

ARC Centre of Excellence for
Electromaterials
Science

Annual Report 2009

creating advanced materials

materials synthesis · energy conversion · energy storage · bionics

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Welcome to ACES

ACES is the Australian Research Council (ARC) Centre of Excellence for Electromaterials Science. It brings together eminent scientists to develop the nano-science and nanotechnology related to the movement of electric charge within and between materials. The approach provides an alternative to varying the composition of a material to alter physical and biological properties – instead we alter dimensions and shape in the nanodomain. These processes are fundamentally important to a diverse array of phenomena important in medicine and industry. ACES is studying these processes and, in so doing, is developing improved electromaterials and applying these in energy harvesting systems, highly efficient energy storage materials and medical bionics.

Through the investigation of new nanomaterials and new theories to explain their behaviour, ACES will tackle some of the biggest challenges facing society. These include the development of renewable energy systems in the form of plastic solar cells, lightweight batteries and electronic textiles: the growth of sustainable industries which would benefit from advances in the recovery of precious metals and new corrosion protection technologies; advances

in medical science through the regeneration of damaged nerves such as in spinal injury; and the development of artificial muscles.

In early 2009 ACES was made up of components from four research organisations: the University of Wollongong (including the Intelligent Polymer Research Institute and the Institute for Superconducting & Electronic Materials), Monash University (including the Ionic Liquids group), the Bionic Ear Institute and St Vincents's Health in Melbourne. By the end of 2009 the research organisations in ACES now number 5: the University of Wollongong (including the Intelligent Polymer Research Institute and the Institute for Superconducting & Electronic Materials), Monash University (including the Ionic Liquids group), St Vincents's Health in Melbourne, La Trobe University in Melbourne and University of Tasmania.

ACES was established in 2005 and was funded by the ARC with \$12 million in federal funding over five years. ACES also received support from the NSW Department of State & Regional Development to achieve technology transfer to NSW and Australian industry. In 2009 the ARC announced that ACES will receive a further \$7.7 million in funding from July 2010 until December 2013.



ACES was established to bring together eminent scientists to develop the nano-science and nanotechnology related to the movement of electric charge within and between materials.

The Director's Message

Following the successful review of the centre in 2008, we have been able to look beyond the horizon in 2009 and to start to build the bridges that will carry us into the next phase of ACES research.

Our activities moving forward will build on our success to date in new electromaterials and their application in energy and medical bionics. The development of multifunctional nanostructured carbons based on graphene and nanotubes, as well as new metal oxide structures, will be an area of intense activity. Inherently conducting polymers and novel electrolyte formulations will provide platforms on which to incorporate and integrate appropriate functionality for energy conversion, and our capabilities in solar cell science place us in an enviable position to tackle the challenging area of water splitting.

We will also build on the novel organic bionics platforms we have produced and move towards *in vivo* studies.

Device fabrication and prototype development have often proved to be a bridge too far – as we strive to demonstrate practical feasibility and look to take our research closer to commercialisation. An exciting development during 2009 is that the IPRI node of ACES in partnership with ISEM (www.uow.edu.au/eng/research/ISEM) has been granted Federal Government funding to establish a prototyping and device fabrication facility at the Wollongong Innovation Campus (www.electromaterials.edu.au). This important new development provides an opportunity to build world class research capabilities not only in materials but in the design and fabrication of devices that use these materials.

These new capabilities add to the recently established state-of-the-art research spaces at Monash and Wollongong and the additional capabilities brought by our partner at the Graeme Clark Centre for Bionic Ear and Neurosensory Research at La Trobe University.

During 2009, Prof Graeme Clark has established a new team at La Trobe with the Director of this Centre, Prof Anthony Paolini, who will also join the ACES Bionics programme. Other important additions to the chief investigator team include Prof Mark Cook (from St Vincents, Melbourne) to our Bionics research team and Dr Marc in het Panhuis (recently appointed Future Fellow at University of Wollongong) to the Electromaterials programme. Prof Susan Dodds continues to head our ethics research team but from further south (University of Tasmania).

As we prepare to embark on 2010 we are encouraged by the steps we have taken on the research, end-user and outreach fronts during 2009. We have invested substantial time and energy into new materials synthesis, fabrication and characterisation with significant progress in the area of graphene functionalisation and a marked expansion in our fibre spinning and printing facilities and capabilities. These advances in materials fabrication have enabled significant breakthroughs in our Energy and Bionics research programs.

Once again, it has been a great pleasure to work with an extraordinarily talented group of researchers supported by staff in all of our partner organisations that share our vision.

The challenges that confront us in the areas of Energy and Bionics are complex and the potential returns to society are great. Through ACES, we have established a world renowned research team now housed in facilities with equipment and support second to none around the globe.

I think we really can say that what we can achieve is limited only by our own vision and drive – a truly privileged position- from which we aim to return substantial benefits to all who have shown faith in us.

I hope you enjoy reading the following pages that highlight some of our activities during 2009.

Regards



Professor Gordon Wallace
Executive Director of ACES



From the International Advisory Board

The International Advisory Board reviewed the 2009 progress of the ARC Centre of Excellence for Electromaterials Science (ACES) on 19th February 2010 and received a flavour of what was being planned by ACES for 2010 and beyond. Those in attendance were: Dr (Dame) Bridget Ogilvie (Chair), Prof Siegmund Roth, Prof Richard Kaner, Prof Ray Baughman, Dr Greg Smith, Dr Abid Khan, Prof Tom Kay and Ms Sharon Martin for Prof Judy Raper. The Board congratulated Gordon Wallace and the ACES team on exceeding the IAB's high expectations and were impressed by the quality and quantity of outcomes achieved by the Centre in 2009.

