 October.
52.	Zhang, Jizhen (2018) PhD Deakin University visited ACES UOW to work on "Wearable Supercapacitors", 5-30 November. The trip was supported by ANN long-term visit program.
53.	Faisal, Shaikh Nayeem (2018) ACES UOW RF visited and provided samples to the ACES team at Monash University for analysing nitrogen reduction, 19-20 & 23 November.
54.	Officer, David (2018) ACES CI visited ACES Monash to examine materials synthesised at UOW for nitrogen reduction, 19 November.
55.	Officer, David (2018) ACES CI visited ACES Deakin to discuss ANFF ionic liquid synthesis and graphene use in batteries, 20 November.
56.	Caballero Aguilar, Lilith (2018) ACES PhD Swinburne at ACES UOW to undertake research into core/shell printing of microspheres for drug delivery applications; specifically to produce composite scaffolds by coaxial extrusion and melting-cooling dual extrusion and test 3D printing parameters, 3-13 December.
57.	Lei Yan, Sena Ozawa & Yoshiki Tate, students from Yokohama National University, Japan were hosted at ACES UOW for 1 week working on the electrical stimulation of hair follicle cells with polypyrrole, tissue origami and cell printing; electrical cell detachment and hair regeneration, 13-18 December 2018.
58.	MacFarlane, D (2018) ACES CI Monash has fortnightly meetings at ACES Deakin for thermocell and battery research discussions.
59.	Pringle, J (2018) ACES CI Deakin visits the ACES node at Monash fortnightly for meetings, with ACES CIs, discussing student research progress and to discuss progress towards ACES milestones in the SES theme.
60.	Bond, Alan (2018) ACES AI Monash visits ACES Deakin bimonthly for research discussions and to progress collaborative projects within the SES theme.

#### APPENDIX 3: END-USER VISITS TO ACES 2018

End-l	Jser and Industry Visits to ACES in 2018
1.	ACES Deakin hosted intern Naoto Saito from Toyota for 12 months to progress collaborative projects, 1 January 2018- 1 January 2019. Fellow collaborator Fuminori Mizuno from Toyota visited ACES Deakin also throughout the year.
2.	Grant McAdam and Wayne Neil, DSTG, visited ACES Deakin fortnightly throughout 2018 to progress collaborative research projects.
3.	Dr John Chiefari, CSIRO, has fortnightly meetings at ACES Deakin throughout 2018 to progress collaborative research projects.
4.	Justin Walters and Zoran Manev, Boron Molecular, visited ACES Deakin several times throughout 2018 for collaborative project discussions.
5.	Dylan Thorpe from SMR automotive Visited ACES UOW to discuss experiments and design on the biopen, 24-25 January 2018.
6.	Colleen Riley, Rob Wood, Rob Carter, Jose Moctezuma, Ulrich Buehner from Styker visited ACES at UOW to discuss collaborative opportunities in bioprinting and sensor technologies, 1 February 2018.
7.	Mr Jiaquan Zhang and Dr Ming Liu, Peiyang Future Technologies P/L, visited ACES Deakin for discussions, 2 February 2018.
8.	Prof SC Kim; Prof J Choi; Prof IK Shim & Prof C Hwang from ASAN Medical Center in Korea, visited ACES at UOW to discuss collaborative research activities in the area of 3D Bioprinting 7 February 2018.
9.	Dr Joe Varga, Dr Noel Dunlop, ANT Energy Solutions, visited ACES at Monash to finalise a CRC project to design a new electrolyser device on the basis of ACES research, 8 February.
10.	Dean Smith, AGL, visited ACES at Monash to finalise the ARENA project application to design new electrodes for water splitting on the basis of ACES research, 20 February.
11.	Prof Thomas Kay, Director ACMD facility at St Vincents Hospital Melbourne, visited ACES UOW to discuss 3D printing of islet cells, 7 March 2018.
12.	Dr Jerry Barker, Faradion, UK held two teleconferences with ACES Deakin to progress collaborative projects, 15 March and 31 August 2018.
13.	ACES UOW hosted a delegation from Slintec in Sri Lanka which included the Consul General of Sri Lanka Sydney Lal Wikrematunge, CEO SLINTEC Harin De S Wijeyratne, Chief of Research and Innovation Prof Gehan Amaratunge, Senior scientist Dr Shehan de Silva and Head of Business Development Dr Lakshitha R Pahalagedara, to view the facilities and discuss 3D bioprinting, 20 March 2018.
14.	David Robinson and Tracey Cameron from Mudjala Medical Facility, The Colony Texas visited ACES UOW for a tour of the facilities and discussion of industry collaboration for electrospinning fibres, 12 April 2018.
15.	Vanessa Peterson, ANSTO, visited ACES UOW to review the facilities and discuss areas of potential research collaboration, 17 April 2018.
16.	ACES AI, Dr Robert Kerr attended a luncheon on behalf of ACES and BatTRIhub organised by the Australia-Israel Chamber of Commerce Melbourne and guest speaker was Mr Andy Vesey, Managing Director & CEO, AGL Energy Limited, 26 April 2018.
17.	Dawn O'Neil, director of Verdant Company, visited CI MacFarlane and RF Simonov at ACES Monash to discuss implementation of the Monash University water splitting technologies into their electrolyser devices for sanitisation, 30 April.
18.	Moulton, S (2018), ACES CI Swinburne held preliminary discussion with companies, Magellan Stem Cells (Melbourne) and Seevix Materials Science Pty Ltd (Israel) with a view towards research collaborations, April-May 2018.
19.	Advanced Nano-Technologies P/L meeting at Monash University with ACES CI MacFarlane, 24 April 2018.
20.	ETR Solar meeting at Monash University with ACES CI MacFarlane, 16 May 2018.
21.	Glen Waverley and Ed Wilson, Wilsons Transformers, met with ACES Deakin researchers to progress collaborations, 16 May and this was followed up with visits by Robert Wilson, Mohinder Pann and Yuriy Odarenko in 2018.
22.	Veronica Glattauer, CSIRO, visited ACES UOW to tour the facilities and for research discussions, 23 May 2018.

End-	Jser and Industry Visits to ACES in 2018
23.	Tim Hughes, CSIRO, visited ACES UOW to tour the facilities and for research discussions, 24 May 2018.
24.	Bruce Godfrey, Wyld Group Pty Ltd visited ACES Deakin for collaborative research discussions, 25 May 2018.*Several other visits followed during 2018.
25.	Prof Leszek lisowski and PhD student Jay Ward, Children's Medical Research Institute, Sydney visited ACES UOW to tour the facilities and hold research discussions, 28 May 2018.
26.	Dr Wes Henderson, US Army Research Office, USA, visited ACES Deakin, 28 May 2018.
27.	Doug Newton, Questacon, visited ACES UOW to tour the facilities, 6 June 2018.
28.	Yasuhiro Nishimura from the Honda Research Institute visited CI Spinks at ACES UOW to discuss collaborative research projects, 18 - 28 June 2018.
29.	Neil Wilson, Romar, visited ACES UOW to discuss customised PDMS printers, 19 June 2018.
30.	Tamer Mohamed, Aspect Biosystems, Canada, visited ACES UOW to give a presentation and hold collaborative talks, 25 June 2018.
31.	Eric Gatenholm, CEO Cellink, collaboration visit to ACES node at St Vincent's Hospital Melbourne, 27 June 2018.
32.	Stuart Nettle, Swellnet, visited ACES UOW for discussions on research and lab tour, focusing on 3D printing equipment for use in surfing research, 27 June 2018.
33.	Akira Ohno, Mitsubishi Chemical Holdings Group at The Kaiteki Institute Japan visited CI Spinks at ACES UOW to tour the facilities and discuss technology trends with a view to future collaborations, 2 July 2018.
34.	Tomohiro Mori, Industrial Technology Center of Wakayama, Japan, visited ACES UOW for a lab tour and discussions regarding photon upconversion project, 6 July 2018.
35.	Yaoxuan Zhang, Neware, China, visited ACES UOW and held discussions with SRF Wang, 16 July 2018.
36.	Prof Robert Cowan, Director Hearing CRC, visited ACES UOW for research discussions, 25 July 2018.
37.	Courtney Potter, 3D Fins, visited ACES UOW for a facilities tour, 3 August 2018.
38.	Bo Weng, editor Wiley, visited ACES UOW to give a seminar and had discussions with researchers, 3 August 2018.
39.	David Howard and team, CSIRO Brisbane, hosted at ACES UOW to tour the facilities and for soft robotic research discussions, 23 August 2018.
40.	ACES Monash University hosts the Ammonia Energy Association - Australian Chapter. Online meetings were held 30 August and 6 December (attendance approx. 30 in each case).
41.	Dr Dave Danielson, CEO Breakthrough Energy Ventures, visited ACES at Monash to discuss commercialisation options for ACES ammonia developments, 3-4 September.
42.	David Wiseman, Southern Prosthetics and Orthotics visited ACES UOW for discussions in testing the prosthetic hand, sensors feedback and other research associated with the soft robotic hand, 4 September 2018.
43.	Lance Smith, InKorr, visited ACES Deakin and BatTRIhub facilities, 7 September 2018.
44.	Mark Mills, Generation Investment Management, UK, visited ACES UOW for a tour of facilities, including TRICEP, 25 September 2018.
45.	Greg Dicinoski and the team from Reserve Bank Australia (RBA) visited ACES UOW to discuss the collaboration project progress, 25 September 2018.
46.	Ewa Kapera from Perkin-Elmer met with ACES members at UOW to discuss a potential collaborative partnership, 11 September and 2 October.
47.	Dr Laura Raymond, SCION, visited ACES ANU for research discussions, 3-4 October 2018.
48.	Gita Rahardjo from ANSTO visited ACES UOW for ethic committee discussions around in vivo testing of samples, 4 October 2018.
49.	Rupert Partridge, Urbnsurf, visited ACES UOW and the 3D printing team for a facilities tour, 15 October 2018.

End-	User and Industry Visits to ACES in 2018
50.	Zhi Li, Concord Hospital, met with ACES UOW to discuss collaboration opportunities and participate in a lab tour, 7 November 2018.
51.	David Wiseman, Southern Prosthetics & Orthotics, and Thomas Much, Ottobock Australia met with ACES Soft Robotics team exploring the possibility of a research collaboration on robotic prosthetic hands, 30 November 2018.
52.	Dr Peter Nesvadba, BASF Switzerland, visited ACES ANU for research discussions, 17 December 2018.
53.	Iris Degenhardt, Hepburn Wind, meeting to discuss various German community energy projects and policy changes, regulatory environment at ACES Deakin, 3 November 2018.
54.	Yufei Wang SuprG Energy Pty Ltd, Herbert Ho Sensorplex Pty Ltd, Simon Savage Ionic industries Ltd, Peter Buss Sentek Pty Ltf, Richard Brodribb M Brodribb Pty Ltd, Peter Voight Cleantec Ltd, Tim Macpherson Raedyne Systems Pty Ltd, Iratxe de Meatza Cidetec and Andrew Rider DSTG toured the facilities at ACES Deakin and the BatTRIhub as part of an ITTC workshop, 21 November 2018.
55.	Cherian, Matthew (2018) ACES PhD Deakin was interviewed by DG Sunil Misra Electrical Energy Chamber of Commerce, New Delhi, November.
56.	Armand Atanacio, ANSTO, visited ACES UOW for collaborative research discussions, 4 December 2018.
57.	Shinji Hasegawa, Asahi Kasei Corp, Japan, visited ACES UOW to tour the facilities and hold collaborative research opportunities, 11 December 2018.
58.	Chameen Samarawickrama, clinician from Westmead and Liverpool Hospitals and University of Sydney, visited ACES UOW to discuss project opportunities relating to the work on the a corneal glue, as presented at Cornea Bioengineering meeting at Sydney Eye Hospital, and 3D printing of nerve scaffolds, 14 December 2018.

# APPENDIX 4: GOVERNMENT AND NON-GOVERNMENT ORGANISATION INTERACTIONS 2018

Government and Non-Government Organisation Interactions 2018		
1.	Sparrow, R. (2018) ACES CI Monash, provided peer review of ACOLA report on "Synthetic biology in Australia: an outlook to 2030".	
2.	Howlett, P (2018), Deakin University gave a presentation at the "Science Meets Parliament" Forum in front of Members of Parliament including Australia's Chief Scientist followed by a meeting with Pat Conroy MP, Canberra, 13-14 February.	
3.	Senator Zed Seselja, Assistant Minister for Science, Jobs and Innovation, toured ACES UOW where the importance of the fundamental research - fabrication-translation - manufacturing pipeline was illustrated using specific examples of biopen for cartilage regeneration and 3D printed ears to treat microtia, 21 February 2018.	
4.	Wallace, G (2018) ACES CI UOW '3D Printing, Bioprinters & Clinical Application' at the NSW Science & Research Breakfast Seminar, NSW Parliament House, Sydney, Australia, 21 February 2018.	
5.	Cherian, M (2018) ACES PhD Deakin met with funders in the International Aid, Disaster Resilience sector including President of the Bill and Melinda Gates foundation in India, April.	
6.	A delegation from China, hosted by Austrade, toured the facilities of ACES UOW, 17 May 2018.	
7.	Chris Armstrong, Acting NSW Chief Scientist visited ACES at UOW for a tour of facilities and research discussions, 23 May 2018.	
8.	Hon Simon Birmingham, Minister for Trade, Tourism and Investment, visited ACES UOW for a tour of facilities, 23 May 2018.	
9.	Amanda Caples, Victorian Government Chief Scientist, site visit to ACES node at St Vincent's Hospital Melbourne, 17 July 2018.	
10.	Lord Mayor Bradbery, Wollongong City Council, visited ACES UOW for lab tours during Science week, 13 August 2018.	
11.	Cherian, Matthew (2018) ACES PhD Deakin undertook relief work during the Kerala floods India and held meetings with Sphere Group, HelpAge and Government of Kerala, 20-30 August 2018.	

Gove	rnment and Non-Government Organisation Interactions 2018
12.	Howlett, Patrick (2018) ACES CI Deakin attended Senate Select committee on Electric Vehicles, 31 August 2018.
13.	Susan Fitzgerald, Deputy Secretary Prime Minister's office, and a contingent of guests, site visit to ACES node at St Vincent's Hospital Melbourne, 5 September 2018.
14.	Nik Guruprasad, Victorian Department of Economic Development, Jobs, Transport and Resources with a Singapore Industry Delegation had a site visit to ACES node at St Vincent's Hospital Melbourne on 3 October 2018. Included in the delegation were: – Joshua Lim (Mgr Enterprize, National Health Innovation Ctr) – Adrian Ang (CEO, AEvice Health) – Leong Man Chun (Product Dev Mgr, Clearbridge Health) – Johnny Teo (Director, Healthcare & Biomed and NE Asia & Oceania, Enterprize, Singapore) – Timothy Chua (Regional Director, NE Asia & Oceania, Enterprize Singapore) – Gladys Leong (Snr Dev Partner, Healthcare & Biomed, Enterprize Singapore) – Eunice Chew (Business Dev Mgr, Trendline Medical Singapore) – Victoria Quek Si Min (Asst Mgr, Biomed Cluster, JTC Corp) – Brian Cheung (Programme Mgr, CoNEX Systems and Services) – Chevlin Lee, (Snr Investment Director, Government of Victoria) – Dr Jackie Watts (Councillor, Knowledge City Chair, City of Melbourne)
15.	Martyn Myer AO, President, Myer Foundation, had a site visit to ACES node at St Vincent's Hospital Melbourne on 5 October 2018.
16.	Dr Sharma, Kalam Institute of Health Technology (Department of Biotechnology, Government of India Project), India, visited ACES UOW to tour the facilities, 9 October 2018.
17.	Parliamentary State Secretary Thomas Rachel and a senior delegation from the German Federal Ministry of Education and Research (BMBF) visited ACES at Monash for a tour of the hydrogen research laboratory, 22 October.
18.	Bruce Thompson, Innovation Connections, had a TRICEP facilities tour, 7 November 2018.
19.	Sangeetha Krishnamoorthy, Austrade India, met with ACES UOW to opportunities and explore synergies for 3D Bioprinting activities in India, 7 November 2018.
20.	Forsyth, M (2018) ACES CI Deakin gave a talk 'Australia (Deakin) French relationships and collaboration' as well as a meet and greet with the French Ambassador, Melbourne 20 November.
21.	Senator Brian Burston, United Australia Party, visited ACES UOW as part of a larger tour of UOW Innovation campus, 21 November 2018.
22.	Cherian, Matthew (2018) ACES PhD Deakin presented to NDMA and World Bank on Kerala Floods in New Delhi, November.
23.	Cherian, Matthew (2018) ACES PhD Deakin was interviewed by Maj General Rana, Director General National Disaster Rescue Force (NDRF), New Delhi, November.
24.	Peter Masterson and Denise Eaton, Austrade, visited ACES UOW to look at Austrade's global network, and identify the level and type of support that can be extended to ACES, 10 December 2018.

#### APPENDIX 5: ACES OUT AND ABOUT INTERACTING WITH INDUSTRY 2018

ACES Out and About Interacting with End-Users and Industry in 2018		
1.	Forsyth, M (2018), ACES CI Deakin University, visited Dr Jerry Barker at Faradion, a world leader in non-aqueous sodium- ion cell technology, UK, 17 January.	
2.	Hancock, Linda (2018) ACES CI Deakin is an appointed board member of Hepburn Wind Farm; Board, Finance & Risk committee, Future Generation Working Group meetings. Meetings were held: 24 January 24, 13 & 22 March, 16 & 27.	
3.	Forsyth, M (2018) ACES CI Deakin meeting with Prof Brian Kinsella and Dr Andrew Bell at Curtin University with their industry partners (Chevron, Woodside, INPEX) to tal about collaborative opportunities, 30 January.	
4.	Forsyth, M (2018) ACES CI Deakin attended a Defence workshop, Curtin University, 31 January.	