Key Performance Measures

The performance of the Centre has exceeded the 2009 targets as outlined in the key performance measures. In particular the Centre published 98 refereed journal articles, of which 68 (69%) were in journals with an impact factor greater than 2 and 37 (38%) where the impact factor was greater than 4; ACES research graced the covers of 11 refereed journals; recruited 8 postgraduate students; had 6 postgraduate completions; held 7 national/international workshops; received 39 invitations to international conferences; made 54 visits to leading international laboratories (in 14 different countries); published 101 media interest stories; with 41 articles in print, 34 articles online/web, 16 radio interviews and 10 TV appearances; hosted 92 international visitors (from 19 countries) and lodged 2 patents.

Progress in 2009

Electromaterials

The development of new electromaterials (1st generation), their testing in specific applications, and then refining or redeveloping further materials (2nd generation) continued as an on-going cycle.

Porphyryns have been synthesised for use as solar cell dyes and electrocatalysts. Cobalt porphyryns are the most promising electrocatalyst for oxygen reduction. Non-porphyrinic cobalt complexes have also been made. Porphyrin GD2 continues to be the best performing dye in solar cells and is still used as a standard with ACES. However, the octylphenyl analogue has been shown this year to be the best performing dye when using ionic liquids as the electrolyte. Other new dyes that have been prepared include a series of exciting new hole transport porphyryns and porphyryns with multiple binders.

Functionalised terthiophenes from ACES were combined with functionalised spiropyrans from Dublin City University (DCU) to create for the first time exciting new photochromic polythiophenes. The sensing and binding capabilities of these materials are being jointly investigated.

A range of new chemistries have been developed to produce **functionalised graphene**. Both layer-by-layer and electrophoretic deposition methods were used to assemble graphene structures. **CNT NanoWeb** can be deposited onto various substrates, including metals and carbon, for use as electrodes.

Novel **tough gel compositions** have been developed (*Advanced Materials* 2009) based on poly(vinyl alcohol) utilising the protein ferritin as a modifier; and **porous, sponge-like gels** were obtained using carbon nanotubes as a scaffold for DNA and ionic liquids as a coagulant (*Angewandte Chemie-International Edition* 2009).

Energy Conversion

This program had two streams of activity in 2009: flexible solar cells and actuators.

Dye-Sensitised Solar Cells (DSSCs): Achievements by ACES in 2009 pave the way for the future development of low cost flexible DSSCs. A monolithic all solid state DSSC with 3.65% efficiency was prepared (*Appl. Phys. Lett.* 2009), as well as a flexible polymer-based DSSC with 4.2% efficiency (*J. Photochem. Photobiol. A: Chem.* 2009).

Work on highly conductive PEDOT and a PEDOT-based solid state DSSCs made possible the invention of a GoreTex-PEDOT membrane electrode. This electrode was used in solar cells (*Langmuir* 2009), overcoming the limitations of conventional counter electrodes. p-type DSSCs have previously shown very poor photovoltaic performance. However, a team of ACES researchers in collaboration with the University of Ulm, discovered a fundamental design concept that allows absorbed photons to be converted to positive charge carriers with a conversion rate of up to 96%, making it possible to construct tandem solar cells that exceed the performance of their individual components (*Nature* 2009).

Actuators: A collaborative venture with Korean researchers has shown enhanced motor function (both power stroke and force generated) by the attachment of fullerenes to the ends of DNA strands to produce solution-based molecular machines that respond to pH changes (*Advanced Materials* 2009).

DNA was also attached to carbon nanotubes, where it was demonstrated that pH changes could dramatically alter the redox properties, thereby acting like a molecular switch (*Chemical Communications* 2009). This SWNT/DNA hybrid showed controllable / switchable electrochemical activity and capacitor behaviour, which will form the basis for new intelligent electrode materials for nano-biodesigns, such as a biosensor or actuator.

Mechanically robust but flexible bundles of aligned, electrospun polyurethane nanofibres that were coated with polyaniline were found to generate appreciable actuation strains (*Chemical Materials* 2009) that produced a linear actuation strain as high as 1.65% at an applied stress of 1.03 MPa in 1 M methanesulfonic acid (MSA). They were stable for up to 100 cycles and up to an applied load of 11 mN (2.263 Mpa).

The use of electrochemically generated gas was investigated for pneumatic actuation (*Sensors and Actuators B: Chemical*). A carbon nanotube electrode of 2.4 mm^3 was capable of producing 0.5 cm^3 of gas at atmospheric pressure. The work capacity based on the size of the electrode

was 5000 kJ/m^3 , nearly two orders of magnitude larger than other low voltage electrochemical actuators.

2009 saw ACES research use conducting polymer tri-layer bender-type actuators for propelling a "robotic fish" (*Smart Materials & Structures* 2009). Small, highly-mobile "swimming" robots are desired for underwater monitoring operations, including pollution detection, video mapping and other tasks. The bending actuators (2 mm wide, 25 mm long), gave fast operation in air (up to 90 Hz), and were utilised as active flexural joints on the tail fin of a fishshaped floating "boat" (*in press*). The boat had a turning circle as small as 15 cm in radius and a maximum speed of 2m/min when operating with a tail frequency of approximately 0.7 Hz.

Energy Storage

Lithium batteries have two main issues of concern: safety and cycle life. The safety aspects include fire and explosion. ACES research showed that some organic salts used in ionic liquid and plastic crystal batteries were unsafe as they were prone to thermal runaway.

1000 life cycles are required for commercial batteries. Flexible polyaniline nanofibre electrodes made in ACES exhibited a specific capacitance of 235 Fg^{-1} ; and a capacitance of 195 Fg^{-1} was retained over 10,000 charge-discharge cycles after encapsulating the electrode in Nafion. Polypyrrole doped with Nafion ions had specific capacitance of 344 Fg^{-1} ; at scan rate of 1000 mVs^{-1} , an energy density of 14.6 Whkg^{-1} and power density of

4.3 kWkg^{-1} , whilst maintaining 98% of the original capacitance after 3000 cycles (*Journal of Power Sources* 2009).

Cathode films based on multi-wall carbon nanotubes (MWCNTs) showed stable cycling behaviour and allowed up to a 10C-rate, better than either single-wall or double-wall CNTs films (*Synthetic Metals* 2009). A high discharge capacity of 94.7 mAhg^{-1} was obtained for an all-polymer battery system composed of electrodeposited polypyrrole cathode and functionalised polyterthiophene anode (*Synthetic Metals* 2009).

Using solid-state plastic crystal electrolytes in lithium metal rechargeable cells were found to improve the rate capability after a preconditioning process. 2.5% Zinc oxide (ZnO)-doped lithium iron phosphate showed a higher electrochemical reactivity for lithium insertion and extraction than the undoped material (*Journal of Alloys and Compounds* 2009).

Bionics

Research efforts were focused on the cochlear implant, and spinal cord and peripheral nerve regeneration.

Cochlear Implant: There has been concern regarding the safety of nanomaterials for biological use, from both the lay and scientific community. Therefore, the biocompatibility of composite materials containing CNTs *in vivo* was studied to determine whether they could be used safely in a physiological setting. The experimental phase is complete and the results of the chronic study are currently being evaluated.

Spinal Cord and Peripheral Nerve

Regeneration: In 2009, directed nerve fibre growth has been achieved *in vitro* (2D structures) using a novel conducting polymer/biodegradable polymer fibre platform. This provides the basis for a biodegradable nerve repair conduit consisting of a knitted sheath (electrospun with biodegradable polymer nanofibres), and an internal engineered matrix consisting of fibres for neuronal support and Schwann cell mobilisation, suspended within a hydrogel containing biofactors (*Advanced Materials 2009*). These conduits have also been tested *in vivo*, and found to promote the repair of a 1.2 cm gap created in the sciatic nerve of rats. The development of a second-generation conduit has received support from NHMRC, with funding starting in 2010.

Ethics

Work towards developing an integrated position on the development of bionics, human health and ethical relations slowed in 2009 due to the CI's relocation to the University of Tasmania in February 2009 and the resignation of the UOW based Research Fellow in January 2009. Nonetheless, the grounding research is completed and there is a good prospect for a new PhD student commencing research on this project in early 2010. As a result of the CI's move, ACES has expanded into Tasmania.

Education, Training and Outreach

The focus again this year has been to give a broad range of training opportunities in particular areas of need (identified by a process of close consultation) for post-graduate students and early career researchers, as well as providing opportunities for external participants. The Education committee ensured training opportunities brought together staff and students from different nodes of the Centre.

The DVD "Nanostructures for Electromaterials" was completed and distributed to high schools throughout the country and is on the ACES, IPRI and UOW websites. It covers the topic of electromaterials, their applications, benefits and impact on society, by addressing how nanostructured nanomaterials are used in applications for advancing the cochlear ear implant and for nerve and muscle growth.

To bring the research area of Bionics into the public arena, a High School competition 'Bionics for 2020' was launched in July. The competition was open to all High Schools in the Illawarra Region whose students had to address the question: "what new Bionic parts would you develop for humans, why and how". The competition certainly fired the imagination of both students and teachers and gained good media coverage.

ACES 2010-2013

Research Programs

Both energy and human health rank highly in the research priorities of most (if not all) industrialised countries, and electromaterials, energy, bionics and ethics will remain the foci for ACES going forward.

Electromaterials will be at the core of a wide range of technologies that will generate future energy supplies and form the basis of the bionic medical devices. This program will continue to encompass materials synthesis, fabrication and characterisation. The development of the ANFF Materials Node, led by ACES researchers, provides the opportunity to perform scaled-up synthesis of materials needed in a number of Centre programs.

The energy program will utilise advances in the design and synthesis of new light harvesting and electrocatalytic materials for applications such as energy conversion/storage and water splitting.

ACES intends to exploit cutting edge materials to ensure development of an efficient water splitting device. In addition to water splitting, polymer fuel cells and metal air battery techniques will be developed.

The Bionics program will continue to exploit new electromaterials in the areas of nerve repair and will move to construction of 3-dimensional networks and devices for *in vivo* experiments. ACES will also continue in

its quest to develop an advanced cochlear implant with improved control and sensing mechanisms towards a steerable electrode. The Ethics program will continue in its role of developing a critical social and ethical response to the emerging bionics program and nanomedicine.

End-Users

Throughout 2009, ACES partners have worked towards developing a simple, single co-ordinated shopfront approach for end-users. The ACES patent portfolio has been established and updated with technology promotion flyers and is now available (via ACE website) on selected topics.

The advent of the Australian Institute for Innovative Materials: Processing and Devices (AIIM P&D) facility at the University of Wollongong's Innovation Campus (\$40M) and the expansion of ANFF materials node in 2009 (with a further \$3.9M in equipment funding) provides a further dimension to end-user engagement for ACES researchers. Expansion of ANFF allows expansion of capabilities in the synthesis and supply of advanced organic materials for application in the different research areas as well as providing expertise via consultancies in the area of materials synthesis, processing and characterisation. Upon completion in 2011, the AIIM P&D will offer extensive and unique capabilities

in the design, development and fabrication of nanostructured electronic materials and devices for both researchers and industry.

The IAB acknowledged that the creation of the AIIM P&D facility will further enhance the opportunities available to ACES, particularly in developing even stronger collaborative end-user linkages. The IAB is also pleased to note the strong international relevance of the strategic development plan that has been produced and adopted, which is aimed at consolidating and expanding the end-user base.

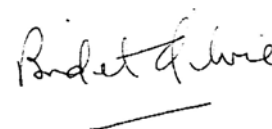
International Links

ACES has an open and vibrant research environment that ensures close interaction with other Australian and international scientists. An IAB board member is of the opinion that ACES has assembled research at the highest level of competence in several areas making it an attractive point of contact for those interested in the area. The large number of international research visits is testimony to this. ACES has truly become an International Centre of Excellence. In 2010 a global research consortium on Electromaterials Science will be established to further encourage ACES global links.