ACES	ACES Out and About Interacting with End-Users and Industry in 2018		
5.	ACES soft robotics team (2018) visited Prince of Wales Hospital, Department of Rehabilitation Medicine (Dr Greg Bowring), to inform the clinic practitioners about our project on prosthetic hand, and explore the possibility of accessing their clients to receive their feedback on or research on ACEs prosthetic hand, 15 February, 6 September and 15 November.		
6.	Williams, J (2018) Masters Biofab student UOW gave a presentation "3D Printing Sound" at Cochlear HQ, Macquarie University, Australia, 6 March. * <b>Open to all staff</b>		
7.	Williams, J (2018) Masters Biofab UOW gave a presentation "3D Printing Sound" to the CICADA User Group, Old Gladesville Hospital, Sydney, Australia, 11 March. * <b>Open to public</b>		
8.	Dodds, S. (2018) ACES CI UNSW presented on Humanities and Social Sciences Researchers in STEM at the ARC Centres of Excellence bids meeting of the Biological Sciences Australian Academy of Science, 13 March.		
9.	Sparrow, R. (2018) ACES CI Monash was an invited participant in the debate on the future of transport at WSP, a globally recognised professional services firm, Melbourne, 19 March.		
10.	Wallace, G. (2018) ACES CI UOW, visited Aquahydrex, Denver USA and met with D Abrams who has an interest in catalyst development and 3D printed metal electrodes 29 March.		
11.	In het Panhuis, M (2018), ACES CI UOW visited Brightlands Facility, Geleen, the Netherlands to visit their Incubator facility and several start-up companies, 19 April. htps://www.brightlands.com		
12.	Pringle, J (2018) ACES CI Deakin presented to the ARC National Major Income forum at ACT on an overview of the Research Training provided by ACES, 24 April.		
13.	Ralph, N. & L. Hancock, Exporting Renewable Energy?, presentation at ARENA Magazine, ARENA Project Space, Melbourne, 1 May.		
14.	Innis, P (2018) ACES CI UOW attended the Western Sydney Manufacturing Connection Event at Sydney Olympic Park to develop new external users opportunities for ANFF-ACES and leverage NSW tech innovation connections, 3 May.		
15.	Hancock, L (2018) sat on the Hepburn Wind Farm Board of Directors: Strategic Planning Meeting, Daylesford, Victoria, 18 June.		
16.	ACES – ANFF 3D printing display at the Sydney Innovation and Research Symposium, Australian Technology Park, Sydney, 21-22 June 2018.		
17.	Alici, Gursel and soft robotics team (2018) ACES CI UOW visited Southern Prosthetics and Orthotics located in Unanderra, Wollongong, to establish research collaboration and access their clients to receive feedback on ACES prosthetic hand research, 28 June.		
18.	Zhang, Jie (2018) ACES CI Monash met with redT to discuss redox flow battery research with a view towards a potential collaboration and grant application, June.		
19.	Zhang, Jie (2018) Monash University held collaborative meetings with Woodside, June.		
20.	Innis, P (2018), ACES UOW CI has ongoing collaborations with Allegra on 3D Scaffold development (in partnership with ANFF) via Innovation Connections Grant 2018.		
21.	Wollersheim, Linda (2018) ACES PhD Deakin had a webinar meeting 'on the draft design of the national energy guarantee' with the Energy Security Board, 2 July 2018.		
22.	Zhang, Jie (2018) ACES CI Monash presented at the Chemicals and Plastics Manufacturing Innovation Network and Training Program (C&P GRIP) Showcase, Monash University, 18 July.		
23.	Wollersheim, Linda (2018) ACES PhD Deakin attended the Melbourne Energy Network's event 'The Democratisation of Energy' on 20 July 2018.		
24.	Crook, J (2018) ACES CI UOW met with Prof Melissa Little, Program leader for Stem Cells Australia at the Murdoch Children's Research Institute, 20 July 2018.		
25.	Blum, A (2018) ACES UNSW PhD visited Merle Spriggs at the Royal Children's Hospital Melbourne to discuss paediatric clinical trials ethics approval issues and procedures, 23 July 2018.		
26.	ACES soft robotics team (2018) visited Port Kembla hospital in Wollongong exploring collaboration in testing the soft robotic prosthetic hand, 31 July 2018.		

ACES	6 Out and About Interacting with End-Users and Industry in 2018
27.	Wollersheim, Linda (2018) ACES Deakin PhD visited Tom Küster, Manager Department Wissens management at EnergieAgentur.NRW, Düsseldorf, Germany to discuss and detail the tasks and organisational structure of the agency (EnergieAgentur.NRW),which is a key facilitator of the German energy transition, 7 August 2018.
28.	Coote, Michelle (2018) ACES CI ANU visited SCION, Rotorura, 10-14 August 2018.
29.	Hancock, L (2018) ACES CI Deakin held a meeting with John Breukel Chief Librarian at Victorian Parliamentary Library regarding Victorian environmental committees, 14 August 2018.
30.	Howlett, P (2018) ACES CI Deakin visited Drs Mark Sceats, Phil Hodgsen and Kmajumber, Calix Bacchus Marsh, Maddingley to progress reseach collaborations, 15 August 2018.
31.	Wollersheim, Linda (2018) ACES Deakin PhD visited Torsten Schwarz, Manager Department Outreach at Bürgerwerke eG, Heidelberg Germany to discuss the approach of the energy cooperative collective on community engagement in Germany and gauge the potential to transfer that approach into an Australian context, 20 August 2018.
32.	Wang, C (2018) ACES SRF UOW visit battery assembly lines with Prof Libao Chen, Hunan Boltpower New Energy Co Ltd, Beijing, 22 August 2018.
33.	Howlett, P (2018) ACES CI Deakin was hosted by Sustainability Victoria, Melbourne, 24 August 2018.
34.	Wollersheim, Linda (2018) ACES Deakin PhD attended the Australian-German Climate & Energy College event 'National Electricity Market: Tail between its NEG?', 29 August 2018.
35.	Innis, Peter (2018) Invited ACES –ANFF presenter at the NCRIS-NSW Government Workshop, Sydney, 31 August 2018. This workshop between government agencies and NCRIS facilities centred on health/medical research/human and animal genetics/health data involving the Office of Health and Medical Research, the Department of Primary Industries, the Cancer Institute, Taronga Zoo, the Department of Education, and the Australian Museum Research Institute who are engaged in work in these areas.
36.	Li, Jianfeng (2018) ACES PhD UOW visited Dr Arvind Parmar at ANSTO to discuss in vivo testing protocols, 3 September 2018.
37.	Zhou, Hao (2018) ACES RF UOW visited Greg Bowring and Melissa Leong at Prince of Wales Hospital to explore the possibility of collaborating on prosthetic hand research, 6 September 2018.
38.	Zhang, Jie (2018) ACES CI Monash gave a talk at the Monash Energy Materials and Systems Institute Advisory Council meeting on 18 September 2018.
39.	Officer, D (2018) ACES CI UOW met with Mr Johnny Pak, CEO iGlass, to discuss commercialisation of electrochromics technology, Melbourne, 8 October 2018.
40.	Walker, M (2018) ACES RF Monash visited Dr Julian Koplin at the Murdoch Children's Research Institute to discuss organoids and ethics, 16 October 2018.
41.	ACES – ANFF booth at the SIBOS trade show at International Convention Centre. 22-25 October 2018.
42.	Fay C, Sayyar S, Jeirani A (2018) ACES AI and Fab technicians visited Romar Engineering in Sydney to discuss printer development and materials use, 30 October 2018.
43.	Zhang, J (2018) ACES CI Monash presented at poster at the Industrial Energy Showcase, Monash University, Clayton, Victoria, 31 October.
44.	Crook, J (2018) ACES CI UOW attended the Stem Cells Australia planning workshop at Monash University Institute of Pharmaceutical Science, Melbourne, 1-2 November 2018.
45	TELSTRA invited Dr Frederic Gilbert to present his research at TELSTRA annual business meeting, which involved 420 legal & corporate affairs staff. Dr Gilbert presented a talk entitled "Me, Myself and e-I: Ethics of Artificially Intelligent Brain-Computer Interfaces "at the Telstra Annual Legal & Corporate Staff Meeting, 21 November 2018.

# **APPENDIX 6: END-USER EVENTS**

A list of Events where in 2018 members from the ACES-ANFF partnership raised awareness of the facilities and research activities amongst end-users.

End-User Event description		Date	Venue
1.	<b>Human Upper Airway Symposium.</b> The program centred on results and translational activities from the research activities done as part of the Garnett Passe and Rodney Williams Memorial Foundation grant. Eight ear nose and throat clinical experts, national and international, were amongst the 20 attendees.	2 January	iC campus UOW Wollongong
2.	<b>Engineering your Imagination: ANFF short course on nanofabrication technologies</b> <b>at ICONN18.</b> This ANFF Short Course on Nanofabrication Technologies provided participants with a technical and research introduction to the range of nanofabrication capabilities at their disposal in the ANFF network. They learnt what types of process tools ANFF has, what you can do with these tools, and the range of devices or structures that you can make. The journey into nanofabrication will be facilitated by a team of expert process engineers and researchers drawn from the ranks of the ANFF network, the very people you will engage with when you use ANFF's facilities.	29 February	UOW Northfields Ave Campus Wollongong
3.	<b>End-User Engagement Session at ICONN18.</b> This half day workshop showcased how industry and research activities can be beneficial for both parties. The focus was to highlight how the fundamental knowledge accrued from research is available to the end user community and where appropriate commercial opportunities are supported to ensure maximum impact.	1 February	UOW Northfields Ave Campus Wollongong
4.	<b>Clinical Connections workshop.</b> Attendees could network with clinicians and hear about the end-user problems they encounter in their occupation.	7 February	iC campus UOW Wollongong
5.	<b>3D Bioprint – Dublin City University Australian Embassy Event.</b> Hosted by Simon Mamouney, Deputy Ambassador of the Australian Embassy in Dublin, 73 attendees (13 from industry) had the opportunity to hear about collaborative opportunities ACES has had in translating fundamental research findings to end-users. For example: (i) how advances at the frontiers of human health and energy benefit from interdisciplinary and global collaborations and (ii) the rapid movement towards solar derived chemical fuels. Can the energy from Australian sunshine be packaged and transported around the globe?	31 May	Australian Embassy, Dublin, Ireland
6.	Antimicrobial and Biofouling Resistant Materials – Academic and Industry Engagement and Planning Workshop. This ACES event had speakers from Industry, Academia and Government Agencies.	7 June	iC campus UOW Wollongong
7.	ACES was invited to give presentations and participate in round table discussions at the <b>NSW Future Economy Breakfast Series event on Quantum &amp; Nanotech.</b>	8 June	Sydney
8.	Inaugural <b>'3D Bioprint Translational Workshop'</b> and MTPConnect project launch. The program covered for the 91 attendees, materials sourcing, materials science development, engineering new hardware, the use of stem cells (focusing on clinical applications in islet cell transplantation for this workshop) and regulatory and commercial issues.	14 June	iC campus UOW Wollongong
9.	<b>Sydney Innovation and Research Symposium</b> ACES-ANFF and collaborator A/ Prof Payal Mukherjee, ENT surgeon and Clinical Associate Professor at the University of Sydney presented on 'Printing and replacing a new body part' in the Leaders in Healthcare session. Watch it on YouTube (https://www.youtube.com/ watch?v=YiLSmyTf3cs&feature=youtu.be).	21-22 June	Sydney Olympic Park, Homebush
10.	ACES-ANFF invited presenters at the <b>NCRIS – NSW Government Workshop</b> . This workshop between government agencies and NCRIS facilities centred on health/ medical research/human and animal genetics/health data involving the Office of Health and Medical Research, the Department of Primary Industries, the Cancer Institute, Taronga Zoo, the Department of Education, and the Australian Museum Research Institute who are engaged in work in these areas.	31 August	MLC Centre, Sydney

End-User Event description		Date	Venue
11.	<b>BIOPLUS</b> – 'game-changing insights to grow your bio business'. With a focus on innovation, Bioplus is industry-centred convention covering biotechnology and healthcare. Held in Korea it attracted experts from industry, academia, research institutes and governments from around the world. Prof Wallace showcased ACES work in the Medical 3D printing area.	6-7 September	Korea
12.	<b>Korea</b> • <b>Australia Medical-Bio 3D Printing Forum</b> . This was an ACES-Korea Society of 3D Printing in Medicine (KS3DPM) event, part of "NaNO Korea" an event with more than 1500 participants and 100 companies in attendance. An MOU between the 2 hosts was signed then research applications for medical innovation in 3D printing showcased.	7 September	Korea
13.	ACES CI UOW invited panellist for " <b>ANFF: Connecting with Industry Users</b> ", ACES CI Innis was an invited panellist for this discussion.	13 September	University of Adelaide, SA
14.	' <b>3D Bioprint Translational Workshop</b> ' MTPconnect. Attracted in excess of 64 attendees.	17 September	Royal Adelaide Hospital, SA
15.	' <b>3D Bioprint Translational Workshop</b> ' MTPconnect. Attracted in excess of 42 attendees.	17 October	St Vincent's, Melbourne
16.	ACES invited to SIBOS2018. Our ability at ACES to translate fundamental research into strategic applications was on display for over 7,000 international delegates at Sibos 2018. It is only the third time in 40 years that the city has hosted Sibos, a premier global financial services networking event organised by SWIFT (Society for Worldwide Interbank Financial Telecommunications). The team showcased our innovative devices in the Sibos Discover Zone, where executives, decision makers and thought leaders from the world's financial institutions, top FinTech companies, local FinTech start-ups and leading universities came together to collaborate with and attract future investors for ACES-ANFF. The ACES-ANFF team showcased a suite of next generation 'smart devices' that have resulted from our research collaborations with clinicians. The suite included: the Biopen (to repair damaged cartilage), the iFix Pen (to treat corneal ulcerations), and 3D Alek (to treat microtia), as well as a range of polymer and metal 3D printed parts. In addition, delegates were able to learn about our ability to synthesise advanced materials and supply customised bioinks for each of the hardware applications. The inventory of bioinks included: - gelatin methacrylamide (GelMA) based inks for adipose stem cells for cartilage regeneration - alginate based inks for nuscle cells - collagen based inks for nerve cells - multi-material inks for human neural stem cells and induced pluripotent stem cells - alginate/GelMA based inks for pancreatic islet cells.	22-25 October	Sydney
17.	ACES – ANFF represented at the <b>Advanced Manufacturing Growth Centre (AMGC)</b> <b>Outreach workshop.</b> The purpose of AMGC is to transform Australian Manufacturing to be more globally competitive and generate the demand for jobs. ACES CI Peter Innis gave his presentation on "From Electromaterials to Integrated 3D structures".	1 November	Sydney
18.	ACES-KS3DPM Innovation Showcase was held at the Australian Embassy Republic of Korea. The event was hosted by the Australian Ambassador to the republic of Korea His Excellency Mr James Choi and showcased the significant collaborative relationship between ACES, KS3DPM and other members of the Korean clinical community interested in Bioprinting. Opportunities for future work were highlighted and a 3D printing demonstration by ACES and the Australian National Fabrication Facility (ANFF) followed the presentations. ACES AI A/Prof Payal Mukherjee, ENT Surgeon at Royal Prince Alfred Hospital in Sydney was ACES's featured speaker along with Director Wallace.	6 November	Australian Embassy Seoul Korea
19.	<b>3DBioprint ACES-ASAN technical symposium.</b> The symposium featured talks from our partners, covering topics such as using 3D bioprinting to make parts for bodies and sensors.	7 November	ASAN Institute Seoul.

End-User Event description		Date	Venue
20,	University of Wollongong launches TRICEP medical 3D printing and bioprinting initiative. Through the collaboration of two expert facilities ACES and ANFF Materials Node, UOW has launched the TRICEP initiative. Standing for Translational Research Initiative for Cellular Engineering and Printing, TRICEP gives researchers the in-house ability to development hardware and biomaterials. Prof Gordon Wallace, Director ACES and TRICEP, states the new initiative "makes us uniquely placed to help companies create a complete end product that is tailor-made to combat a specific medical challenge. In addition, our extensive medical network throughout Australia and that network reaching overseas enables collaborations to ensure that clinically relevant systems and protocols are developed."	27 November	iC campus UOW Wollongong
21.	Australia-Japan Battery Research Industry Engagement 2018 workshop. ACES AI Robert Kerr, presented on behalf of ACES CIs Forsyth and Howlett. Organised by CSIRO and Austrade, presentations from Australia's battery industry and research sectors included companies such as Talga, CapXX, PMB Defence, BatTRIhub and VSPC. Over 40 representatives from the Japanese industry (including Panasonic, Sumitomo, Hitachi, Toyota, Toray, Softbank, Eliiy Power) in the Osaka prefecture were in attendance.	5 December	Osakla Japan

## APPENDIX 7: ACES PLENARY AND KEYNOTE ADDRESSES 2018

Plenary and Keynote Addresses given by ACES members in 2018		
1.	Coote, M.L. (2018) ACES CI ANU (Coote, M.L.; Noble, B.B.; Haworth, N.L.; Ciampi, S.) Plenary Lecture: "Catalysing and Controlling Reactions with Electric Fields" at the International CONFERENCE on Nanoscience and Nanotechnology (ICONN), Wollongong, Australia, 29 January -2 February.	
2.	MacFarlane D.R. (2018) ACES CI Monash Keynote address: Materials for Hydrogen and Ammonia Generation from Renewable ICONN 29-31 January.	
3.	Cook, M (2018), ACES CI University of Melbourne, Keynote Address: "Implantable Devices for Monitoring Brain Electrical Activity" Symposium on Engineering, Medicine, and Biology Applications, Taipei, 3 February.	
4.	MacFarlane D.R. (2018) ACES CI Monash Keynote address: "Progress Towards Hydrogen and Ammonia Generation from Renewables", Third Energy Future Conference 2018, UNSW, NSW, 5-8 February.	
5.	Coote, M.L. (2018) Keynote Lecture: "Practical Applications of COSMO-RS: pKa values, redox potentials and more" at 5th- COSMO-RS-Symposium Cologne, Germany, 6-8 March.	
6.	Cook, M (2018), ACES CI University of Melbourne, Keynote Address 'Seizure detection and prediction to individualise treatment' at the International Epilepsy Colloquium, Frankfurt, Germany, 13 March.	
7.	Wang, X (2018) Keynote lecture "Three Dimensional Silk Based Scaffolds" at the Australasian Society for Biomaterials and Tissue Engineering Conference 2018, Fremantle, W.A., 2-5 April.	
8.	MacFarlane D.R. (2018) Plenary Lecture: "Direct Nitrogen Reduction to Ammonia in Ionic Liquids" at the Symposium on Ionic Liquids, University College Dublin 31 May.	
9.	Wang, X (2018) Keynote lecture "Quantitative Evaluation of Odour Retention on Different Fibre Type" at the Fiber Society Spring Conference, Tokyo, Japan, 12-14 June.	
10.	Coote, M.L. (2018) Plenary Lecture: "Electrostatic Catalysis of Radical Reactions", EuCHeMS conference on Organic Free Radicals (ECOFR 2018), Marseilles, 17-20 June.	
11.	Coote, M.L. (2018) Keynote lecture: "Directionality and the role of polarization in electrostatic catalysis", VALBO Understanding Chemistry and Biochemistry with Conceptual Models, Marseilles, 24-29 June.	
12.	Coote, M.L. (2018) Keynote lecture: "Catalyzing Chemical Reactions with Electric Fields: Implications for Polymer Science", IUPAC World Polymer Congress (Macro2018), Cairns, 1-5 July.	
13.	Officer, D. L. (2018) ACES CI UOW Plenary address: "Creating Porphyrin-based Materials for Energy Applications" at the Tenth International Conference on Porphyrins and Phthalocyanines (ICPP-10), Munich, Germany, 1-6 July.	

Plena	ary and Keynote Addresses given by ACES members in 2018
14.	Wallace, G (2018) ACES CI UOW Plenary address "Graphene: The Development Pipeline" UOW-BUAA Joint Workshop on Advanced Materials, Physics and Chemistry, Wollongong, 26 July.
15.	Cherian, M (2018) ACES PhD Deakin, Plenary speaker at the International Federation on Aging 14th Global Conference on Ageing held in Toronto, Canada, 8-10 August.
16.	Wallace, G (2018) ACES CI UOW Plenary address "Graphene – Cellular Interactions and Implications for Medical Device Technologies" at The 9th Vacuum and Surface Science Conference of Asia and Australia (VASSCAA-9), Sydney, 13-16 August.
17.	in het Panhuis, M (2018) ACES CI UOW, Plenary address: "3D and 4D printing of polymer and hydrogel materials" at the 4th International Conference on bio-based polymers and composite, Lake Balaton, Hungary, 2-6 September.
18.	Chen, Fangfang (2018) ACES RF Deakin, keynote address "Atomistic interrogation of ionic liquid and polymeric electrolytes: the effect of composition, chemistry and structure" at the 6th international conference on ionic liquid for electrochemical devices, Rome, 9-11 September.
19.	MacFarlane D.R. (2018) ACES CI Monash plenary lecture "My journey through the world of ionic liquids with K.R. Seddon" at the Symposium for Ken Seddon Queens at University Belfast, Ireland 13 September.
20.	Wallace, G (2018) ACES CI UOW keynote lecture "Printing printers" at 2nd Corneal Bioengineering Working Group, Sydney Eye Hospital, Australia, 27 September.
21.	Sparrow, Robert (2018) ACES CI Monash Invited keynote speaker "Regulating research on 'revolutionary' technologies" at the Australasian Ethics Network Conference 2018, Townsville, 28 September.
22.	Howlett, P (2018) ACES CI Deakin keynote address "Solid state organic ionic plastic crystals and composite materials for energy", at ECS conference, Cancun, 29 September-4 October.
23.	MacFarlane D.R. (2018) ACES CI Monash plenary lecture "Direct Nitrogen Reduction to Ammonia in Ionic Liquids" at the 6th Asia Pacific Conference on Ionic Liquids, Tottori, October.
24.	Wallace, G (2018) ACES CI UOW keynote lecture "3D Printing: How did we do without it?" at Australian Biomedical Engineering Conference (ABEC) 2018, The Sydney Masonic Centre (SMC), Sydney, Australia, 7-10 October.
25.	Spinks, Geoff (2018) ACES CI UOW plenary talk "Turning Twist into Tension in Highly Twisted and Coiled Fibres" at the 3rd International Workshop on Active Materials and Soft Mechatronics (AMSM2018), KAIST, Daejeon, South Korea, 24-25 October.
26.	Wallace, G (2018) ACES CI UOW keynote lecture "Customised Printers to Create Customised Structures for Clinical Applications" at International Society for Biofabrication (ISBF), Würzburg, Germany, 28-31 October.
27.	Wallace, G (2018) ACES CI UOW keynote speaker "3D Bioprinting: Printing Parts for Bodies" at Annual Cutting Edge STEM Conference for Teachers, Gold Coast & Brisbance, Australia, 3-4 December.
28.	Sparrow, Robert (2018) ACES CI Monash Invited keynote speaker "Virtues and vices in our relationships with robots: Is there an asymmetry and how might it be explained?", Robots and AI in Society, Western Sydney University, 8-9 November.
29.	Coote, M.L. (2018) ACES CI ANU Keynote lecture: "Catalyzing Chemical Reactions with Electric Fields: Implications for Polymer Science", South Australian Physical Chemistry Symposium, Adelaide, 22 November.
30.	Sparrow, Robert (2018) ACES CI Monash Invited keynote speaker "What Computers Can and Cannot Do in Healthcare" at the 2018 Workshop on Artificial Intelligence and Digital Healthcare, Chinese University of Hong Kong, Hong Kong, 22 November. <b>*Open to public</b>
31.	MacFarlane D.R. (2018) ACES CI Monash plenary lecture "Materials Chemistry for Exportable Renewables" at the Materials Symposium, University of Canterbury, 2-3 December.
32.	Alici, G. (2018) ACES CI UOW gave a keynote address "Soft robotics for prosthetic devices; research challenges and opportunities" at the 2018 IEEE International Conference on Robotics and Biomimetics (IEEE ROBIO 2018), Kuala Lumpur, Malaysia, 12-15 December.

### APPENDIX 8: ACES INVITED TALKS 2018

Invite	ed Talks or Panels by ACES members in 2018
1.	MacFarlane, Douglas (2018) CI Monash University invited talk "Nanostructured Electromaterials for Chemical Energy Storage - Progress Towards Hydrogen and Ammonia as Fuels", 2018 International Conference on Nanoscience and Nanotechnology (ICONN), 29 January-2 February.
2.	Hancock, L & Ralph, N Hancock (presented by Hancock) (2018) "Exploring Issues of Conflict/Critical and Nanomaterials Used in Renewable Energy " at International Conference on Nanoscience and Nanotechnology (ICONN 2018) Nano Safety and Societal Issues stream, 29 January-2 February.
3.	Wang, Caiyun (2018) ACES SRF UOW invited talk 'Nanostructured Tin-Based Catalyst for Electrochemical Reduction of Aqueous Carbon Dioxide' International Conference on Nanoscience and Nanotechnology (ICONN), 29 January-2 February.
4.	Chen, J. (2018) ACES UOW CI gave an invited talk "Thermo-Electrochemical Cells: Using Redox-Gel Integrated Flexible Electrodes to Covert Body Heat into Electricity" at the International Conference of Nanoscience and Nanotechnology 2018, Wollongong, 29 January-2 February.
5.	Pringle, J. (2018) ACES CI invited talk "Development of Organic Ionic Plastic Crystals as Solid State Electrolytes for Energy Applications", ICONN 2018, Wollongong, 29 January-2 February.
6.	Simonov A. N. (2018) ACES SRF Monash invited talk "Nanostructured and thin film metal chalcogenides for solar fuel synthesis" ICONN 2018, Wollongong, 29 January-2 February.
7.	Yue, Z. (2018) ACES AI UOW invited talk "Formulating Bioinks for 3D Printing", ICONN2018, Wollongong, 29 January-2 February.
8.	Chatti M, Pai N, Senevirathna D.C, Lu JF, Andrews PC, Cheng YB., Spiccia L, Simonov A.N (2018) Simonov SRF ACES Monash invited talk "Nanostructured and thin film metal chalcogenides for solar fuel synthesis", ICONN 2018, Wollongong, 29 January -2 February.
9.	Howlett, P. (2018) ACES CI Deakin "Battery research in Australia in collaboration with France", at the 1st Australian- French Energy Symposium, Sydney, Australia, 7 February.
10.	Higgins, M (2018) ACES CI UOW invited talk "Probing Cell-Material Interactions, One Molecule at a Time" at Nano-Life Sciences International Symposium, Tokyo, Japan, February.
11.	Cook, M (2018), ACES CI University of Melbourne, gave an invited talk "Seizure Detection, prediction and brain dynamics: lessons from long term monitoring" at the German Society of Clinical Neurophysiology meeting, Berlin, Germany, 15 March.
12.	Pringle, J (2018) ACES CI Deakin oral "Ionic liquid electrolytes for harvesting low-grade waste heat" at the 255th ACS (American Chemical Society) National Meeting & Exposition, New Orleans, US, 18-22 March.
13.	MacFarlane, D (2018) ACES CI Monash "Direct Reduction of Nitrogen to Ammonia in Ionic Liquids" at the 255th American Chemical Society National Meeting New Orleans, 18- 22 March.
14.	Forsyth, Maria (2018) "Ion structure and dynamics in highly concentrated ionic liquid-alkali metal salt electrolytes" at the Physical Chemistry of Ionic Liquids Symposium at the 255th ACS Meeting in New Orleans, 18-22 March.
15.	Ngan, Catherine et al (2018) ACES AI UOM gave an invited talk "Bioprinting Mouse Skeletal Muscle Fibres" at the Australian Society for Biomaterials and Tissue Engineering Annual Conference, Perth, 3-5 April.
16.	Wallace, G (2018) invited talk "3D Bioprinting – Should it be in every Hospital?" at the 9th Korea Healthcare Congress 2018, Seoul, Korea, 12 April.
17.	In het Panhuis, M (2018) ACES CI UOW "3D/4D printing of hydrogels (fins for surfboards)" at the 4D Printing & Meta Materials Conference, Geleen, The Netherlands, 17-18 April.
18.	Sparrow, R. (2018) ACES CI Monash, invited talk "Windows Brain '98: What could possibly go wrong?" at the MICCN and MIME Symposium on Ethics in Neurotechnological Innovation, Melbourne, 1 May.
19.	Gilbert F., (2018) ACES AI UTAS "Experimental Usage of AI-Controlled Brain Implants in Military Personal: Any Moral Obligation Ahead?" 8th ICMM Workshop on Military Ethics, Ermatingen, Switzerland, 3-5 May. **full written paper- refereed proceedings.
20.	Alici, G, (2018), ACES CI UOW "Soft robotics for prosthetic devices: research challenges and opportunities", 2018 Emerging Technologies Conference, Whistler, Vancouver, Canada, 9-11 May.

Invite	d Talks or Panels by ACES members in 2018
21.	Sparrow, R. (2018) ACES CI Monash gave an invited paper, "What robots represent And why it matters" at the 2018 Uehiro-Carnegie-Oxford Conference on 'Ethics and the Future of Artificial Intelligence', New York, USA, 16-18 May.
22.	Pringle, Jennifer (2018) ACES CI Deakin "Ionic liquid electrolytes for harvesting low-grade waste heat" 8th Australian Symposium on Ionic Liquids (ASIL8), Deakin University, Melbourne, 21 May.
23.	Cheng, Fangfang (2018) RF Deakin University, invited talk "Computational investigation of ionic liquids with high concentration of alkali metal ion salts and the effect from cation structures", ASIL8, Deakin University, Melbourne, 22 May.
24.	Sparrow, R. (2018) ACES CI Monash gave an invited talk, "What robots represent And why it matters" at the Ethics Forum at International Conference on Robotics and Automation, Brisbane, 22 May.
25.	Wallace, G. (2018) invited talk "ACES Discoveries – ANFF Supply" at the Antimicrobial and Fouling Resistant Materials Workshop, University of Wollongong, AIIM Facility, Innovation Campus, Wollongong, 7 June.
26.	Cook, M (2018), ACES CI University of Melbourne, at the American College of Veterinary Medicine Forum on "Seizure Forecasting – Recent Developments and Applications / Novel Methods of Drug Delivery in Epilepsy", Seattle, USA, 13 June.
27.	Cook, M (2018), ACES CI University of Melbourne, Novel Methods of Drug Delivery in Epilepsy, American College of Veterinary Internal Medicine Forum, Seattle Washington, United States, 13 June.
28.	Hancock, L. and Ralph, N (2018). Invited paper 'Clean energy or Coal, jobs and displaced carbon emissions at any cost? Assessing Australia's brown coal v. solar-produced liquid hydrogen exports to Japan' at 7th International Workshop on Advances in Cleaner Production 'Cleaner Production for Achieving the Sustainable Development Goals' International Workshop, Barranquilla, Colombia, 21 June.
29.	Ngan, Catherine et al (2018) ACES AI UOM gave an invited talk "Bioprinted Mouse Skeletal Muscle Fibres in a Gelatin Methacrylate Hydrogel Ink" at the International Society for Stem Cell Research Congress, Melbourne, 20-23 June.
30.	Duchi, Serina et al (2018) ACES AI UOM gave an invited talk "Biofabrication of human articular cartilage: In situ bioprinted human stem cells trigger neocartilage integration in an ex vivo osteochondral model" at the International Society for Stem Cell Research Congress, Melbourne, 20-23 June.
31.	Duchi, Serina et al (2018) ACES AI UOM gave an invited talk "Mesenchymal stem cells and nanotechnology based drug delivery systems: A showcase of multimodal approaches to induce osteosarcoma cell death" at the International Society for Stem Cell Research Congress, Melbourne, 20-23 June.
32.	Forsyth, M (2018), ACES CI Deakin, "Enhanced Lithium Ion Transport in Polymer Composite Electrolytes for Lithium Metal Anodes" at ISPE2018 conference, Japan, 23-29 June.
33.	Crook JM (2018) ACES UOW CI was an invited speaker & Chair "Biomaterials development for stem cell therapy" at the International Stem Cell Banking Workshop, Melbourne, Australia, 24-25 June.
34.	Higgins, M (2018) ACES CI UOW invited talk "Hydration Layer Structure of Biofouling Resistant Nanoparticles" at 13th International Nanomedicine Conference, Sydney 25-28 June.
35.	Forsyth, M (2018), ACES CI Deakin, given an invited talk at MACR02018, Cairns, 1-5 July.
36.	Wagner, P (2018) ACES SRF UOW invited talk "Photovoltaic Application of Porphyrin Protein Maquette – Based Reaction Centres" at International Conference on Porphyrins and Phthalocyanines (ICPP18), Munich, Germany, 1-6 July.
37.	Bourke J, Quigley AF, Duchi S, O'Connell CD, Crook JM, Wallace GG, Cook MJ, Kapsa RM (2018) "Three dimensional microenvironments on multi-electrode arrays produce neuronal networks that function like the brain" at the 11th International Meeting on Substrate Integrated Microelectrode Arrays, Reutlingen, Germany, 4-6 July.
38.	Zhang, J (2018) ACES CI Monash gave an invited talk at The 3rd International Symposium on Renewable Energy Technologies, Gold Coast, Australia, 19-22 July.
39.	Bourke Justin., et al., (2018) ACES RF UOM an invited talk "in vitro Electrophysiological Modelling", ISSCR Satellite Meeting, South Australian Health and Medical Research Institute, Adelaide, 19 July.
40.	Quigley, A., et al., (2018) ACES RF UOW/ St V an invited talk "iPSC Models in Neuroscience", ACES RF UOM South Australian Health and Medical Research Institute, Adelaide, 19 July.
41.	Howlett, P (2018) invited talk "Superconcentrated NaFSI Based Ionic Liquid Electrolytes; Na+ Ion Transport to Remarkable Cycling and Device Stability" at Beyond Lithium Conference Cleveland, NASA Ohio, USA, 24-26 July.

Invite	Invited Talks or Panels by ACES members in 2018		
42.	Chen, Jun (2018) invited talk "Highly enhanced visible light photocatalysis through hydrogen re-treated and in situ FT-IR studies on defective BiOCl" at International Symposium on Advancement and Prospect of Catalysis Science, Sydney, 25-27 July.		
43.	Wang, Caiyun (2018) ACES SRF UOW invited talk "Engineering Metal-Based Catalysts for Electrochemical Reduction of Aqueous Carbon Dioxide" at the ACS Catalysis 2018 International Symposium on Advancement and Prospect of Catalysis Science and Technology, Sydney, 26 July.		
44.	Simonov A, B. Suryanto, R. Hodgetts, F. Zhou, M. Kar, A, D. MacFarlane (2018) ACES RF Monash invited talk 'Engineering solvent-electrolyte systems for efficient electroreduction of di-nitrogen to ammonia under ambient conditions' at the ACS National Meeting and Exposition, Boston, USA, 19-23 August.		
45.	Wang, C (2018) ACES SRF UOW, invited talk "Engineering Metal-Based Catalysts for Electrochemical Reduction of Aqueous Carbon Dioxide" at the 2018 Conference on Chemistry of Energy Materials, Beijing, 24-27 August.		
46.	Cook, M. (2018) ACES CI UOM, "Target systems", 13th European Congress on Epileptology, Vienna, Austria, 28 August.		
47.	Cook, M. (2018) ACES CI UOM, "Invasive EEG-based seizure detection", 13th European Congress on Epileptology, Vienna, Austria, 29 August.		
48.	Wallace G (2018) ACES CI UOW invited talk "Tackling Medical Challenges using 3D Printing" at Frontiers 2018: The Art, Science and Future of Otolaryngology, Head and Neck Surgery, Cairns, Australia, 30 August – 1 September.		
49.	Wallace G (2018) ACES CI UOW invited talk "The Convergence of Biomaterials, Cellular Engineering and 3D Biofabrication" at BIOPLUS, South Korea, 6-7 September.		
50.	Chung, J (2018) ACES AI UOW invited talk on ACES collaboration "Bioprinting for structure and function: the printing ears project" at BIOPLUS, South Korea, 6-7 September.		
51.	Sparrow, Robert (2018) ACES CI Monash invited panellist "Geoffrey Robertson's Hypothetical – Do robotic slaves have rights and can a robot love? Can it think? How about kill?" at the Australian Engineering Conference 2018, Sydney, 19 September.		
52.	Crook JM (2018) ACES CI UOW, Invited Chair and Symposium Organiser: "Organoids" symposium of the Developmental, Stem Cell and Regenerative Biology stream, ComBio2018 Meeting, Sydney, 23-26 September.		
53.	Tomaskovic-Crook E, Zhang B, Bourke JL, Gu Q, Kapsa RM, Wallace GG, Crook JM (2018), ACES RF UOW an invited speaker: "Nextgen' human brain organoids using 3D printed gelatin methacrylate" at ComBio2018 Meeting, Sydney, 23-26 September.		
54.	Crook JM (2018), ACES CI UOW, invited speaker "Modelling of major mental disorders using tissue engineering approaches" in 'Molecular Insights on organoid and 3D models to study brain diseases and development' session at the 6th Annual Molecular Psychiatry Meeting, Kauai, Hawaii, 27-29 September.		
55.	Forsyth, M (2018) ACES CI Deakin invited talk "Ionic liquid electrolytes and ionogel composites that enable high capacity anodes for lithium and sodium batteries" at ECS conference, Cancun, 29 September-4 October.		
56.	Wallace G (2018) ACES CI UOW invited speaker "3D Bioprinting - Practical Applications and Fundamental Explorations" at Royal Society of New South Wales, 1267th OGM and Open Lecture, State Library of NSW, Sydney, Australia, 3 October **Open to Public		
57.	Officer, D (2018) ACES CI UOW invited speaker 'Graphene – the Challenge in Transitioning from Lab to Industry' at The Australian Graphene Industry Association Graphene 2018 Conference, Melbourne, Australia, 8 October.		
58.	Forsyth, M (2018) ACES CI Deakin invited talk "Ion structure and dynamics in highly concentrated ionic liquid- alkali metal salt electrolytes; enabling metal anodes for high energy density batteries" at Ionic Liquids for Materials Design Conference, Lyon France, 13 October.		
59	Sparrow, R. (2018) ACES CI Monash invited speaker, FNQ Student Constitutional Convention: Is the Australian Constitution future proof? The current year is 2040. Can our Constitution cope with the technology changes and situations of today? In Cairns, Queensland, 18 October.		
60.	Cook, M. (2018) ACES CI UOM oral CNS 'Drug Delivery – what we need', Controlled Drug Delivery Workshop, Wollongong, Australia, 22 October.		
61.	Zhang, J (2018) ACES CI Monash gave an invited talk at ALIGN-CCUS (Accelerating Low Carbon Industrial Growth through CCUS) –CSIRO workshop 2018, Melbourne, 26 October.		