Final Comments From the Chair

"In 2009, ACES researchers have continued to perform at an outstanding level by all accepted measures. I am most impressed by the progress and by the collaborative approach, both national and international, that is one of its outstanding characteristics and source of strength. All members of the IAB enjoy their interactions with this exceptional group of scientists of whom their host universities can be really proud."

Dr (Dame) Bridget Ogilvie
(AC, DBE, FAA, FRS, FMedSci)



Chair

International Advisory Board for ACES



Highlights of the Core Funded Activities

Program 1 (P1): Electromaterials

With the ACES extension commencing in June 2010, this has enabled us to continue to discover and develop new electromaterial structures, while continuing to supply those developed in previous years to the energy conversion, energy storage and bionics programs.

The cycle between materials discovery and testing has been refined as we further identify the properties needed for our targeted applications in ENERGY and MEDICAL BIONICS.

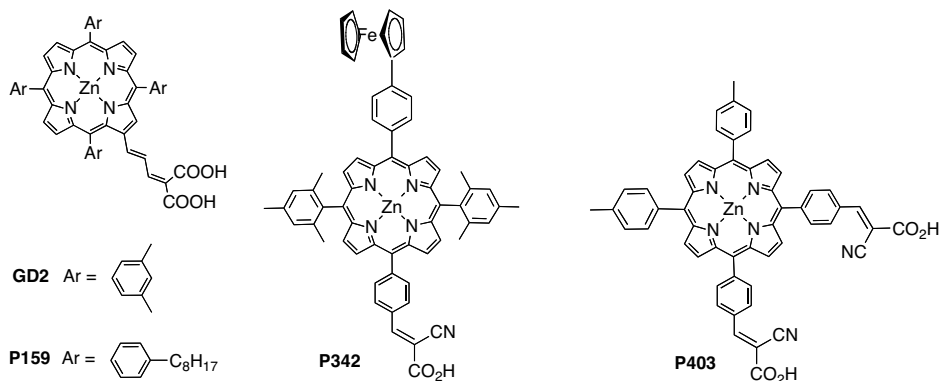
ACES materials have also been supplied to our international collaborators in New Zealand, Japan, Ireland and the US. In particular:

- ▶ porphyrins for use as solar cell dyes and electrocatalysts,
- ▶ functionalised thiophenes for batteries, capacitors, electrochromic devices and bionics,
- ▶ graphenes for solar cells, batteries, capacitors and bionics.

A selection of these materials is highlighted next but described in more detail in the Activity Report.

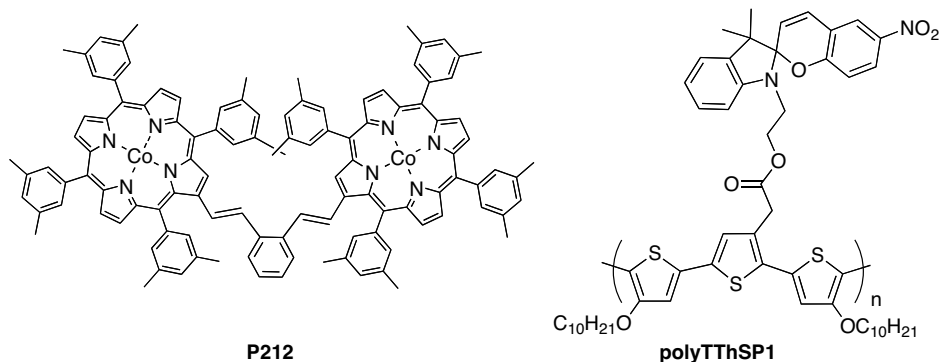
Porphyrins for solar cells

Porphyrin **GD2** continues to be the best performing dye in solar cells and therefore is still used as a standard with ACES at both Wollongong and Monash. However, the octylphenyl analogue **P159** has been shown this year to be the best performing dye when using ionic liquids as the electrolyte. Other new dyes that have been prepared include a series of exciting new hole transport porphyrins exemplified by **P342** and porphyrins with multiple binders such as **P403**.



Porphyrins as electrocatalysts

Cobalt porphyrins are the most promising electrocatalyst for oxygen reduction. Control of interporphyrin distance is important. Therefore, porphyrin dimers with controlled architectures such as **P212** have been synthesised for this purpose. Non-porphyrinic cobalt complexes have also been made.



Functionalised thiophenes

Functionalised thiophenes and terthiophenes and their polymers continue to be investigated for in a wide variety of applications. The most exciting new polythiophene materials were made this year with researchers at Dublin City University (DCU). In a perfect collaboration, functionalised terthiophenes from ACES were combined with functionalised spiropyran from DCU to create for the first time exciting new photochromic polythiophenes such as **polyTThSP1**. The sensing and binding capabilities of these materials are being jointly investigated.

Graphene

A range of new chemistries have been developed to produce functionalised graphene. Both layer-by-layer and electrophoretic deposition methods are being used to assemble graphene structures.

Tough Gels

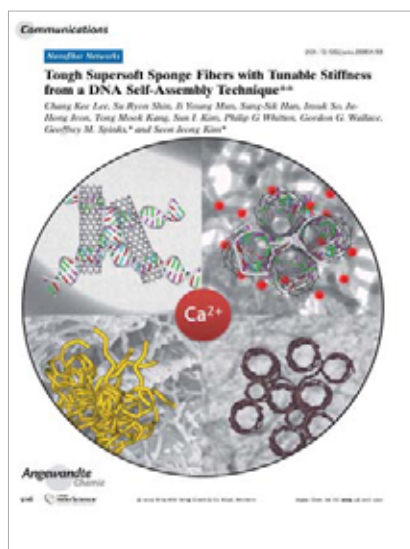
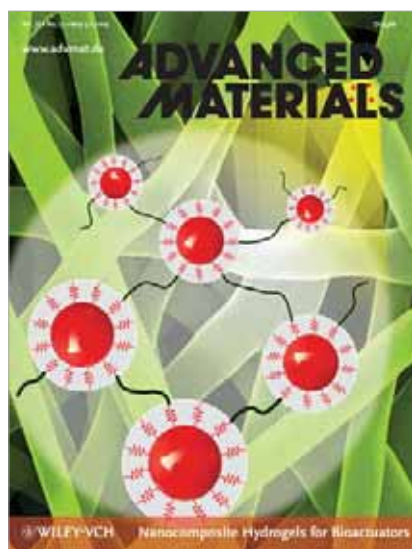
Development of tough polymer gels is important for solid electrolytes, actuators and some bionic applications. Gels are notoriously brittle, yet their high water content provides a very flexible substrate that is attractive for solid state actuators and energy storage devices. Gels are also similar to certain biological tissues, so offer potential advantages for cell growth work. ACES activities in gel synthesis have focussed on improving the mechanical strength of the gels, while maintaining low modulus and high water content. In some cases, pH responsiveness is also desired – such as in actuators. The major developments in 2009 include novel tough gels (**Advanced Materials 2009**) based on poly(vinyl alcohol) utilising the protein ferritin as a modifier. A three-fold increase in strength was achieved by addition of ferritin. This work was featured on the inside cover of *Advanced Materials*. A second major advance was the development of tough, porous, sponge-like gels. Highly porous materials are desirable for cell culture work and for implant in soft tissues,

such as cardiac muscle. The use of carbon nanotubes as a scaffold for attached DNA and ionic liquids as a coagulant enabled the fabrication of fibres that combined the properties of being very soft, porous and tough. This work was published in *Angewandte Chemie (Angewandte Chemie-International Edition 2009)*.

Nanostructured Carbons

Optimising the ability to grow CNT NanoWeb architectures, we have developed protocols that enable CNT NanoWeb to be deposited onto various substrates, including metals and carbon for use as electrodes. The direct deposition of the NanoWeb onto carbon fibre paper provides stable and high charge-discharge performance when used in a Li-ion battery (**Energy & Environmental Science 2009**). Our Atomate CVD system has been upgraded to enable growth of larger nanoweb samples.

Novel biogel structures that were shown to be non-cytotoxic and provide a vehicle for controlled release were obtained by combining carbon nanotubes and appropriate biopolymers (**Carbon 2009**).



Program 2 (P2): Energy Conversion

Advances in Energy Conversion projects have been made possible by the development of new materials and innovative configurations of devices containing them.

Dye-Sensitised Solar Cells

A considerable number of key developments were made in the area of dye-sensitised solar cells (DSSC). A monolithic all solid state DSSC giving 3.65% efficiency was achieved (**Appl. Phys. Lett.** 2009), approaching the Centre milestone of 4% for such a device. However, a 4.2% efficient flexible polymer-based DSSC was attained using ball milling to create mechanically stable TiO_2 films on polymer electrodes (**J. Photochem. Photobiol. A: Chem.** 2009). The integration of two developments within ACES, the formation of highly conductive PEDOT and a PEDOT-based solid state DSSC, led to the invention of a Goretex-PEDOT membrane

electrode (**Langmuir** 2009). All of these achievements pave the way for the future development of low cost flexible DSSCs.

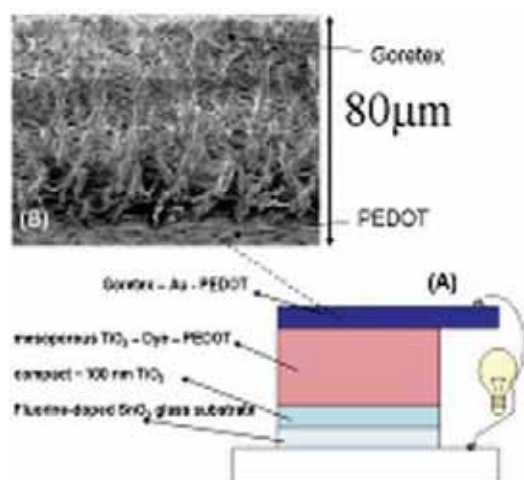
Equally significant was the publication of the first example of charge injection into TiO_2 in a DSSC from both the porphyrins in a porphyrin dimer (**J. Am. Chem. Soc.** 2009). Other highlights include the development with international collaborators in Korea and Switzerland of high molar extinction coefficient ruthenium dyes (**J. Phys. Chem. C** 2009); the use of phosphinic acids to increase the efficiency of porphyrin sensitised solar cells (**Energy Environ. Sci.** 2009); and a US patent application on dye mixtures for use in photoelectric materials (**US Prov. Patent Appl.** 60/202,164).

Dye-sensitized solar cells based on dye-sensitized hole-injection into p-type electrolytes have until recently shown very poor photovoltaic performance. A team of ACES researchers from Monash and Wollongong, in collaboration with the group of Prof. Baeuerle at the University

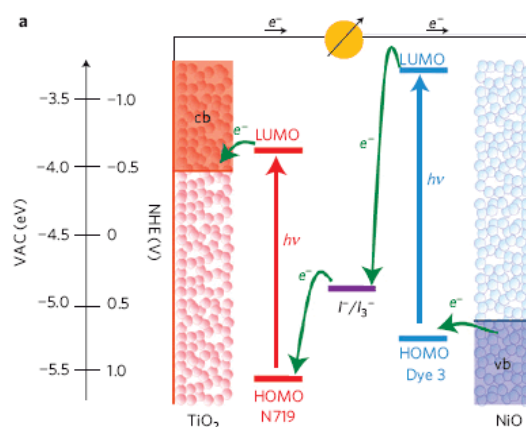
of Ulm, discovered a fundamental design concept for p-type DSSC sensitizers that allows absorbed photons to be converted to positive charge carriers, with a conversion rate of up to 96%. By combining these markedly improved p-type DSSCs with conventional photoanodic DSSCs, it was possible to construct tandem solar cells that exceed the performance of their individual components (**Nature Materials**, 2009, online publication: 29/11/2009).