Invited Talks or Panels by ACES members in 2018		
62.	Cook, M. (2018) ACES CI UOM "Case Study 2: A example of a world first drug-device combination in drug resistant epilepsy", AusBiotech 2018, 1 November.	
63.	Gilbert F. (2018) ACES AI and ARC DECRA invited talk 'Deflating the "DBS Causes Personality Changes" Bubble' at the International Neuroethics Society, San Diego, USA, 1-2 November. * full written paper-refereed proceedings	
64.	Wang, C (2018) ACES SRF UOW, invited talk "Tuning Conducting Polymers for Bio-related Energy Applications", 2018 International Conference of Young Researchers on Advanced Materials, Adelaide, 4-7 November.	
65.	Forsyth, M (2018) ACES CI Deakin invited talk "Ionic liquid electrolytes and their composites for next generation batteries" at ICYRAM2018, Adelaide, 4-8 November.	
66.	Wallace, G (2018) ACES CI UOW invited talks "Better clinical outcomes through technology" and "Bioprinting" at Annual Joint Academic Meetings, Concurrent Academic Workshops, Clinical Innovations, University of Technology Sydney, Australia, 8-9 November.	
67.	Forsyth, M (2018) ACES CI Deakin invited talk "Ionomers, poly(ionic liquids) and their composites in next generation solid state batteries", at Polymer Victoria, Clayton, 21-22 November.	
68.	Moulton, SE (2018) ACES CI Swinburne oral 'Active Polymers and Structures for Drug Delivery' at the 8th Annual Meeting of the Korean Society of Pharmaceutical Sciences and Technology, Korea, 22 November.	
69.	Molino P, Higgins M.J., Wallace G (2018) ACES RF invited talk "Characterising Material Properties and Biological – Material Interactions for Conducting Polymer Biomaterials", MRS Conference, Boston, USA, 24 -30 November.	
70.	Forsyth, M (2018) ACES CI Deakin invited talk "Novel solid state electrolytes - enabling future energy technologies", at CAMS2018, Wollongong, 21-22 November.	
71.	Wallace, G (2018) ACES CI UOW invited talk "Research and Footy - what do they have in common?" at Institute for Frontier Materials 2018 Annual Conference, Geelong, Australia, 6 December.	
72	Zhang, J (2018) ACES CI Monash gave an invited talk at ICON-2DMAT 2018, Melbourne, 11-13 December.	

# APPENDIX 9: ACES INVITED SEMINARS / COLLABORATIVE RESEARCH VISITS

ALES Invited Seminars / Collaborative visits snowcasing research activities		
Invited SEMINARS		
1.	Coote, M (2018) ACES CI ANU lecture and research discussions for group retreat of Professor Barner-Kowollik at QUT, Queensland, 2-4 February.	
2.	Wallace, G (2018) ACES CI UOW "3D Bioprinting: Fixing Knees, Ears, Eyes and Helping Neural Regeneration" at ANZ Cornea Society & Eye Bank Meeting, Intercontinental Sydney, Sydney, Australia, 23-24 February.	
3.	Gilbert, F (2018) presented an invited guest lecture on "Neuroethics & Behaviour" at University of Washington, Seattle, US, 27 February.	
4.	Alici, Gursel (2018) invited lecture 'What is mechatronics? What are career paths in mechatronics?' at Beijing Jiao Tong University, 21 March.	
5.	Wallace, G (2018) Invited seminar "Communication with Neurons-New Materials & New Dimensions and 3D Bioprinting at ACES: An Overview" at University of Texas at Dallas with collaborative discussions with Mario Romero-Ortega and colleagues, 26-27 March.	
6.	Wallace, G (2018) Aquahydrex to discuss catalyst development and 3D printed metal electrodes, Denver, US, 29 March.	
7.	Wallace, G (2018) Invited seminar "Communication with Neurons-New Materials & New Dimensions" and "3D Bioprinting at ACES: An Overview" as well as collaborative research discussions with Dan Risooti on machine learning and battery performance and Konrad Walus on microfluidics and 3D printing, at UBC in Vancouver, 4-5 April.	
8.	Wallace, G (2018) Invited seminar "Communication with Neurons-New Materials & New Dimensions" at Institute of Zoology, Beijing, China, 14 April.	
9.	Wallace, G (2018) Invited seminar "3D Bioprinting at ACES: An Overview" at Technical Institute of Physics and Chemistry, CAS, Beihang University, China, 14 April.	

ACES	ACES Invited Seminars / Collaborative visits showcasing research activities			
10.	Wallace, G (2018) Guest lecture "3D Bioprinting - Practical Applications and Fundamental Explorations" at 29th ASM of the Spine Society of Australia, Adelaide Convention Centre, Australia, 27-29 April.			
11.	Wallace, G (2018) invited seminar "3D Bioprinting: Printing Parts for Bodies" at Åbo Akademi University, Turku/Åbo, Finland, 3 May.			
12.	Wallace, G (2018) invited seminar "3D Printing – Accelerating Progress in Medical Science" at Tampere University of Technology, Tampere, Finland, 7 May.			
13.	Officer, D (2018) invited seminar "Shining light on new materials: porphyrins, graphene, conducting polymers, hydrogels and droplets", Tampere University of Technology, Tampere, Finland, 11 May.			
14.	Officer, D (2018) invited seminar "Moving Fluids with Light", Max Planck Institute for Dynamics and Self Organisation, Göttingen, Germany, 16 May.			
15.	Wallace, G (2018) invited seminar "3D Bioprinting – Practical Applications and Fundamental Explorations" for Bioinspired 3D Structures at The Helix - Dublin City University, Ireland, 31 May.			
16.	Officer, D. L. (2018) invited seminar "Graphene – Advances and Tribulations", Bioinspired 3D Structures Symposium, Dublin City University, Dublin, Ireland, 31 May.			
17.	Crook, JM (2018), ACES CI UOW gave an invited guest lecture "Synthetic Biosystems For 3D Modelling Of Development, Disease & Regenerative Medicine" for the 4th Year Biomedical Engineering students within the ARC Centre for Innovative BioEngineering, University of Sydney, 31 May.			
18.	A. Simonov (2018) invited seminar "Understanding and improving water splitting electrocatalysts for solar fuel synthesis" for Prof H Dau group at Frei Universitat Berlin, Germany in May.			
19.	Simonov, A (2018) ACES RF Monash visited the Max Plank Institute for Chemical Energy Conversion, the Fritz Haber Institute and Helmholtz Zentrum to discuss various collaborations in May.			
20.	Alici, G. (2018) invited talk 'Soft robotics for prosthetic devices: is it a new paradigm in robotics? at City University of Hong Kong, 6 June.			
21.	Wallace, G (2018) invited seminar "Graphene: ACES Discoveries – ANFF Supply" at NSW Future Economy Breakfast Series event on Quantum & Nanotech, Sydney Nanoscience Hub, The University of Sydney, Australia, 8 June. (Industry as well Toni.)			
22.	Hancock, L. and Ralph, N. (2018) ACES Deakin University invited paper 'Clean energy or Coal, jobs and displaced carbon emissions at any cost? Assessing Australia's brown coal v. solar-produced liquid hydrogen exports to Japan' at 7th International Workshop on Advances in Cleaner Production 'Cleaner Production for Achieving the Sustainable Development Goals' International Workshop, Barranquilla, Colombia, 21 June.			
23.	Wallace, G (2018) "3D Bioprinting" Sydney Innovation and Research Symposium, Australian Technology Park, Eveleigh, Australia, 22 June. (Industry and Public? as well Toni.)			
24.	Crook JM (2018) Invited speaker and chair "Biomaterials development for stem cell therapy", at the International Stem Cell Banking Workshop, Melbourne, Australia, 24-25 June.			
25.	Gilbert F. (2018) ACES AI and ARC DECRA "Brain Implants and Artificial Intelligence: Implanting Unprecedented Vulnerabilities?" at Human-Technology Relations: Postphenomenology and Philosophy of Technology, University of Twente, Eschedes, Netherland, 11-13 July. <b>*Peer reviewed presentation.</b>			
26.	Wang, C (2018) ACES SRF UOW invited seminar, laboratory visit and collaborative talks with Prof Shiguo Zhang, Huanan University Beijing, 22 August.			
27.	Wang, C (2018) ACES SRF UOW invited seminar, laboratory visit and collaborative talks with Prof Xianyou Wang, Xiangtan University, Beijing, 23 August.			
28.	In het Panhuis, M (2018) ACES CI UOW invited seminar on "3D/4D printing of soft hydrogels and hard surfboard materials" at the School of Engineering, Deakin University, Geelong, Australia, 13 August.			
29.	Sparrow, R. (2018) ACES CI Monash invited panellist Biometric Mirror: Digital Ethics and Society, University of Melbourne, 20 September.			
30.	Gilbert F, Viaña JNM., Ineichen C. (2018) ACES AI and ARC DECRA talk 'Deflating the "DBS Causes Personality Changes" Bubble' at 4S Sydney, 29 August-1 September.			
ACES	ACES Invited Seminars / Collaborative visits showcasing research activities			
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31.	Innis, P (2018) ACES CI UOW invited panelist for "ANFF:Connecting with Industry Users", University of Adelaide, 13 September.			
32.	Moulton, SE (2018) ACES CI Swinburne invited seminar 'Processing of Graphene and Carbon Nanotubes', University of Campinas, Sao Paulo, Brazil, 13 November.			
33.	Moulton SE (2018) ACES CI Swinburne invited seminar 'Interactive materials in Biomedical Research', College of Medicine, Inha University, Korea, 19 November.			
34.	Moulton SE (2018) ACES CI Swinburne invited seminar 'Active Biomaterials for Drug Delivery and Tissue Engineering', Sunchon University, Korea, 21 November.			
35.	Alici, G. (2018) ACES CI UOW invited seminar "From Soft Actuators to Soft Robotics: where are we now?" at the Department of Biomedical Engineering, National University of Singapore, 19 December.			
Colla	aboration Vists			
36.	Forsyth, M (2018), ACES CI Deakin University, visited Tecnalia, CIC Energigune and Basque Country within POLYMAT as Ikerbasque Professor, January 2018.			
37.	Pringle, J (2018), ACES CI Deakin University, visited Dr Lyiu Jin and Prof Peter Bruce visit at Oxford University to discuss future collaboration plans related to electrolytes for energy storage, 16 January.			
38.	Ralph, N (2018) ACES RF Deakin met with M van Dorp, former Senior Researcher for SOMO (The Centre for Research on Multinational Corporations), Netherlands, and consultant to discuss research for the ACES paper 'Renewable Energy Businesses in Conflict/Fragile countries', 16 January.			
39.	Chen, Zhi (2018) ACES PhD UOW visited collaborators Sutton and You at Save Sight Institute, Sydney Eye hospital to discuss primary human corneal keratocytes culture, 24 January.			
40.	Forsyth, M (2018) ACES CI Deakin meeting with Prof Brian Kinsella and Dr Andrew Bell at Curtin University with their industry partners (Chevron, Woodside, INPEX) to tal about collaborative opportunities, 30 January.			
41.	Sparrow, R (2018) ACES CI Monash was a visiting fellow for one month at Department of Philosophy, Carnegie Mellon University, Pittsburgh, Pennsylvania, USA, February.			
42.	Cook, M (2018), ACES CI University of Melbourne "Seizure Prediction: Challenges and Opportunities" at the Biomedical Electronics Translational Research Centre, Taipei, 2 February.			
43.	Coote, M (2018) Australian National University, visited the group retreat of Professor Barner-Kowollik QUT to present a lecture and participate in research discussions, 2-4 February.			
44.	Sparrow, R (2018) ACES CI Monash gave a seminar on 'Ethics of Robots as Carers' at the Rock Ethics Institute, Penn State, Pennsylvania, USA, 8 February.			
45.	Taylor, A (2018) ACES Fabrication Technician UOW visited Sydney Eye Bank for research discussion on the iFixsystem, 9 February.			
46.	Sparrow, R (2018) ACES CI Monash gave a seminar on 'How Robots have Politics' at the Center for Ethics and Policy Colloquium, Carnegie Mellon, Pittsburgh, Pennsylvania, USA, 9 February.			
47.	Taylor, A (2018) UOW Fabrication technician was visited by Elizabeth Kolos of University of Western Sydney regarding Fabrication techniques for gastrointestinal tract 16 February			
48.	Bourke, J (2018) ACES UOM RF visited University of Auckland for a PhD thesis review – Bionics system design – Faculty of Medicine and Health Sciences 11-13 February			
49.	Bourke, J (2018) ACES UOM RF visited Martin Engel at IHMRI to Develop neuronal recordings from organoids 7 February.			
50.	Alici, G (2018) ACES CI UOW, together with 2 PhD students and 2 UG students, visited Dr Tim Scott at Sydney Children's Hospital, Rehab2Kids Clinic, to discuss the prosthetic hand project and its extension to partial prosthetic hands for children, 1 March.			
51.	Guo, S (2018) RF ACES Monash visited Dr. Stephen Feldberg, Brookhaven National Laboratory, USA working to discuss current projects with Alan, Jie and Si-Xuan 5-11 March.			
52.	Guo, S Zhang, J (2018) ACES RF and CI Monash visited Prof Tadaharu Ueda, Kochi University, Japan to discuss current projects, 12-16 March.			

ACES	ACES Invited Seminars / Collaborative visits showcasing research activities			
53.	MacFarlane, D (2018), ACES CI Monash, gave a lecture 'Energy Applications of Ionic Liquids' at University of California, San Diego, USA, 16 March.			
54.	Walker, M (2018) ACES RF Monash visited Centre for Agency, Values & Ethics at Macquarie University, Sydney to attend workshop on "Pathologisation of ugliness' and discuss plans for future collaborations with CAVE members", 19 March 2018.			
55.	Alici, G (2018) ACES CI UOW gave an invited lecture at Beijing Jiao Tong University, China on 21 March 2018.			
56.	Alici, G (2018) ACES CI UOW gave a lecture at the Department of Mechanical and Biomedical Engineering, City University, Hong Kong on 24 March 2018.			
57.	Wallace, G (2018) Met with Dan Abrams USA for research translation discussions, 30 March.			
58.	MacFarlane, D (2018), ACES CI Monash, gave a lecture 'Energy Applications of Ionic Liquids' at University of Texas, Austen, USA, 31 March.			
59.	Wallace, G (2018) ACES CI UOW, visited University of Texas at Dallas – seminar and collaborative discussions with Mario Romero-Ortega and colleagues 26-27 March.			
60.	Bourke, J (2018) ACES UOM RF met with Group from Centre for Nanoscale Biophotonics visited ACMD 3D Biofab facility to discuss various projects and potential for future collaborations 27 March.			
61.	Blum, A (2018) ACES PhD UNSW gave a presentation on ethical limitations of 3D neural models at the UNSW philosophy postgraduate seminar, 8 March.			
62.	Quigley, A (2018) ACES UOW RF at ST V visited Wren Green and Natalie Wolfe-Riley at Deakin Burwood campus to meet to discuss collaborative work, various dates in March and April.			
63.	Pringle, J (2018) ACES CI Deakin discussions with the group of Prof Shanhui Fan at Stanford that make radiative cooling materials about a possible collaboration on new mechanism of cooling of one side of the thermocell. Trial will probably start with pouch cell design if the casing material proves suitable, April.			
64.	Wallace, G (2018) ACES CI UOW, Seminar and collaborative research discussions in UBC Vancouver with D Risooti, an electrochemist regarding machine learning and battery performance and K Walus on microfluidics and 3D printing, 4-5 April.			
65.	Hancock, L (2018) ACES CI Deakin met with members of the sustainability office and researchers at St Andrews University Scotland discussing laboratory procurement policies, 13 April.			
66.	Mozer, A (2018), ACES CI UOW, visited University of Melbourne to view the laser spectroscopy facility of A/Prof Trevor Smith, 18 April.			
67.	Quigley, A (2018) ACES RF UOW at St Vincent's Melbourne gave a lecture on BioPrinting at RMIT, 23 April.			
68.	Chen, F (2018) ACES RF Deakin continued collaborations with Prof Christopher Burba at Northeastern State University, working on Li and Na ion coordination environment in room temperature ionic liquids via Raman, IR and modelling techniques, April.			
69.	Cherian, M (2018) ACES PhD Deakin visited universities in London and Oxford to give talks on 'vulnerability of the elderly in disasters', April.			
70.	Guo, S (2018) ACES RF Monash had collaborative research discussions with Dr. Stephen Feldberg from Brookhaven National Laboratory, April.			
71.	Guo, S (2018) ACES RF Monash held discussions with Prof Tadaharu Ueda of Kochi University, Japan regarding collaborative projects, April.			
72.	Wallace, G., (2018) ACES CI UOW visited Helsinki University, Finland for collaborative research discussions, 30 April-1 May.			
73.	Wallace, G., (2018) ACES CI UOW visited ABO University, Turku, Finland for collaborative research discussions, 2-4 May.			
74.	Officer, D (2018), ACES CI UOW, International laboratory visit for research collaboration discussions and future CoE discussions with Prof Erwin Reisner, Department of Chemistry and Prof George Malliaras, Department of Engineering, University of Cambridge, Cambridge, England, 8 May.			
75.	Blum, A (2018) ACES PhD UNSW visited University of Chicago US working with Tracy Koogler and Lainie Friedman Ross Discuss what governs/shapes approval of pediatric clinical trials 11 May.			

ACES	ACES Invited Seminars / Collaborative visits showcasing research activities			
76.	Officer, D. L. (2018) ACES UOW CI gave a presentation "Shining light on new materials: porphyrins, graphene, conducting polymers, hydrogels and droplets" and held collaborative research discussions, at Tampere University of Technology, Tampere, Finland, 11 May.			
77.	Blum, A (2018) ACES PhD UNSW visited Judy Illes UBC, Vancouver, Canada to discuss neuro-related research at UBC 15 May.			
78.	Blum, A (2018) ACES PhD UNSW visited Sara Goering University of Washington to discuss neuro-related research 16 May.			
79.	Simonov A (2018) ACES RF Monash visited Dr A. Schnegg, Prof S. DeBeer, Dr O. Ruediger, Dr S. Bonke of Max Planck Institute for Chemical Energy Conversion (CEC), Mullheim, Germany to hold collaborative research discussions, 14-16 May.			
80.	Officer, D. L. (2018) ACES UOW CI research presentation "Moving Fluids with Light" and held collaborative research discussions along with ACES affiliated PhD Yang Xiao with Dr Corinna Maass and colleagues at Max Planck Institute for Dynamics and Self Organization, Göttingen, Germany 14-16 May.			
81.	Sparrow, R (2018), ACES CI Monash held a meeting with Dr. Edmond Awad and Dr Sydney Levine from the Scalable Cooperation Laboratory, MIT Media Lab. MIT, Cambridge, MA, USA, 14 May.			
82.	Sparrow, R (2018), ACES CI Monash held a meeting with Dr Amar Asher from the Berkman Klein Centre, Harvard University, 14 May.			
83.	Sparrow, R (2018), ACES CI Monash held collaborative discussions with Prof Louis Chude-Sokei of Boston University, 15 May.			
84.	Simonov A (2018) ACES RF Monash visited Dr T Jones, Dr Skorupska, Dr A Knop-Gericke from Fritz Haber Institute, Berlin, Germany to hold collaborative research discussions, 17- 18 May.			
85.	Officer, D (2018), ACES CI UOW International laboratory visit: Research collaboration discussions with Prof Damien Baigl, Department of Chemistry, Ecole Normale Superieure, Paris, France, 18 May.			
86.	Wang, C (2018) ACES RF UOW visited School of Engineering and Power Engineering at Xi'an Jiatong University, China, to give a talk "Versatile conducting polymers for energy applications" and met with Profs Yan Wei and Shujiang Ding to discuss potential collaborations and student exchanges, 21-23 May.			
87.	Higgins, M (2018) ACES CI UOW visited Prof Christine Kranz, Ulm University, Germany for collaborative research discussions, 21-23 May.			
88.	Simonov A (2018) ACES RF Monash visited the group of Dr K Lange Helmholtz Zentrum Berlin, Germany to hold collaborative research discussions 21 May.			
89.	Officer, D (2018), University of Wollongong, International laboratory visit: Research collaboration discussions and future CoE discussions with Prof Klaus Lips, Energy Materials in Situ Laboratory, Helmholtz Zentrum, Berlin, Germany, 22 May.			
90.	Higgins, M (2018) ACES CI UOW visited Prof Paul Dalton, Wurzburg University, Germany for research discussions and to monitor progress of the European Union Dual Biofabrication masters student progress, 23-27 May.			
91.	Hancock, L (2018) ACES CI Deakin met with economist A/Prof Julie Smith from ANU to discuss political economy accounting in Canberra, 24 May.			
92.	Wang, C (2018) ACES RF UOW visited School of Materials Science and Engineering at Zhengzhou University, China, to give a talk "Surface Engineering Nanostructured Metal-based Catalyst for electrochemical reduction of aqueous carbon dioxide" and met with Prof Qun Xu to discuss potential collaborations and student exchanges, 24-25 May.			
93.	Higgins, M (2018) ACES CI UOW visited Prof Senenxtu Lanceros Mendez, BC Materials Institute Bilbao University, Spain for research discussions on collaborative projects and possible partnerships between BC Materials and ACES, 27-30 May.			
94.	Wang, C (2018) ACES RF UOW visited Nankai University (Prof Yijing Wang and Dr Xiaosong Xue) where she presented a talk on cytocompatible/biodegradable batteries and held research collaboration discussions, 30 May.			
95.	Crook JM (2018) ACES CI UOW was invited to give a seminar "Synthetic Biosystems For 3D Modelling Of Development, Disease & Regenerative Medicine", at the ARC Centre for Innovative BioEngineering and University of Sydney Faculty of Engineering, 31 May.			
96.	Maria, F. (2018), ACES CI Deakin seminar "Ionic liquid electrolytes and their composites for next generation batteries" at AIIBM, University of Queensland, 30 May.			
97.	MacFarlane, D (2018), ACES CI Monash, presented lecture at University College Dublin, Ireland, 31 May.			

ACES	ACES Invited Seminars / Collaborative visits showcasing research activities			
98.	MacFarlane, D (2018), ACES CI Monash, presented lecture at Queen University, Belfast, Ireland, 15 June.			
99.	Wollersheim L. (2018) ACES PhD Deakin visited Clime and Energy College at Melbourne University with Carline Lamber EU Climate and Environment Counsellor on Seminar on Growth Within: the EU Circular Economy vision, re-designing the future, 22 June.			
100.	MacFarlane, D (2018), ACES CI Monash, gave a lecture 'Direct Electrochemical Production of Ammonia' at Fritz Haber Institute, Berlin, Germany, 29 June.			
101.	Chen, Jun (2018) ACES CI UOW visited Beijing Advanced Innovation Center for Biomedical Engineering at Beihang University, China to discuss collaborative research projects and engage on the establishment of potential new collaborative joint-lab, 1-18 July.			
102.	Bourke, J (2018); Invited seminar "in vitro Electrophysiological Modelling" to the BioMediTech NeuroGroup, University of Tampere, Tampere, Finland, 9 July.			
103.	Wagner, P (2018) ACES SRF UOW visited Prof M Lapkowski at Silesian University of technology, Gliwice, Poland to work of water-stable organic n-doped organic materials, 9-20 July.			
104.	Gilbert F. (2018) ACES AI UTAS and ARC DECRA visited and gave his presentation "Brain Implants and Artificial Intelligence: Implanting Unprecedented Vulnerabilities? Human-Technology Relations: Postphenomenology and Philosophy of Technology, University of Twente, Eschedes, Netherland, 11-13 July.			
105.	Gilbert F. (2018) ACES AI UTAS and ARC DECRA visited Dr Andrej Vranic and PhD candidate Mathilde Lancelot at Université Paris Diderot for discussion on a collaborative article, 15-21 July.			
106.	Fournier, M (2018) ACES Monash RF worked with Dr Rosalie Hocking, Swinburne University of Technology, on the K-edge XAS beamtime at the Australian Synchrotron, 18-19 July.			
107.	Gilbert F. (2018) ACES AI UTAS and ARC DECRA visited Dr Christian Ineichen at the University of Geneva for discussion on a collaborative article, 23 July- 6 August.			
108.	Hancock, L (2018) ACES CI Deakin held a meeting with Prof Deanna Kemp and Prof John Owens at the Sustainable Minerals Institute, University of Queensland, Brisbane, 26 July.			
109.	Ralph, N (2018) ACES Deakin RF residency at the Centre for Social Responsibility in Mining, Sustainable Minerals Institute, University of Queensland (UQ) to network with researchers in sustainable mining and circular economy based in UQ and Griffith University, 27 July-3 August.			
110.	Howlett, P (2018) ACES CI Deakin visited Drs Anthony Burrell and Chunmei Ban at the National Renewable Energy Laboratories (NREL), Golden, Colorado, where he presented a seminar "Mixed salt systems and solid electrolytes for safe and stable batteries" and discussed collaborative research opportunities, 27-30 July.			
111.	Periyapperuma K. (2018) ACES Deakin PhD research visit with Dr Chunmei Ban at the National Renewable Energy Lab (NREL), USA, to undertake lithium surface characterisation studies for 4 months from 3 August.			
112.	Ha, The An (2018) ACES affiliate PhD Deakin visited Profs Aninda Bhattacharrya and Sampath at the Indian Institute for Science (IISc) in Bangalore, India to develop in situ Raman techniques, 20 August -25 September.			
113.	Wagner, P (2018) ACES UOW SRF visited Profs Mori and Kimura at Shinshu University, Ueda, Japan on development of new materials for organic photovoltaics, 20 August–7 September.			
114.	Mozer, A (2018) ACES UOW CI visited Profs Mori and Kimura at Shinshu University, Ueda, Japan to perform collaborative research, wrote a research proposal and joint publications, 20 August–7 September.			
115.	Bourke, J (2018) RF UOM skype meeting with Prof Svetha Venkatesh from Deakin University around deep learning for biological neuronal network analysis, 21 August.			
116.	Faisal, S (2018) ACES UOW RF visited Dr Bill Gong at the UNSW to discuss XPS analysis of samples, 30 August.			
117.	Coote, M (2018) ACES CI ANU visited University of Queensland to give a seminar "Catalysing and Controlling Reactions with Electric Fields", 3 September.			
118.	Fournier, M (2018) ACES ECR Monash visited Marc Robert at the Laboratoire d' Electrochimie Moleculaire to tour the laboratories and discuss CO <sub>2</sub> demonstration cell design, 4 September.			
119.	Coote, M (2018) ACES CI ANU visited Singapore University of Design and Technology to give a seminar "Catalysing and Controlling Reactions with Electric Fields" to perform collaborative research, 11-12 September.			

ACES Invited Seminars / Collaborative visits showcasing research activities			
120.	Coote, M (2018) ACES CI ANU visited Nanyang Technological University to give a seminar "Catalysing and Controlling Reactions with Electric Fields", 13 September.		
121.	Howlett, P (2018) ACES CI Deakin was hosted by Profs Dominique Guyomard and Jean Le Bideau and Drs Nicholas Dupre and Bernard Lestriez, at University of Nantes, 19-28 September.		
122.	Prof Forsyth (2018) ACES CI Deakin was hosted by Prof Agilio Padua at the the École Normale Supérieure de Lyon, Laboratoire de Chimie, France, 15 October.		
123.	Howlett, P (2018) ACES CI Deakin visited University of Nantes attending the CNRS network workshop on Ionic Liquids and Polymers, Lyon, France, 15- 16 October.		
124.	McFarlane, D (2018) ACES CI Monash gave a seminar "Exporting Renewables as Hydrogen and Ammonia" at Victoria University, Wellington, 19 October.		
125.	McCaul, Margaret (2018) RF DCU visited ACES UOW to discuss collaborative research project with Enware, 18 October.		
126.	Li, J (2018) ACES UOW PhD oral '3D Graphene Scaffold Development for Tissue Engineering Application' at the AINSE PGRA orientation with the ANSTO/AINSE health team, 25-17 October.		
127.	Williams, J (2018) ACES affiliate biofabrication masters student visited A/Profs Dalton and Woodfield at University of Wurzburg, for a lab tour and to give guest lecture, 2 November.		
128.	Moulton, SE (2018) ACES CI Swinburne visited Dr Stanislav Moshkalev at the Centre for Semiconductor Components and Nanotechnologies; Dr Douglas Barbin at the School of Food Engineering and Dr Hudson Zanin at the Advanced Energy Storage Division, University of Campinas, Sao Paulo, Brazil, to review facilities and discuss research activities, 13-14 November.		
129.	Hancock, L (2018) ACES CI Deakin University met with the Director Rohan Preece and researchers at Praxis, (CSR and public interest NGO) in New Delhi, 14 November.		
130.	Ralph, N (2018) ACES RF Deakin met with Dr Evie Kendel and the Ethical, Legal and Social Implications of Emerging Technologies (ELSIET) network at Deakin University to identify support or funding opportunities for projects on renewable energy, materials and ethics, 15 November.		
131.	Moulton, SE (2018) ACES CI Swinburne visited Prof Sugeun Yang at School of Medicine and Prof Bong-Sup Shim at the Chemical Engineering Department, Inha University, Incheon, Korea to review facilities given an invited lecture and discuss research activities, 19 November.		
132.	Moulton, SE (2018) ACES CI Swinburne visited Prof Benny Kim in Department of Printed Electronics Engineering, Suncheon University, Korea to review facilities given an invited lecture and discuss research activities, 21 November.		
133.	Chung, J (2018) ACES AI UOW visited National Chiao-Tung University, Taiwan to deliver a prototype 3D printer and discuss collaborative projects for student exchanges in 2019, 21-22 November.		
134.	Ralph, N (2018) ACES RF Deakin worked with Prof Greg Barton and Dr Matteo Vergani, Alfred Deakin Institute for Citizenship and Globalisation, Deakin University, Melbourne to discuss possible collaborative work on energy, mining and violent extremism, 22 November.		
135.	Hancock, L (2018) ACES CI Deakin University met with Dr Michelle Ann Miller, a Senior Research Fellow at TECSEA (Transboundary Environmental Commons of Southeast Asia) Asia Research Institute, National University of Singapore to discuss smart villages and resilience to disasters, 22 November.		
136.	Hancock, L (2018) ACES CI Deakin University met with A/Prof Ingrid Graz Soft Matter Physics, Johannes Kepler University Linz, in Singapore on 23 November.		
137.	Coote, M (2018) ACES CI ANU visited City University of Hong Kong to give a seminar "Catalysing and Controlling Reactions with Electric Fields", 4-5 December.		

## APPENDIX 10: ACES CONFERENCE PRESENTATIONS

A list of ACES conference presentations not listed in appendices above. Please note that the lists included in these appendices do not contain presentations by ACES members at ACES run events.

Conference Presentations by ACES members in 2018			
1.	Wallace, G (2018) ACES CI UOW gave an "Introduction to the ACES-ANFF Facilities", at the Human Upper Airway Symposium, iC campus Wollongong, 2 January.		
2.	Howlett, P. (2018) ACES CI Deakin oral at the Symposium for Battery research in Australia, CSIRO, Australia, 2 January.		
3.	Chatti, M, (2018) ACES PhD Monash, "Renewable energy: Solar Fuels" Gordon research conference, Ventura LA, USA, 26 January-5 February.		
4.	Hill, N.S. (2018) ACES ANU PhD poster "Tailoring Photoinitiators to Enhance Visible Light Activity for 3D Bioprinting", the International Conference on Nanoscience and Nanotechnology (ICONN2018), Wollongong, 28 January-2 February.		
5.	Noble, B. (2018) ACES RF ANU presented poster "Generating Nitroxides with Electricity", ICONN 2018, Wollongong NSW, 29 January-2 February.		
6.	Yu, Changchun (2018) ACES affiliate student poster "A cytocompatible roburst hybrid conducting polymers hydrogel for biocompatible battery application, ICONN 2018, 29 January-2 February.		
7.	Wallace, G (2018) ACES CI UOW oral "introduction to the Research activities at the ARC Centre of Excellence for Electromaterials Science, Centres of Excellence Showcase ICONN, University Hall, University of Wollongong, Wollongong, 29 January.		
8.	Officer, David (2018) ACES CI UOW oral "Creating Porphyrin-based Nanomaterials for Energy Applications", ICONN 2018, Wollongong, 30 January.		
9.	Officer D. L., Y. Xiao, S. Zarghami, K. Wagner, P. Wagner, K. C. Gordon, L. Florea, D. Diamond (2018) Oral "Moving Microdroplets in 3D with Light" at ICONN18, Wollongong, Australia, 29 January-2 February.		
10.	Walker A., R. Jalili, G. G. Wallace and D. L. Officer (2018) ACES AI UOW oral "New materials based on the selective edge- functionalization of graphene", ICONN 2018, Wollongong, 29 January-2 February.		
11.	S. Sayyar, D. L. Officer and G. G. Wallace (2018) ACES AI and CIs oral "Processing graphene nano-biocomposites into 3D structures", ICONN18, Wollongong, Australia, 29 January-2 February.		
12.	Faisal, Shaikh Nayeem (2018), ACES RF UOW oral burster "Chemically-Doped Nanostructred 2D Layered Materials for Metal Free Energy Storage and Conversion", ICONN, Wollongong, 30 January.		
13.	Puckert C, Tomaskovic-Crook E, Wallace GG, Crook JM, Higgins MJ.(2018) ACES PhD UOW Oral "AFM measurement of the Electro-Mechanical Properties of Hydrogels and their Interactions with Human Neural Stem Cells", ICONN 2018, Wollongong, Australia, 29 January-2 February.		
14.	J. Choi, P. Wagner, R. Jalili, D. A. Macfarlane, G. G. Wallace, and D. L. Officer (2018) ACES PhD poster "Metalloporphyrin Functionalized Graphene for Electrochemical Reduction of CO <sub>2</sub> ", ICONN 2018, Wollongong, Australia, 29 January-2 February.		
15.	Grant D. Barnsley, Stephen Beirne, Sanjeev Gambhir, Peter C. Innis, David L. Officer, Gordon G. Wallace (2018), ACES AI and CIs poster "Graphite coated titanium alloy powder for porous structure production by selective laser melting additive fabrication techniques", ICONN 2018, Wollongong, Australia, 29 January-2 February.		
16.	Yang Xiao, Klaudia Wagner, Sara Zarghami, Pawel Wagner and David L. Officer (2018) ACES Affiliate PhD poster "Photochemopropulsion: Moving Microdroplets in 3D with Light", ICONN 2018, Wollongong, Australia, 29 January -2 February.		
17.	Sara Zarghami, Yang Xiao, Klaudia Wagner, Pawel Wagner, J. Barnsley, K. Gordon and David L. Officer (2018) ACES Affiliate PhD poster "Investigating the Light-Induced Chemopropulsion of Microdroplets", ICONN 2018, Wollongong, Australia, 29 January-2 February.		
18.	Dupont, Madeline (2018) ACES ECR Deakin oral "Optimising Thermo-Electrochemical Cells for Waste Heat Harvesting" ICONN, Wollongong, 31 January.		
19.	Cabot, JM, Daikuara, LY, Liu, X, Yue, Z, Breadmore, MC, Wallace, GG, Paull, B. (2018) ACES UTAS oral "Thread-based electrofluidics: bioactive delivery in GelMA-based scaffolds", ICONN 2018, Wollongong, 29 January-2 February.		