The thermal stability of sensitizers is of critical importance for DSSC manufacturing processes. ACES researchers, in collaboration with CSIRO and the University of Uppsala, have revealed significant degradation of sensitizers at processing-relevant temperatures (**J. Phys. Chem. C**, 2009). The presence of humidity and oxygen during the heating period was shown to accelerate the degradation process.

Platinum nanoparticles were successfully deposited onto carbon black and carbon nanotubes (CNTs) via microwave-assisted reduction process. The novel electrode



(A) Scheme of the layer structure of a solid state dye-sensitized solar cell using photoelectrochemically deposited PEDOT as hole conductor; (B) Cross-section image of the Goretex®-Au-PEDOT electrode imaged using SEM.



Scheme for the electron-transfer processes occurring in the dye-sensitized tandem solar cell. Also shown are the approximate redox potentials and band energies of the different components.

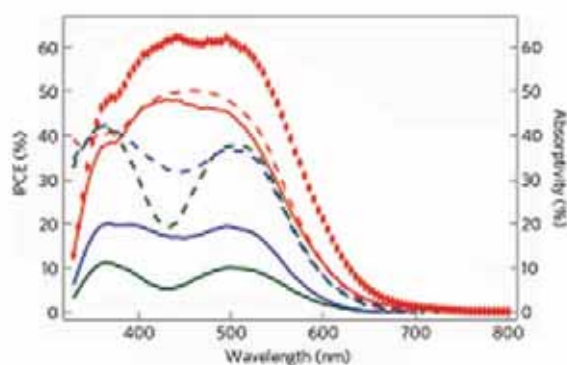
shows enhanced catalytic performance in fuel cell application using functionalised CNTs as the catalysts support materials (**Nanoscale, 2009** available online, DOI: 10.1039/b9nr00140a). The stability of loaded Platinum (Pt)-nanoparticles was improved with increased long-term performance.

Actuators

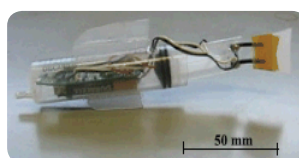
Developments in actuator systems during 2009 spanned from nano- to micro- to the macro- domain. At the smallest level, DNA was used to generate solution-based molecular machines that responded to pH changes. While these systems were previously known, ACES researchers demonstrated that enhanced motor function was possible by the attachment of fullerenes to the ends of the DNA strand (**Advanced Materials 2009**). The same type of DNA was also attached to carbon nanotubes, where it was demonstrated that pH changes could dramatically alter the redox properties, thereby acting like a molecular switch (**Chemical Communications 2009**). Bundles of aligned nanofibres

were also developed for artificial muscles. In this case, electrospun polyurethane fibres were coated with polyaniline and shown to generate appreciable actuation strains (**Chemistry of Materials 2009**). At the micro-level, progress was made in demonstrating solid state micro-cantilever actuators using conducting polymers for the first time (**J. Micromechanics and Microengineering 2009**).

Finally, at the macro-level the use of electrochemically generated gas was investigated for pneumatic actuation (**Sensors and Actuators B-Chemical 2009**), while the use of conducting polymer bender-type actuators for propelling a "robotic fish" (Figure 'NEMO') were also published (**Smart Materials & Structures 2009**). Current work is focussing on developing methods for measuring actuation in single nanofibres; on further miniaturisation of conducting polymer actuators; and on evaluating the mechanisms of actuation in gel and conducting polymers.



The IPCE (Incident photon to electron conversion efficiency) spectra of p-DSSCs assembled from mesoporous NiO electrodes (solid lines), sensitized with 3 different sensitizers: dyes 1 (green), 2 (blue) and 3 (red) as well as the percentage of incident photons that are absorbed by the dye inside the p-DSSC (absorptivity, dashed lines). The red diamonds indicate the IPCE of a mesoporous 2.3-µm-thick NiO electrode sensitized with 3.



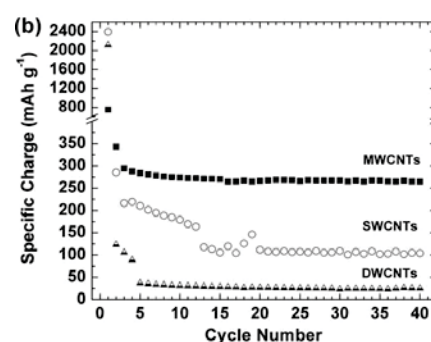
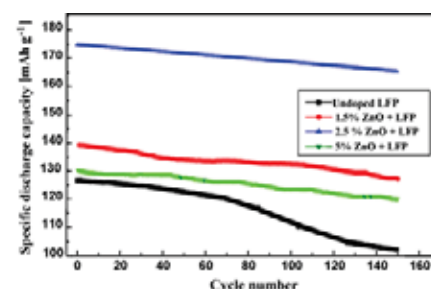
'NEMO' robotic fish prototype.

Program 3 (P3): Energy Storage

In progress towards solid flexible electrolyte materials, lithium metal rechargeable cells incorporating solid-state plastic crystal electrolytes have been investigated and found to exhibit improved rate capability after subjection to a low-current preconditioning process (**Adv. Eng. Mater 2009**, in press). A survey of the high temperature behaviour of a range of organic salts used in ionic liquid and plastic crystal batteries revealed that some, such as fluorosulfonyl imides are prone to thermal runaway and are therefore not safe for battery use (**Chem. Commun., 2009**).

Progress towards thin film, flexible cells

Zinc oxide (ZnO)-doped lithium iron phosphate systems have been investigated to improve capacity. The CV curves show that 2.5% ZnO-doped LiFePO₄ has higher electrochemical reactivity for lithium



insertion and extraction than the undoped material. (**Journal of Alloys and Compounds 2009**).

Experiments revealed that cathode films based on multi-wall CNTs (MWCNTs) are much better than single-wall and double-wall CNTs films in terms of their electrochemical performance. The flexible MWCNT electrodes show stable cycling behavior and allow up to a 10 C-rate (**Carbon 2009**).