Confe	Conference Presentations by ACES members in 2018				
20.	Dakiuara, Luciana (2018) ACES affiliate PhD UOW poster ICONN2018, Wollongong, 29 January -2 February.				
21.	Chen, Jun (2018) ACES CI UOW oral "Thermo-Electrochemical Cells: Using Redox-Gel Integrated Flexible Electrodes to Covert Body Heat into Electricity", ICONN 2018, Wollongong, 29 January -2 February.				
22.	Syamak Farajikhah, Sepidar Sayyar, Joan M Cabot, Peter Innis, Brett Paull and Gordon Wallace (2018), ACES PhD Poster "Power-free Textile-based Microfluidic Pumps", ICONN 2018, Wollongong, 29 January -2 February.				
23.	Goddard, Eliza (2018) ACES RF UNSW oral "What's the Difference between a Brain on a Bench Top and a Brain in Your Head? Philosophical and Ethical Reflections on in Vitro Models for Neuromedicine", ICONN 2018, Wollongong, 29 January - 2 February.				
24.	Hancock, Linda (2018) ACES CI Deakin poster, "Exploring Issues of Conflict/critical and Nano Materials Used in Renewable Energy", ICONN 2018, Wollongong, 29 January -2 February.				
25.	Blum, A & Goddard, E. (2018) ACES PhD and RF UNSW poster "What is the difference between a brain on a bench top and a brain in your head? Philosophical and ethical reflections on in vitro models for neuromedicine", ICONN 2018, Wollongong, 29 January - 2 February.				
26.	Gietman S (2018), ACES PhD Swinburne Poster 'NIR stimulated release of dexamethasone from encapsulated pNIPAM- AuNR particles', ICONN 2018, Wollongong, 29 January - 2 February.				
27.	D. Duc, R. M. I. Kapsa, S. McArthur, P. R. Stoddart and S. E. Moulton (2018) ACES Swinburne PhD Poster 'Fabrication of Biocompatible Interface for Optical and Electrical Cell Co-Stimulation', ICONN 2018, Wollongong, 29 January -2 February. *Winner poster award				
28.	Gilbert, F (2018) ACES AI and ARC DECRA presented a guest lecture on Neuroethics & Behaviour at the University of Washington, Seattle, US, 27 February.				
29.	<ul> <li>Ralph, N &amp; L. Hancock (2018) ACES RF and CI Deakin presented paper on 'Theorizing Energy Security: How Will Australi Renewable Energy Exports to Indonesia Impact Energy Security and Technology Choices?', Alfred Deakin Institute Research conference, Deakin University, Melbourne, 27 February.</li> </ul>				
30.	Aziz, S., Naficy, S., Foroughi, J., Brown, H.R. and Spinks, G.M. (2018) Oral "Twist-Coil Coupling in Artificial Muscles", SPIE: Smart Structures and Materials (2018), Denver, Colorado, USA, 4 March.				
31.	Wouters, B.; Pirok, B.; Macdonald, NP; Cabot, JM; Currivan C; Paull, B; Breadmore MC; Schoenmakers, PJ.(2018) members of ACES at UTAS oral "Towards the use of reaction-modulators in an integrated multi-dimensional liquid chromatography system", Analytical Technologies in the Biopharmaceutical Industry Europe (AT Europe 2018), Barcelona Spain, 6-9 March.				
32.	Dodds, S (2018) CI UNSW, Australian Academy of Science, PRESENTATION on Humanities and Social Sciences Researchers in STEM ARC Centres of Excellence bids for a meeting of the Biological Sciences. 13 March.				
33.	Yu, Changchun (2018) ACES affiliate PhD oral "A single component cytocompatible macroporous Polypyrrole Film for Salinity Power Generation", at MRS Spring Meeting, Phoenix, America, 2-6 April.				
34.	Boyd-Moss M, Quigley A, O'Connell C, Nisbet D, Williams R.(2018) "Development of A Hybrid Gelma Biomaterial Scaffold Functionalised With Novel Self-assembling Peptides For Soft Tissue Engineering Applications", ASBTE conference, Melbourne, 3-5 April.				
35.	Ngan C, Quigley A, Onofrillo C, Duchi S, Blanchard R, Bourke J, O'Connell C, Wallace G, Kapsa R, Choong P. (2018) "Bioprinted Skeletal Muscle Fibres in a Gelma Bioink. ASBTE conference, 3-5 April.				
36.	Adesanaya, O, (2018) Affiliate PhD UTAS Oral "Assessing the Patentability of Bioprinting-Related Inventions" at the New IP Lawyers Conference, Exeter Law School, UK, 16-17 April.				
37.	Daikuara L, Yue Z, Skropeta D, Wallace G (2018) Affiliate PhD UOW Oral and poster 'Fabricating Delivery System for Would Healing' at 26th Annual Conference of the Australasian Society for Biomaterials and Tissue Engineering, Perth, 3-5 April.				
38.	Chen, F (2018) ACES RF Deakin Poster "Electrostatics in Concentrated Electrolytes " at CECAM workshop, Lausanne, Switzerland, 9-11 April.				
39.	Cherian, M (2018) ACES PhD Deakin presented on "social innovation" at the Presidents National conference on innovation: How can we be a developer, innovator and service provider?, April.				
40.	Gilbert F (2018) AI UTAS oral "Implantable Brain Computer Interfaces: Exploring Estrangement and Embodiment" at Ethics in Neurotechnological Innovation MIMI and MICCN Symposium, 1 May.				

Confe	Conference Presentations by ACES members in 2018				
41.	Gilbert F (2018) AI UTAS oral "Experimental Usage of AI-Controlled Brain Implants in Military Personal: Any Moral Obligation Ahead?" at the 8th ICMM Workshop on Military Ethics, Ermatingen, Switzerland, 3-5 May. <b>*Full Written paper</b> <b>referreed proceedings.</b>				
42.	Duc, D (2018) PhD Swinburne, Poster "Fabrication of Biocompatible Interface for Optical and Electrical Neuronal cell Co- Stimulation" at the Swinburne Research Conference, 10 May. <b>*Awarded 2nd Prize.</b>				
43.	Gietman S (2018), ACES PhD Swinburne Poster 'NIR stimulated release of dexamethasone from encapsulated pNIPAM- AuNR particles' at the Swinburne Research Conference, 10 May.				
44.	Gilbert F (2018) ACES AI UTAS oral "Artificial Intelligence and Brain Implants: What could phenomenologically go wrong?" Neuroethics: Re-Mapping the Field, Vita-Salute San Raffaele University, Milan, 16-18 May <b>*Peer reviewed</b>				
45.	Zhao, Y (2018) Affiliate PhD UOW Oral "Tunable and Efficient Tin Modified Nitrogen-doped Carbon Nanofibers for CO <sub>2</sub> Electroreduction" at ECS 233rd meeting, in Seattle, USA, 17 May.				
46.	Tawk, C (2018) ACES PhD UOW gave oral and demonstration of soft actuators "the Gongaroo" at the International Conference on Robotics and Automation (ICRA) 2018 in Brisbane, Australia, 20-25 May. <b>*Winner Category A: Soft Component Technologies challenge.</b>				
47.	Benjamin Stephens-Fripp (2018) Affiliate PhD UOW poster at ICRA 2018 conference, Brisbane, Australia, 20-25 May.				
48.	Mudiyanselage, I. (2018) Affiliate PhD Deakin poster 'NMR and MRI studies of cobalt redox active ionic liquids for thermo- electrochemical cells' at the 8th Australasian Symposium on Ionic Liquids (ASIL8), Deakin University, Melbourne 21-23 May.				
49.	Taheri, A., M., MacFarlane D.R., Pozo-Gonzalo C. and Pringle J. M. (2018) ACES PhD Deakin poster at "Development of polymer-based redox electrolytes for thermal energy harvesting" at 8th Australasian Symposium on Ionic Liquids (ASIL8) Deakin University, Melbourne 21-23 May.				
50.	Russo M., MacFarlane D. R., Spinks G., and Pringle J. M. (2018) ACES Masters poster "Development of quasi-solid electrolytes for thermoelectrochemical cells" at ASIL8, Deakin University, Melbourne 21-23 May.				
51.	Wang, C (2018) ACES RF UOW oral "Organic Conductors for applications in energy storage and conversion" at Conference on Physical Organic Chemistry, Tianjin, China, 31 May- 2 June.				
52.	Yang Xiao, Sara Zarghami, Pawel Wagner, Klaudia Wagner and David L. Officer (2018) ACES affiliate PhD poster "Using photoactive molecules to move droplets" at the 3rd International Conference on Photoalignment and Photopatterning in Soft Materials 2018, Tampere University of Technology, Tampere, Finland, 11-14 June.				
53.	Adesanya, O (2018) Affiliate PhD UTAS oral "Bioprinting: Patents as a Positive Regulatory Tool" at Tilburg Institute for Law, Technology and Society International PhD Colloquium 2018, 14 June.				
54.	Waheed, S (2018) ACES PhD UTAS paper "Breaking barriers within 3D printing technology: Development of low cost 3D printable diamond composite for thermal management" E-MRS Spring Meeting 2018, Strasbourg, France, 18-22 June. *Awarded the European Materials Research Society (E-MRS) Young Scientist Award.				
55.	Tomaskovic-Crook E, Bourke J, Zhang B, Kapsa R, Wallace G, Crook JM (2018) ACES RF Poster "NextGen" human brain organoids using 3D printed gelatin methacrylate at the International Society for Stem Cell Research Conference (ISSCR) 6th Annual Meeting, Melbourne, 20-23 June. <b>*Australasian Society for Stem Cell Research Travel Award.</b>				
56.	Quigley A, Kita M, Bourke J, Sweerts K, Crook J, Wallace GG and Kapsa RMI (2018) ACES RF oral "Skeletal Muscle Progenitor Delivery by Hydrogel Fibres", International Society for Stem Cell Research Conference (ISSCR) Melbourne, 20- 23 June.				
57.	Cherian, M. (2018) ACES PhD Deakin presented a paper on "Impact of natural disaster on older persons in Uttarakhand" presented at IFA 13th Global Conference on Ageing held in Brisbane, 21-23 June 2018.				
58.	Russo, M (2018) MPhil Electromaterials student Deakin Poster "Development of Quasi Solid State Electrolytes for Thermal Energy harvesting" at the 16th International Symposium on Polymer Electrolytes (ISPE) in Yokohama, Japan 24- 29 June.				
59.	Knowles, B., Zhang, B., Shang, E., Kurek, D., Higgins, M., Wagner, P., Molino, P. (2018) ACES researchers supervise this ARC Steel hub student who presented an oral "Utilizing functionalised silica nanoparticles to fabricate biofouling resistant coatings for marine applications" at the International Congress on Marine Corrosion and Biofouling, Melbourne, Florida, USA, 24 -29 June.				

Confe	Conference Presentations by ACES members in 2018			
60.	Fornells E, Waheed S and Breadmore M.C. (2018) Oral 'Integrated 3D printed heaters for microfluidic applications'. Australia and New Zealand Nano and Microfluidic (ANZNMF), Auckland New Zealand, 27-29 June.			
61.	P. Wagner, C. Hobbs, N. Roach, K. Wagner, J. Barnsley, K. C. Gordon, G. Kodali, C. Moser, P. L. Dutton, D. L. Officer (2018) ACES SRF UOW oral "Photovoltaic Application of Porphyrin Protein Maquette- Based Reaction Centres" at the Tenth International Conference on Porphyrins and Phthalocyanines (ICPP-10), Munich, Germany, 1-6 July.			
62.	Noble, B.B. (2018) ACES ANU RF Oral "Towards Stereocontrol in Radical Polymerisation; Lewis Acids and Ionic Auxillaries", IUPAC World Polymer Congress (Macro2018), Cairns, 1-5 July.			
63.	Hill, H.S. (2018) ACES ANU PhD poster "Ab Initio Insight into the Synthesis of Highly Coheterotactic Poly(Methyl Methacrylate-alt-Styrene", IUPAC World Polymer Congress (Macro2018), Cairns, 1-5 July.			
64.	Bourke J, Anita F. Quigley, Serena Duchi, Cathal D. O'Connell, Jeremy Crook, Gordon G. Wallace, Mark J. Cook, Robert M.I. Kapsa (2018) ACES UOM RF oral "Three dimensional microenvironments on multi-electrode arrays produce neuronal networks that function like the brain" at the 11th International Meeting on Substrate Integrated Microelectrode Arrays, Reutlingen Germany, 4-6 July.			
65.	Goddard, E and Dodds, S (2018) ACES UNSW refereed conference paper 'Minding the gap: ethical questions raised by the 'brain on a bench', Australasian Association of Philosophy and New Zealand Association of Philosophy Conference, Wellington NZ, 8-12 July. <b>*Full written paper refereed proceedings</b> .			
66.	Walker, M (2018) ACES RF Monash oral 'Neurotechnologies and the possibility of relational authenticity' at Australasian Association of Philosophy and New Zealand Association of Philosophy Conference, Wellington NZ, 8-12 July.			
67.	Bourke J., Anita F. Quigley, Serena Duchi, Cathal D. O'Connell, Jeremy Crook, Gordon G. Wallace, Mark J. Cook, Robert M.I. Kapsa (2018) presented oral 'Three dimensional microenvironments on multi-electrode arrays produce neuronal networks that function like the brain', MEA CONFERENCE, Germany, July 2018.			
68.	Kalsoom U (2018) ACES RF UTAS oral "Low-Cost 3D printed Passive Sampling Devices with Integrated Porous Membranes" at the ACROSS Winter Gathering, Melbourne, 12-13 July.			
69.	Ralph, N. & van Dorp, M. (2018) ACES Deakin RF oral "What Is the Impact of Renewable Energy-related Businesses in Fragile and Conflict-affected States?" Best and Poor Practice for Ensuring Renewable Energy Supports Peace and Stability, International Political Science Association World Congress, Brisbane, 21-25 July.*Full written paper-non refereed proceedings			
70.	Ralph, N. (2018) ACES Deakin RF oral "How Can Business Help Prevent and Counter Violent Extremism?", International Political Science Association World Congress, Brisbane, 21-25 July.*Full written paper-non refereed proceedings			
71.	Hancock, L., Ralph, N., Ali, S.A. (2018) ACES CI Deakin oral "Bolivia-Australia Comparison on Lithium Governance Models", International Political Science Association World Congress, Brisbane, 21-25 July. <b>*Full written paper-non refereed</b> <b>proceedings</b>			
72.	Alici, G (2018) ACES CI UOW presented papers at 2018 IEEE International Conference on Advanced Intelligent Mechatronics, Auckland, New Zealand, July 2018 <b>*Full written paper - refereed conference proceedings</b>			
73.	Duc D, R. M. I. Kapsa, S. McArthur, P. R. Stoddart and S. E. Moulton (2018) Poster 'Fabrication of Biocompatible Interface for Optical and Electrical cell Co-Stimulation' Aikenhead Centre for Medical Discovery (ACMD) Research Week, St Vincent's Hospital, Melbourne, 6-10 August.			
74.	Bourke J., Anita F. Quigley, Serena Duchi, Cathal D. O'Connell, Jeremy Crook, Gordon G. Wallace, Mark J. Cook, Robert M.I. Kapsa (2018) poster 'Development of a personalised clinical system for fast selection of anti-epileptic drugs' , ACMD Research Week St Vincent's Hospital, Melbourne, 6-10 August.			
75.	Quigley A, Kita M, Bourke J, Sweerts K, Duchi S, Crook J, Wallace GG, Kapsa RMI (2018) Poster 'Hydrogel based Muscle Progenitor Delivery Enhances Long Term Muscle Engraftment', ACMD Research Week St Vincent's Hospital, Melbourne, 6-10 August.			
76.	Ngan C, Quigley A, Onofrillo C, Duchi S, Blanchard R, Bourke J, O'Connell C, Wallace G, Kapsa R, Choong P (2018), 'Tissue engineering functional skeletal muscle through bioprinting', ACMD Research Week St Vincent's Hospital, Melbourne, 6-10 August. <b>*Selected for Junior Investigator Award</b>			
77.	Walker MJ (2018) Oral 'The epistemic status of narrative and improving patient care' at the European Society for Philosophy of Medicine and Healthcare, Lisbon, 22-26 August.			
78.	Gilbert F., (2018) paper "Is it me or the Machine?" Brain Computer Interfaces, Control and Vulnerabilities presented at the Neuroscience and Society Conference, Sydney, Australia, 24-25 August.			

Conference Presentations by ACES members in 2018			
79.	Blum, A (2018) PhD UNSW paper "Reasons to limit expectations of 3D neural tissue models" presented at Society for Social Studies of Science (4S) conference, Sydney, 29 August-1 September. <b>*Full written paper-non-refereed proceedings.</b>		
80.	Gilbert F., Viaña JNM., Ineichen C., (2018) ACES AI and affiliate PhD UTAS presented 'Deflating the "Neurostimulation Causes Personality Changes" Bubble' at 4S Sydney, Australia, 29 August-1 September.		
81.	Zhang. Y. (2018), PhD at Monash University, Poster 'Electrochemical reduction of CO <sub>2</sub> on defect-rich Bi derived from Bi <sub>2</sub> S <sub>3</sub> ' at the 69th Annual Meeting of the International Society of Electrochemistry, Bologna, Italy 2-7 September.* <b>Travel award received to attend.</b>		
82.	Walker, M (2018) ACES RF Monash oral in "Ethics in personalised medicine research: Case study of an iPSC-based system for predicting individual treatment responses" at the Australasian Association of Bioethics and Health Law, Townsville, 23-26 September.		
83.	Zhou, H; Alici G (2018) ACES RF and CI at UOW "A 3D-printed soft robotic hand prosthesis: UoW/ACES Prosthetic Hand", at the Australian Biomedical Engineering Conference 2018, Sydney 8-10 October.		
84.	Chen, Jun (2018) ACES CI UOW oral "Efficient photocatalytic properties of BiOX via defect engineering" at International Conference on Emerging Advanced NanoMaterials (ICEAN) 2018, Newcastle, Australia, 30 October-2 November.		
85.	Williams, Joanne (2018) ACES UOW Biofabrication Masters affiliate poster "3D Printing PDMS for drug delivery", The International Conference on Biofabrication 2018, Wurzburg, Germany, 28 -31 October.		
86.	Chen, Xifang (2018) ACES UOW affiliate PhD oral "Development of ulvan based bioinks for wound healing application" at the International conference on Biofabrication, Wurzburg Germany, 31 October.		
87.	Daikuara, Luciana (2018) ACES UOW affiliate PhD poster "Fabricating Delivery System for Wound Healing" at the International conference on Biofabrication, Wurzburg Germany, 31 October.		
88.	Gilbert F. (2018) ACES AI and DECRA UTAS Oral "The Robot in my Head: What are the Risks of Interacting with an Implantable Brain-Computer Interface that 'Knows Better'" at the Robots and AI in Society, Western Sydney University, Sydney, 8-9 November. <b>*Full written paper-refereed proceedings</b>		
89.	Gilbert F. (2018) ACES AI and DECRA UTAS Oral "Is it Me or the Machine? Cyborging Human Control. The Cyborg Days", at the University of Zurich, Switzerland, 26-28 November. <b>*Full written paper-refereed proceedings</b>		
90.	Paull, B (2018) ACES CI oral 'Fibre Based Electrophoresis and Isoelectric Focussing, Together with Ambient Mass Spectrometry-based Detection', Micro-symposium on Analytical Chemistry, Tarraleah, Tasmania, 9-10 December.		

### APPENDIX 11: ACES INTERNATIONAL EVENTS 2018

Global Engagement Event Description		Date	Venue
1.	International Conference on Nanoscience and Technology (ICONN 2018) (http://ausnano.net/iconn2018/) ICONN 2018 brought together nearly 700 Australian and international delegates working in the field of nanoscale science and technology. The event included a list of inspiring	29 Jan-2 Feb	UOW Northfields Ave Campus Wollongong
	speakers, including three Nobel Prize Winners, who discussed the latest advances in nanoscience and their applications. It was a fantastic opportunity to share ideas, success stories and was aspiring for all delegates. Symposia themes covered: nano safety and societal issues; nanomaterials, nanofabrication and nanocharacterisation, computational nanotechnology; nanophotonics; nanoelectronics and nanobiotechnology.		
	Special events on the 2018 program included:		
	<ul> <li>End User Engagement Session</li> <li>ARC Centres of Excellence Showcase</li> <li>Public Lecture: My Journey to Stockholm with Nobel Prize Winner, Sir Fraser Stoddart</li> <li>Engineering your Imagination: ANFF Short Course on Nanofabrication Technologies</li> </ul>		

Globa	al Engagement Event Description	Date	Venue
2.	ACES-BETRC Collaboration workshop A team of 5 professors from National Chiao Tung University in Taiwan exchanged ideas with presenters and attendees for collaborative research. An MOU was signed at this workshop.	15-16 March	iC campus UOW Wollongong
3.	Sri Lanka Institute of Nanotechnology Visit The Consul General of Sri Lanka; CEO SLINTEC; Chief of Research and Innovation; a Senior scientist and Head of Business Development met with ACES research scientists to discuss opportunities for 3D bio printing, materials engineering and medicinal chemistry.	20 March	iC campus UOW Wollongong
4.	<ul> <li>8th Australian symposium on ionic liquids (ASIL8) (https://blogs.deakin.edu.au/asil8/)</li> <li>ASIL is the main forum for the ionic liquid research community in the Australasian region. Speakers from world-leading local and international institutions discussing a diverse range of topics with the aim of encouraging idea exchange and collaboration in ionic liquid research.</li> <li>Computational simulation of properties and processes in ionic liquids</li> <li>Energy storage and generation applications</li> <li>Novel classes of ionic liquids</li> <li>Fundamentals, preparation and applications in ionic liquids</li> <li>Emerging technologies</li> </ul>	21-23 May	Deakin University Melbourne
5.	<b>Bioinspired 3D Structures - an ACES and DCU Event.</b> ACES and their European collaborators presented at this workshop. The 79 attendees then were able to network with many discussions centred on research progress and future research activities.	31 May	Dublin City University Dublin Ireland
6.	<b>The Future of Bionics and the Ethical Issues.</b> In partnership with the Australian Embassy in Ireland, Science Gallery Dublin presented a talk exploring the ethical issues relating to bionics and stem cell research around the world. ACES CI Gordon Wallace (UOW) spoke on work in the area of nanotechnology and the promise of new medical solutions using stem cells and 3D bioprinting; ACES CI Susan Dodds (UNSW) and David Hoey (Trinity College Dublin) explored the ethical ramification. Simon Mamouney, Deputy Ambassador of the Australian Embassy in Dublin, introduced the event. https://dublin.sciencegallery.com/events/2018/05/futurebionicsandethicalissues#	1 June	Science Gallery Dublin Ireland
7.	Korea•Australia Medical-Bio 3D Printing Forum. This was an ACES -Korea Society of 3D Printing in Medicine (KS3DPM) event, part of "NaNO Korea" an event with more than 1500 participants and 100 companies in attendance. An MOU between the the 2 hosts was signed then research applications for medical innovation in 3D printing showcased.	7 September	Korea
8.	<b>ACES- KS3DPM Innovation Showcase</b> was held at the Australian Embassy Republic of Korea. The event was hosted by the Australian Ambassador to the republic of Korea His Excellency Mr James Choi and showcased the significant collaborative relationship between ACES, KS3DPM and other members of the Korean clinical community interested in Bioprinting. Opportunities for future work were highlighted and a 3D printing demonstration by ACES and the Australian National Fabrication Facility (ANFF) followed the presentations. ACES AI A/Prof Payal Mukherjee, ENT Surgeon at Royal Prince Alfred Hospital in Sydney was ACES's featured speaker along with Director Wallace.	6 November	Australian Embassy Seoul
9.	<b>3DBioprint ACES- ASAN technical symposium.</b> The symposium featured talks from our partners, covering topics such as using 3D bioprinting to make parts for bodies and sensors.	7 November	ASAN Institute Seoul, Korea.

#### APPENDIX 12: ACES INTERNATIONAL ACADEMIC VISITORS 2018

The list below does not include visitors to ACES as part of events or conferences that ACES organised throughout 2018.

ACES	International Academic Visitors
1.	Xiaomin Zhang from Nanjing University, China was hosted on a postgraduate research exchange at ACES Monash University from 29 September 2016 through to 3 March 2018.
2.	A/Prof Nobutake Nakatani from Rakuno Gakuen University, Japan spent one year visiting ACES UTAS node to work on "Photonic crystal fibre for electrophoretic separation of inorganic cations in CE-C4D", March 2017 – March 2018.
3.	Maxim Brodmerkel, Wurzburg University in Germany, spent ten months at ACES UOW completing the second year of the dual degree, from July 2017 – March 2018.
4.	Juliane Kade, Wurzburg University in Germany, spent ten months at ACES UOW completing the second year of the dual degree, from July 2017 – March 2018.
5.	Marius Berthel, Wurzburg University in Germany, spent ten months at ACES UOW completing the second year of the dual degree, from July 2017 – March 2018.
6.	Rhiannon Morris, Cardiff University, hosted at ACES UOW, 20 August 2017-1 May 2018.
7.	Bing Lin, Beijing University of Chemical Technology China, hosted at ACES Deakin from 25 September 2017- June 2018.
8.	Diego Castañeda Garay, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017 – July 2018.
9.	Stefan Zaharievski, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017– July 2018.
10.	Laura Blanco Peña, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017– July 2018.
11.	Max Renes, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017– July 2018.
12.	Gilles van Tienderen, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017– July 2018.
13.	Gregor Weisgrab, Utrecht University in Netherlands, spent ten months at ACES UOW completing the second year of the dual degree, from September 2017– July 2018.
14.	Fleurine Eberle from Wurburg University, Germany was hosted at ACES UOW to undertake 6 months of her masters thesis working on metal 3D printing from 1 October 2017 to 31 March 2018.
15.	Koralina Biernacka from Amiens France, undertook her masters project at ACES Deakin, January to August 2018.
16.	Alexandra Grzelak, undertook her masters project at ACES Deakin, January to August 2018.
17.	Tony Pointu from France was hosted at ACES Deakin for his internship from January to June 2018.
18.	Barthélémy Hugon, a French exchange student was hosted at ACES Deakin for her internship from January to June 2018.
19.	Florentin Guilbault, a French exchange student was hosted at ACES Deakin for her internship from January to June 2018.
20.	Prof John Scully, University of Virginia, USA, visited ACES Deakin for a tour of the facilities and for research discussions. He gave a seminar "Recent development and utilization of electrochemical techniques in applied electrochemistry", 9 January 2018.
21.	Sylvie Riber, PhD student from Senentxu's group in Portugal spent a 2 months at ACES UOW working with CI Higgins on high speed AFM, 15 January - March 2018.
22.	Prof Subbu Venkatraman, Chair of School of Materials Science and Engineering and Dr Huang Yingying, Principal Research Fellow at Nanyang Technological University in Singapore visited ACES at UOW to tour the additive fabrication facilities and discuss potential areas of collaboration, 30 January 2018.
23.	Prof Wei Yan from Xi'an jiatong University visited ACES UOW for research discussions for a new collaboration in the area of polymer materials for energy storage, 31 January 2018.

ACES	ACES International Academic Visitors			
24.	Profs SC Kim, J Choi, IK Shim and C Hwang from ASAN Medical Center, Korea, visited ACES UOW to discuss bioprinting, 7 February 2018.			
25.	Diego Ghezzi from Ecole Polytechnique Federale de Lausanne in Switzerland visited ACES at UOW for collaborative research discussions, 13 February 2018.			
26.	Heidi Kaisvuo, Tampere University Finland, at ACES UOW working on masters project, February-July 2018.			
27.	Annika Ahtiainen, Tampere University Finland, at ACES UOW working on masters project, February-July 2018.			
28.	Mike Burgess from UBC in Canada visited ACES UNSW node to discuss Deliberative and Participatory Public Engagement with CI Dodds, 26 February 2018.			
29.	Hannah Haag, Biofabrication Masters student University Hospital Wurzburg, completed her degree at ACES UOW from 1 March- 20 December 2018.			
30.	Anne Gruska, Wurzburg University, Germany spent ten months at ACES UOW completing the second year of the dual degree, 1 March – 20 December 2018.			
31.	Markus Ebert, Wurzburg University, Germany spent ten months at ACES UOW completing the second year of the dual degree, 1 March – 20 December 2018.			
32.	Chung-Yu Wu, Ming-Dou Ker, Yu-Ting Cheng, Pu-Wei Wu, Jui-I Chao from National Chiao Tung University, Taiwan, visited ACES at UOW for a tour of facilities, collaborative workshop and signing of a memorandum of understanding, 15 March 2018.			
33.	Visiting academics from Sri Lanka Institute of Nanotechnology visited ACES at UOW for a tour of the facilities, 20 March 2018.			
34.	Prof Louis-César Pasquier, Institut National de la Recherche Scientifique (INRS) Université de Recherche, France visited ACES Deakin for collaborative research activities, 21 March 2018.			
35.	ACES members at St Vincent's Hospital Melbourne hosted 4th year Advanced Medical Science students from Indonesia to conduct masterclasses in laboratory techniques, including 3D bioprinting, April 2018.			
36.	Prof Terry Steele, Nanyang Technological University in Singapore, visited ACES UOW to discuss potential collaborations in the areas of 3D Bioprinting and materials engineering, 3 April 2018.			
37.	Dr Stephanie Hughes, Senior Research Fellow, University of Otago visited ACES at UOW for collaborative discussions, 19 April 2018.			
38.	Seth Rasmussen, North Dakota State University, USA, visited ACES UOW for research discussions with CI Spinks, 4 May 2018.			
39.	Prof Choon-Hong Tan NTU, Taiwan, gave a seminar "Unmasking catalytic reaction mechanisms: From small molecules to enzymes" and held research discussions at ACES ANU, 16 May 2018.			
40.	Guangdon delegation visited ACES at UOW to review facilities and conduct collaborative research discussions, 17 May 2018.			
41.	Prof Jadranka Travas-Sejdic from University of Auckland New Zealand visited ACES at UOW to discuss collaborative research opportunities, 22 May 2018.			
42.	Tom Welton of Imperial College London visited ACES Deakin to discuss collaboration project 24 May 2018.			
43.	Dr Wesley Henderson, Pacific Northwest National Laboratory (PNNL) North Carolina USA, visited ACES Deakin to progress collaborative research, 13-16 June 2018.			
44.	Margaret McCaul, NCSR, Dublin City University, Ireland visited ACES at UTAS for research discussions on "Deployable systems for environmental monitoring" and "Electrolyte monitoring on skin" and to review facilities, 14 June 2018.			
45.	A/Prof Susanna Narkilahti, Group leader NeuroGroup, BioMeditech and Faculty of Medicine and Life Sciences, and Mervi Ristola from the University of Tampere, Tampere, Finland visited ACES at UOW to discuss collaborative research and to review facilities, 14-29 June 2018.			
46.	Susanna Miettinen, BioMediTech, University of Tampere, Finland, visited ACES UOW for collaborations and workshop, 14 June 2018.			

ACES	ACES International Academic Visitors			
47.	Mario Romero Ortega, University of Texas at Dallas, USA, visited ACES UOW to attend a workshop and hold collaborative research discussions, 15-20 June 2018.			
48.	Emer Duffy, INSIGHT, Dublin City University, Ireland visited ACES at UTAS for research discussions on "Ink smart tattoos to monitor air pollution" and to review the facilities, 19 June 2018.			
49.	Prof Konrad Walus, Director of Electrical Engineering Undergraduate Program, Faculty of Applied Science, Department of Electrical and Computer Engineering, The University of British Columbia, Vancouver BC, Canada visited ACES UOW to present a lecture, discuss collaborative research and to review facilities, 26-28 June 2018.			
50.	Dr Lee Johnson, Nottingham Research Fellow, Faculty of Science, University of Nottingham, vivsetd ACES Deakin and gave a seminar "The rechargeable aprotic Li-O <sub>2</sub> battery", 26-29 June 2018.			
51.	Prof Renxian Tang, Associate Dean of Medicine School; A/Prof. Yanxian Wei, Associate Head of Department of Medical Microbiology and Immunology; Mr Xiangyang Li, Manager of Jiangshu Key Lab of Immunity and Metabolism from Xuzhou Medical University, China, toured the facilities at ACES UOW, 28 June 2018.			
52.	Susana Toresi, University of São Paulo, Brazil visited ACES UOW and held research discussions with CI Higgins, 29 June 2018.			
53.	Dr Minjae Lee, Kunsan University South Korea, visited ACES Deakin and gave a seminar "Dicationic OIPCs", 29 June 2018.			
54.	Asier Fernandez, Polymat Spain, is working at ACES Deakin on iongels for sodium-air battery technologies, 1 July-1 October 2018.			
55.	Two students, Mr Kun-Lin Tsou and Mr Yu-Wei Lin, from Institute of Electronics (BETRC) at the National Chaio-Tung University (NCTU) in Taiwan visited ACES UOW to collaborate on printer development for cell printing and microvalves, 2-29 July 2018.			
56.	A delegation from Industry-University Cooperation Foundation at Hanbat National University, Korea, visited ACES UOW to learn how to develop university-business co-operation or entrepreneurship at a university, 4 July 2018.			
57.	Tomohiro Mori, Industrial Technology Center of Wakayama, Japan, toured the facilities at ACES UOW and held research discussions in the area of materials for energy conversion, 6 July 2018.			
58.	BioMediTech NeuroGroup, University of Tampere, Tampere, Finland visited ACES UOM at St Vincents Hopstial Melbourne to hold research discussions and review the facilities, 9 July 2018.			
59.	Prof Ker, NCTU, Taiwan visited ACES UOW to discuss research plans for visiting research students, 9 July 2018.			
60.	Rezan Aljafari, German-Jordanian University, visited ACES UOW to explore research/PhD opportunities in biomaterials & tissue engineering, 10 July 2018.			
61.	Prof Wesley Henderson, U.S. Army Research Office visited ACES Deakin Geelong to discuss emerging energy materials, 13-16 July.			
62.	Libao Chen, Central South University, China, visited ACES UOW for research discussions, 25 July 2018.			
63.	Prof Thomas Hyde, Lieber Institute for Brain Development, Baltimore, Maryland met with ACES CI Crook, 30 July.			
64.	Rajendra Bordia, Clemson University, USA, visited ACES UOW for research discussions, seminar and a tour of the facilities, 2 August 2018.			
65.	Aravind Vijayaraghavan, University of Manchester, UK visited ACES UOW for collaborative research discussions, 3 August 2018.			
66.	Prof Edwin Jager, Linköping University, Sweden, visited ACES UOW to undertake collaborative research activities, 6-10 August 2018.			
67.	Ivan Maguire, Dublin City University, Ireland, visited ACES UOW for seminar and lab tour, 15 August 2018.			
68.	Dr Hiromasa Yamada from Japan was hosted by ACES Deakin, 24 August to 25 September 2018.			
69.	Shiju Raveendran, University of Amsterdam, Netherlands, visited ACES UOW for a seminar and to discuss opportunities for faculty positions in Australian Universities, 28 August 2018.			
70.	Dr Peter Fischer, Würzburg, Germany, visited ACES UOW to discuss Memorandum of Agreement, 30-31 August 2018.			
71.	Mr Dexter Cole from Cardiff University is working with CI Jun Chen on "Redox-Gel Electrolytes" at ACES UOW from September 2018- June 2019.			

ACES International Academic Visitors			
72.	Paul Dalton, Würzburg, Germany, visited ACES UOW for biofabrication project discussions and gave a series of lectures, 26-28 September 2018.		
73.	A/Prof Amitava Bhattacharyya, PSG College of Technology India, visited ACES node at St Vincent's Hospital Melbourne for collaborative discussions, 12 October 2018.		
74.	Prof Anders Plamqvist, Charmers University Sweden, visited ACES Deakin to progress collaborative project, 12 October 2018.		
75.	Dr Nagore Ortiz Vitoriano from CIC Energigune visited ACES Deakin, 20 October to 4 November 2018.		
76.	Dr Anna Loresen, Department of Chemistry and Biochemistry, Ithaca College, New York USA, spent a month undertaking research activities at ACES Deakin, 20 October-30 November 2018.		
77.	Prof Tadaharu Ueda, Kochi University, Japan, worked with the ACES Monash team at Monash University from 25 October - 1 November 2018.		
78.	Prof Kris Matyjaszewski, Carnegie Mellon University, visited the ACES team at ANU for collaborative discussions and to present the 2018 Birch Lecture 'Macromolecular Engineering by Taming Free Radicals', 29-31 October 2018.		
79.	Marleen Kristen, Utrecht University Netherlands, spending ten months at ACES UOW completing the second year of the dual degree, from November 2018.		
80.	Ane Urigoitia Asua, Utrecht University Netherlands, spending ten months at ACES UOW completing the second year of the dual degree, from November 2018.		
81.	Borja Sanz Gutierrez, Utrecht University Netherlands, spending ten months at ACES UOW completing the second year of the dual degree, from November 2018.		
82.	Karen Butina, PhD student in organic bioelectronics from Karolinska Institute Sweden, spent 3 weeks at ACES UOW using AFM to study bacteria on conducting polymer surfaces. Her aim is to use conducting polymers to create novel devices for detecting, monitoring and controlling bacterial growth. 3- 24 November 2018.		
83.	Mark Buckingham, PhD student from King's College London, visited ACES UOW to work with CI Jun Chen on collaborative project "thermal harvesting devices, 20 November 2018 – 18 January 2019.		
84.	Shogo Mori, Shinshu University, Japan, visited ACES UOW to work on a joint paper based on his student's last visit, 4-11 December, 2018		
85.	David NG Chee Keong, Shantou University, China, visited ACES UOW for discussions and a lab tour, 7 December 2018.		
86.	Various delegates in conjunction with the Lanzhou Institute of Chemical Physics (LICP) from the Chinese Academy of Science in China here attending the Australia-China Tribology Workshop, visited ACES UOW to review the facilities and understand more about the research activities undertaken in ACES, 6-7 December 2018.		
87.	Prof Ming-Dou Ker and his team from National Chiao-Tung University Taiwan visited ACES UOW to deliver a customised electrical stimulator for ACES projects and provide training to ACES members, 11-13 December.		
88.	Prof Katina Michael, Arizona State University US, visited CI Dodds at UNSW for collaborative ethics discussion, December.		
89.	Anna Gunnarsdottir, University of Cambridge, UK visited ACES Deakin and gave a seminar "In situ NMR Studies on Li metal", 11 December 2018.		
90.	Prof Max Lu, Surrey University, England, visited ACES UOW, 12 December 2018.		
91.	Drs Peter Sherrell and Amy Gelmi, Imperial College London UK, visited ACES UOW and TRICEP for a lab tour, 21 December 2018.		