Polymer composite materials with high capacities and energy density characteristics have been developed (**Journal of Power Sources 2009**). Polypyrrole doped with Nafion (Nf) ions or perchlorate ions exhibits a specific capacitance of 344 or 355 Fg^{-1} , respectively. It was observed that the energy density and power density of PPy-Nf at a scan rate of 1000 mVs^{-1} were 14.6 Whkg^{-1} and 4.3 kWkg^{-1} , respectively. Cycle life experiments revealed that the Nafion-doped material retains 98% of the original capacitance after 3000 cycles.

Significant progress has been made in the development of flexible all-polymer capacitors (and batteries) based on the use of nanostructured conducting polymers (**Journal of Power Sources and Synthetic Metals 2009**). Flexible polyaniline nanofibres electrode exhibited a specific capacitance of 235 Fg^{-1} ; and a capacitance of 195 Fg^{-1} was retained over 10,000 charge–discharge cycles after encapsulating the electrode in Nafion (**Synthetic Metals 2009**). A high discharge capacity of 94.7 mAhg^{-1} was obtained for the all-polymer battery system composed of electrodeposited polypyrrole cathode and functionalised polyterthiophene anode. (**Synthetic Metals 2009**).

Program 4 (P4): Bionics

Directional growth of muscle fibres has been achieved using a conducting platform with degradable microfibre/structure. A novel bio-synthetic platform that supports *in vivo* growth of partially differentiated muscle cells in an aligned linear orientation that is consistent with the structural requirements of muscle tissue has been constructed (**Advanced Functional Materials 2009**). These platforms consist of a biodegradable polymer fibre array spatially aligned on an organic conducting polymer (OCP) substrate. Long multinucleated myotubes were shown to form on the platform via differentiation of adherent myoblasts, which aligned longitudinally with the fibre axis to form linear cell-seeded bio-synthetic fibre constructs. The biodegradable polymer fibres bearing differentiated myotubes can be detached from the substrate during culture. The ability to remove the muscle cell-seeded polymer fibres when required provides the means by which the biodegradable fibers can be used as linear myofibre-seeded scaffold components suitable for *in vivo* implantation into muscle.

Directed growth of sensory nerves and migration of Schwann cells was shown to be enhanced by electrical stimulation using a variant version of the hybrid conducting polymer/biodegradable fibre platform used for muscle studies (**Advanced Materials 2009**). In the case of neuro-regeneration applications, the platform represents the basis for a highly versatile three-dimensional electrically conductive hybrid neural scaffold, that may be easily modified by use of any combination of OCP and biodegradable polymer microfibres. In the short term,

this hybrid platform provides an interface by which to connect neural circuitry with electronics, to promote communication between implantable electronics devices designed to rectify/adjust tissue function by interaction with the nervous system. With the development of truly biodegradable OCPs, the hybrid platform generated within the ACES Bionics activities will ultimately find application in the encouragement of effective regeneration in damaged neural tissues of the CNS and PNS.

Our work into the use of neurotrophin-loaded organic conducting polymers to promote neurite outgrowth has continued. Dramatic synergistic effects being observed when both NT-3 and BDNF are incorporated into polypyrrole as this platform is used to provide both direct electrical stimulation and a method of controlled release (**Journal of Controlled Release 2009**). This extension of work demonstrates the applicability of the conducting polymers as platforms to release multiple growth factors, with the two growth factors used here being particularly chosen for cochlear and spinal applications.

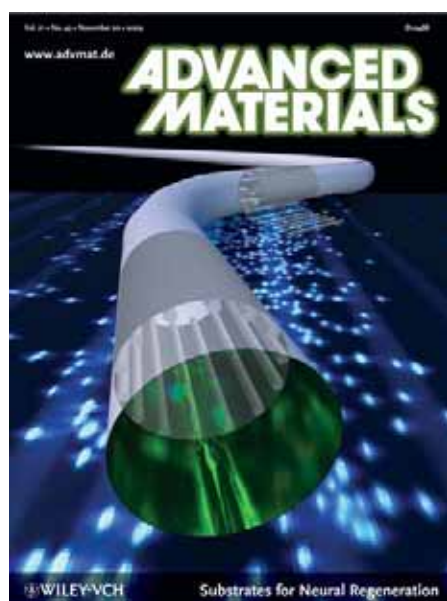
The first work describing the use of neurotrophin-loaded conducting polymers in animal models has been conducted (**Biomaterials 2009**). It was found that the controlled release of neurotrophins from conducting polymer substrates on cochlear implants improved the number of neurons remaining after deafening of the animals. The small mass of neurotrophin released reached and affected the neurons after release in the cochlear duct, which shows great promise for the cochlear application of released neurotrophins. It also suggests that applications in spinal cord regeneration via neurotrophin release could be successful.

ACES CIs were invited to provide a PERSPECTIVE article for the prestigious journal *Science* on the electrode-cellular interface (**Science 2009**).

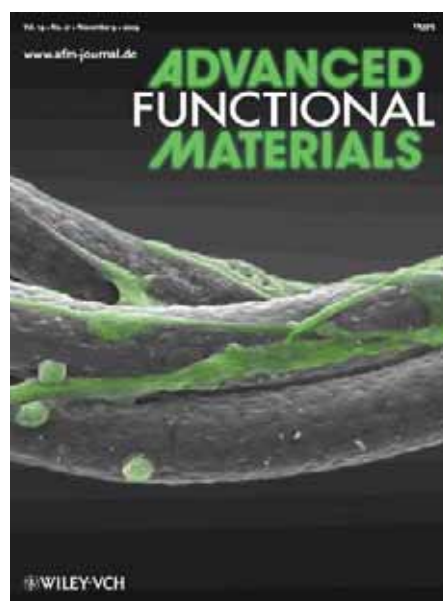
NHMRC funding has been obtained for Nerve Repair and Epilepsy drug release materials. This research is complimentary to a newly established collaboration with Stephen Livesey and development of a biologically-informed neuro matrix for peripheral nerve and spinal cord repair. These foci will be developed using 3-D printing paradigms with a translational clinical outcome target within 3 years. In addition, the nerve repair studies form part of a clinical translational pipeline which will facilitate the incorporation of ACES Bionics devices into common surgical practice. For the spinal cord repair studies, collaborative agreements have been made with surgeons who currently operate on chronic spinal cord injury in people [Jim Faed (NZ), Gustavo Moviglio (Argentina) and Carlos Lima (Portugal)].