#### APPENDIX 13: ACES NATIONAL ACADEMIC VISITORS 2018

The list below does not include visitors to ACES as part of events or conferences that ACES organised throughout 2018.

ACES	National Academic Visitors	
1.	Evans, University of South Australia, visited ACES Deakin for collaborations on PEDOT as a cathode for Lithium battery technologies, 12 July 2018.	
2.	Robert Cowan, Hearing CRC, visited ACES UOW to discuss progress on collaborative projects, 25 July 2018.	
3.	Nicole Van Bergen and John Christodoulou, MCRI, visited ACES St Vincent's Hospital to discuss iPSC experiments on epilepsy with RF Anita Quigley, 31 July 2018.	
4.	Shadi Houshyar, RMIT visited ACES St Vincent's Hospital to discuss material formulations with RF Anita Quigley, 31 July 2018.	
5.	Mr David Wiseman, Southern Prosthetics and Orthotics located in Unanderra, Wollongong, visited ACES UOW to establish research collaboration involving soft robotic technologies developed by ACES, July 2018.	
6.	Prof Martina Stenzel, University of NSW, visited the ACES team at ANU to give a seminar and discuss potential collaborations, 2 August 2018.	
7.	Dr Zhongfan Jia, Queensland University, visited ACES Deakin and gave a seminar "Nitroxide Radical Materials towards Sustainable Organic Energy Storage", 9 August 2018.	
8.	Dr David Howard and 10 researchers from CSIRO Manufacturing and Data61, Brisbane, visited ACES UOW to explore joint research opportunities in soft robotics, 23 August 2018.	
9.	David Winlaw, University of Sydney visited ACES UOW as a follow up from a RACS/ACI session and to give a research seminar to the group, 24 August 2018.	
10.	Patrick McGivern, University of Wollongong, visited ACES UOW for a seminar and discussion regarding the active materials project, 31 August 2018.	
11.	Biswanath Das, UNSW, visited ACES UOW for collaborative talks and gave a seminar, 7 September 2018.	
12.	Dani Li, University of Melbourne, visited ACES UOW for collaboration discussions, 13 September 2018.	
13.	Cohort of UOW Advanced Mechanical Engineering students visited for ACES-ANFF for a lab tour, 18 September	
14.	Mia Woodruff, Queensland University of Technology, visited ACES UOW to discuss 2020 Biofab conference and progress on collaborative projects, 19 September 2018.	
15.	Ms Gita Rahardjo, Imaging Biologist, ANSTO, visited ACES UOW for collaborative discussions on imaging biology, 4 October 2018.	
16.	Anna Waterhouse, University of Sydney, visited ACES UOW for collaborative talks and gave a seminar, 10 October 2018.	
17.	Prof Roy Choudhury, RMIT, visited ACES node at St Vincent's Hospital Melbourne for collaborative discussions, 12 October 2018.	
18.	Cohort of UOW Biomed students visited ACES-ANFF for a lab tour, 15 October 2018.	
19.	Prof Kylie Catchpole, A/Prof Klaus Weber, A/Prof Thomas White, ANU, visited ACES at Monash to discuss future collaborations in engineering solar powered electrolysers, 18 October 2018.	
20.	Prof Catriona Mackenzie, Associate Dean Arts Macquarie University visited ACES RF Mary Walker to discuss a collaborative paper on neurotechnologies and authenticity, 19 October 2018.	
21.	Mr Jizhen Zhang, Deakin University, hosted at ACES UOW and supported by the ANN long term visit program to work on "Wearable Supercapacitors" with CI Chen, 5-30 November 2018.	
22.	Rosalie Hocking, Swinburne University of Technology, visited ACES at Monash to finalise joint projects and planning for new collaborative work, 9 and 30 November 2018.	
23.	Peter Lay, University of Sydney, visited ACES UOW to give a seminar and undertake a lab tour, 13 November 2018.	
24.	Gregg Suanning, University of Sydney, visited ACES UOW for a seminar presentation, 15 November 2018	

ACES	ACES National Academic Visitors			
25.	Dr Huimin Liu, University of Sydney, visited ACES UOW for collaborative discussions, 15 November 2018.			
26.	A/Prof Paul Sheehy, Deputy Head of Sydney School of Veterinary Science, The University of Sydney, visited ACES UOW fo collaborative discussions, 15 November 2018.			
27.	Prof Peter Talbat and Dr Jose Alarco (QUT), A/Prof Drew Evens (Uni SA), Dr Parama Banerjee (Monash), Dr Hualin Zha (University of Melbourne) and Stephanie Chua (UNSW) toured ACES Deakin and BatTRIhub as part of the ITTC worksh 21 November 2018.			
28.	Stephanie Chua, UNSW, undertook research within the facilities at ACES Deakin, 26 November – 6 December 2018.			
29.	Dr Jingjing You, The University of Sydney/Sydney Eye Hospital, visited ACES at UOW for a demonstration of updated 3D printing capabilities, 27 November 2018.			
30.	Dr David Garrett, Dr Melanie Elisabeth and Miss Maryam Hejazi from University of Melbourne visited ACES Deakin Geelong to discuss collaboration on dopamine sensing using carbon fibre electrodes, 27 November 2018.			
31.	Mia Woodruff, Queensland University of Technology, visited ACES UOW to discuss project progress with Anatomics as part of the ARC Training Centre, 27 November 2018.			
32.	Milan Brandt, Royal Melbourne Institute of Technology RMIT, visited ACES UOW, 27-30 November 2018.			
33.	AI UOM Peter Choong, University of Melbourne, visited with a UOM biomedical student to discuss a research project, 9-11 December 2018.			
34.	Damien Harkin, Queensland University of Technology (QUT), visited ACES UOW to plan a collaborative research grant application and scope out potential further projects, 10 December 2018.			
35.	Mahmoud Mohammed, University of South Australia, research visit to ACES Deakin, 10-14 December 2018.			
36.	David Adams, IHMRI UOW, visited ACES UOW to discuss a joint 2019 workshop, 11 December 2018.			
37.	Chiara Neto, University of Sydney, visited ACES UOW to review the facilities and give a seminar, 14 December 2018.			
38.	Sammy Florczak, Queensland University of Technology, visited ACES UOW to update with his experience in MEW and building printers, 14 December 2018.			
39.	Blanka Golebiowski, University of New South Wales, visited ACES UOW to visit TRICEP facility after meeting at the Corneal Bioengineering workshop, 18 December 2018.			
40.	Evans, University of South Australia, visited ACES Deakin for collaborations on PEDOT as a cathode for Lithium battery technologies, 12 July 2018.			
41.	Robert Cowan, Hearing CRC, visited ACES UOW to discuss progress on collaborative projects, 25 July 2018.			
42.	Nicole Van Bergen and John Christodoulou, MCRI, visited ACES St Vincent's Hospital to discuss iPSC experiments on epilepsy with RF Anita Quigley, 31 July 2018.			
43.	Shadi Houshyar, RMIT visited ACES St Vincent's Hospital to discuss material formulations with RF Anita Quigley, 31 July 2018.			
44.	Mr David Wiseman, Southern Prosthetics and Orthotics located in Unanderra, Wollongong, visited ACES UOW to establish research collaboration involving soft robotic technologies developed by ACES, July 2018.			
45.	Prof Martina Stenzel, University of NSW, visited the ACES team at ANU to give a seminar and discuss potential collaborations, 2 August 2018.			
46.	Dr Zhongfan Jia, Queensland University, visited ACES Deakin and gave a seminar "Nitroxide Radical Materials towards Sustainable Organic Energy Storage", 9 August 2018.			
47.	Dr David Howard and 10 researchers from CSIRO Manufacturing and Data61, Brisbane, visited ACES UOW to explore joint research opportunities in soft robotics, 23 August 2018.			
48.	David Winlaw, University of Sydney visited ACES UOW as a follow up from a RACS/ACI session and to give a research seminar to the group, 24 August 2018.			
49.	Patrick McGivern, University of Wollongong, visited ACES UOW for a seminar and discussion regarding the active materials project, 31 August 2018.			
50.	Biswanath Das, UNSW, visited ACES UOW for collaborative talks and gave a seminar, 7 September 2018.			

ACES National Academic Visitors				
51.	Dani Li, University of Melbourne, visited ACES UOW for collaboration discussions, 13 September 2018.			
52.	Cohort of UOW Advanced Mechanical Engineering students visited for ACES-ANFF for a lab tour, 18 September			
53.	Mia Woodruff, Queensland University of Technology, visited ACES UOW to discuss 2020 Biofab conference and progress on collaborative projects, 19 September 2018.			
54.	Ms Gita Rahardjo, Imaging Biologist, ANSTO, visited ACES UOW for collaborative discussions on imaging biology, 4 October 2018.			
55.	Anna Waterhouse, University of Sydney, visited ACES UOW for collaborative talks and gave a seminar, 10 October 2018.			
56.	Prof Roy Choudhury, RMIT, visited ACES node at St Vincent's Hospital Melbourne for collaborative discussions, 12 October 2018.			
57.	Cohort of UOW Biomed students visited ACES-ANFF for a lab tour, 15 October 2018.			
58.	Prof Kylie Catchpole, A/Prof Klaus Weber, A/Prof Thomas White, ANU, visited ACES at Monash to discuss future collaborations in engineering solar powered electrolysers, 18 October 2018.			
59.	Prof Catriona Mackenzie, Associate Dean Arts Macquarie University visited ACES RF Mary Walker to discuss a collaborative paper on neurotechnologies and authenticity, 19 October 2018.			
60.	Mr Jizhen Zhang, Deakin University, hosted at ACES UOW and supported by the ANN long term visit program to work on "Wearable Supercapacitors" with CI Chen, 5-30 November 2018.			
61.	Rosalie Hocking, Swinburne University of Technology, visited ACES at Monash to finalise joint projects and planning for new collaborative work, 9 and 30 November 2018.			
62.	Peter Lay, University of Sydney, visited ACES UOW to give a seminar and undertake a lab tour, 13 November 2018.			

# APPENDIX 14: A SUMMARY OF ACES OUTREACH ACTIVITIES IN 2018

ACES	6 Outreach Activities in 2018	When	Where
1.	<b>"My journey to Stockholm" Public Lecture ICONN18</b> . Sir Fraser Stoddart, Nobel laureate, in his public lecture explained about molecular machines and nanotechnology to the audience of around 350 people. ICONN 2018 attracted three Nobel laureates to Wollongong – Professor Steven Chu (Physics, 1997), Professor Ada Yonath (Chemistry, 2009) and Sir Fraser Stoddart (Chemistry, 2016) among the headline speakers.	29 January	UOW Northfields Ave Campus Wollongong
2.	<b>LKM Event.</b> This annual public address celebrates the life of one of Australia's great scientific minds. Leon Kane-Maguire was on of Australia's leading scientists, pioneering research in nanomaterials – all balanced by his down to earth attitude and wicked sense of humour. In 2018 Prof Tim Hanks, from Furman University in USA, gave the address. In 2011, Tim spent six months as a Fulbright Senior scholar with ACES at UOW. Tim's research interests focus on mechanisms of self-assembly and the construction of functional materials from highly conjugated polymers.	6 February	iC campus UOW Wollongong
3.	<b>World Science Festival Brisbane 2018</b> presented by the Queensland Museum. Prof Gordon Wallace a guest panellist on 'BETTER FOR LONGER: The Path to Human Regeneration' in which a panel of world experts explored the theme of human regeneration - one of the festival's signature events. The World Science Festival Brisbane a premier celebration of scientific insight in the southern hemisphere.	21-25 March	QPAC Brisbane
4.	Science at the Shinedome. ACES partnered the Australian Academy of Science to support the EMCR Luncheon at Science at the Shine Dome. Prof Maria Forsyth spoke of the ACES commitment to innovative research training and career development.	24 May	Shinedome, Canberra

ACES	0 Outreach Activities in 2018	When	Where
5.	<b>The Future of Bionics and the Ethical Issues.</b> In partnership with the Australian Embassy in Ireland, Science Gallery Dublin presented a talk exploring the ethical issues relating to bionics and stem cell research around the world. ACES CI Gordon Wallace (UOW) spoke on work in the area of nanotechnology and the promise of new medical solutions using stem cells and 3D bioprinting; ACES CI Susan Dodds (UNSW) and David Hoey (Trinity College Dublin) explored the ethical ramification. Simon Mamouney, Deputy Ambassador of the Australian Embassy in Dublin, introduced the event.	1 June	Science Gallery Dublin
	nttps://dublin.sciencegallery.com/events/2018/05/tuturebionicsandethicalissues#		
6.	Portraits of Gordons2 Portraits of Gordons2 was the theme for this year's artist-led Science of Portraiture, which involved 10 local artists creating the likeness of both the ACES Director, Prof Gordon Wallace, and Lord Mayor of Wollongong, Gordon Bradbery. The exhibition was held at Red Point Artists Association (RPAA) with the public being invited to vote on the accuracy of the portraits. Gordon was present to talk to the public about his portrait and ACES science throughout 11 August.	Science week	Red Point Artists Association (RPAA), Port Kembla
7.	ACES Director speaks at the Sydney Science Festival	12 August	Powerhouse
	Joining a number of speakers at the Powerhouse Museum for the Sydney Science Festival, Prof Gordon Wallace participated in 'Invisible Forces: Changing the World'. This public event conversation led by popular astronomer and science communicator Fred Watson, allowed the audience to learn from various speakers about the invisible forces that underpin our greatest technology.		Museum, Sydney
8.	<b>Showcasing ground-breaking research made in the 'Gong'</b> . City of Wollongong Lord Mayor Councillor Gordon Bradbery AM launched the ACES National Science Week when he was presented with the 'Keys to the Labs' – printed in 3D, as part of a tour of the IPRI facility to learn about the ground-breaking research being conducted in the region at the Innovation Campus.	13 August	iC campus UOW Wollongong
9.	<b>3D Heals.</b> ACES Research fellow Dr Anita Quigley was an invited speaker for this community event, where she spoke of the ACES work on '3D Heals: 3D Fabrication of Tissue Constructs'.	16 August	RMIT, Melbourne
11.	Illawarra Community Open Day	16 August	iC campus
	94 members of the general public enjoyed touring the ACES headquarters. Tours operated every 30 mins between 9am and 4pm. Visitors were able to speak with local researchers about their cutting edge technologies including: human hair size graphene fibre electrodes to provide recordings from brain cells; materials that can electrically stimulate brain cells to potentially reverse schizophrenia; and the amazing properties of bioinks to assist in wound healing, the regrowing of ears, and treating diabetics.		UOW Wollongong
	opportunities to repair damaged cartilage to prevent osteoarthritis and corneal damage, and develop prosthetic ears to treat the congenital deformity microtia.		
11.	Bill Wheeler Prize and Symposium	16 August	iC campus
	A/Prof Payal Mukherjee, an Ear, Nose and Throat Surgeon at the Royal Prince Alfred Hospital, gave the feature presentation for this public event that attracted 87 attendees.		UUW Wollongong
	2018 marked the tenth annual public talk, where a high-achieving University of Wollongong Bionics student was awarded \$2,000 of community-raised funds to assist with travel to share their cutting-edge research and build new collaborative relationships. Luciana Yumiko Daikuara, an affiliate ACES UOW PhD student in Biofabrication, was presented with the 2018 Bill Wheeler Prize for her research into using bioprinting as a manufacturing approach to offer customisable biosynthetic skin grafts for patients with complex open wounds.		

ACES Outreach Activities in 2018		When	Where
12.	<b>Monash Future Thinkers are looking towards 2050</b> . The future of the nation is at stake, and Monash Future Thinkers invited students to offer their ideas and solutions for the biggest issues facing Australia. ACES CI Prof Rob Sparrow was an invited panellist "The future of humanity." Scientific progress, especially advances in artificial intelligence and computing technologies, give society immense potential to extend human ability and productivity.	11 September	Melbourne
	The panel were asked to discuss, not only about the potential for human progress as a result of these developments, but about how scientific progress could change our interactions with one another, whether this is desirable, whether it changes the way we think about what it means to be human and whether there are any elegant solutions to ethical dilemmas posed by machines that can be ultimately responsible for life and death.		
	The aim of the program was to encourage students across disciplines with different backgrounds and different academic approaches to have a real conversation about shaping 2050.		
13.	Future Students Open Day - "Considering WHAT'S NEXT in your studies? ACES promoted this event for future students to "Get involved in ground-breaking research making a real difference in shaping the NEXT GENERATION of smart materials to improve people's lives!" Short presentations from current students, supervisors was followed by a BBQ lunch, allowing for further networking and conversations with ACES staff members, current students and potential supervisors.	13 September	iC campus UOW Wollongong
14.	The Royal Society 1267th OGM and open lecture. ACES Director Prof Gordon Wallace gave this lecture on "3D printing of body parts: practical applications and fundamental explorations". The Society encourages " studies and investigations in Science, Art, Literature and Philosophy" and holds meetings for the benefit of members and the public.	3 October	State Library NSW, Sydney





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ARC Centre of Excellence for Electromaterials Science University of Wollongong, Innovation Campus North Wollongong NSW 2500 Australia +61 2 4221 3127 www.electromaterials.edu.au

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