Program 5 (P5): Ethics

Work towards this milestone has proceeded at a slower pace than originally intended due to the CI's move to the University of Tasmania in February 2009, the resignation of the UOW based Research Fellow in January 2009, and the delay in transfer of ACES funds to Tasmania which has prevented the appointment of a new Research Fellow. Nonetheless, the grounding research is completed and there is a good prospect for a new PhD student commencing research on this project in early 2010.



Neuronal axons (green) growing on wet-spun PLA:PLGA fibres within the proposed 3-D structure being developed for Peripheral Nerve Repair.



Muscle cells (green) growing on wet-spun PLA:PLGA fibres.



The trio whose Perspectives article was published in *Science* are (from left) Dr Simon Moulton, Prof Gordon Wallace and (inset) Prof Graeme Clark.

ACES Education and Training

The goals for 2009 have been to conduct training programs for staff and research students in the area of ethics in research, further workshops on the characterisation of nanomaterials, and a range of other specific training and education programs through seminar programs and short courses. The focus again this year has been to give a broad range of training opportunities for postgraduate students and early career researchers as well as provide opportunities for external participants. Particular areas of need for ACES researchers have been identified via a process of close consultation. As in previous years, attention has been given to ensure the training opportunities organised have brought together staff and students from different nodes of the Centre, thus facilitating cross-fertilisation of ideas and collaboration. Another highly successful related activity has been close integration of Centre activities at the Wollongong node with the Nanotechnology undergraduate degree.

In addition, there has been significant progress in our general public education and outreach program with the official opening

of our educational exhibition in the area of Electromaterials and their impact on society. This has been done in collaboration with the Wollongong Science Centre.

Specifically, during 2009 the following special events and workshops/short courses have been organised and successfully run:

- ▶ Electrochemistry week (Wollongong, February)
- ▶ Actuators for Bionic and Biomimetics (Wollongong, May)
- ▶ Assembly and Characterisation of Batteries and Capacitors (Wollongong, June)
- ▶ Bio AFM Workshop (Wollongong, August)
- ▶ In-house workshop on working with the media (Wollongong, September)
- ▶ Assembly and Characterisation of Solar Cells (Wollongong, November)
- ▶ IPRI/Chemistry Annual Conference (Nowra, November)
- ▶ Media Workshop (Monash, November)
- ▶ Challenges in Solar Cell Characterisation Forum (Wollongong, November)
- ▶ Printing of Bio Related Structures (Wollongong, December)
- ▶ Ethics in Research and Publishing Workshop (Wollongong, December)
- ▶ Training for the Research Information System (RIS), an online tool used to store information about publications (Wollongong, December)

Full reports on most of these events are to be found on the ACES website: (www.electromaterials.edu.au/news), whilst a summary and excerpts of some of the activities carried out are given below.

There is a constant (and growing) pressure on researchers to publish their research in peer-reviewed journals. A very relevant workshop was held, in Wollongong on 1 December, on the ethical issues in scientific publication: peer review, publishing ethics and the integrity of the scientific record.

The Workshop, attended by approximately 30 people, was convened and led by Prof. Susan Dodds (ACES), who introduced some of the issues associated with publication and the responsibilities of researchers, publishers, research institutions and



The panel sitting at the ACES ethics workshop (L to R): Dr Wendy Lipworth, Prof Susan Dodds, Prof Will Price and Dr Andrew Minett.

research funding bodies as they arise in the *Australian Code for the Responsible Conduct of Research*.

Dr Wendy Lipworth, from the Centre for Values, Ethics and Medicine at the University of Sydney, extended the discussion to the quality of the peer review process as a means of ensuring that the best research is published, noting the many limitations her research uncovered in the editorial and review process in medical journals (where the findings often directly inform clinical practice). The workshop then concluded with a lively panel discussion during which a number of case studies on ethical issues in publishing were debated.

A forum entitled “Challenges in Solar Cell Characterisation: Theory, Spectroscopy and Devices” was hosted by ACES in Wollongong on November 16-17. The forum workshop was organised by Prof David Officer and Dr Attila Mozer, leaders of solar energy research strength at ACES/IPRI. Featured speakers included Prof Keith Gordon (University of Otago New Zealand),

Prof Shogo Mori, (Shinshu University, Japan), and Prof Officer (ACES/IPRI). Forum participants discussed the scientific challenges to making solar power a more efficient and attractive proposition, and possible routes to achieving this. Following the presentations and panel discussions, a hands-on session, was provided.

An in-house workshop on fabrication and characterisation of batteries and supercapacitors was successfully hosted by ACES in June. More than 20 people from ACES/IPRI and ACES/ISEM attended the workshop. Following lectures covering the relevant background knowledge, a hands-on session was held where the attendees were shown the procedures for making batteries and supercapacitors, and how to characterise and test those cells.

ACES held a number of major outreach and education events to celebrate National Science Week in August. A public lecture by ACES senior researcher and bionic ear pioneer Prof Graeme Clark was hosted by ACES in conjunction with the University

of Wollongong and Wollongong Science Centre. In his lecture, titled “Big thinking, small technologies” Prof Clark took the audience through some of the implications of nano-bio-technology, including how it may help with spinal cord repair, drug delivery and the development of a visual prosthesis – the bionic eye, and his collaborative research with ACES (read more about this event in the Outreach section of this report).

The ACES Education Committee developed the inaugural High School competition ‘Bionics for 2020’, which was launched in July. The competition sponsored by ACES/IPRI, The Faculty of Science, the Wollongong Science Centre and supported by RACI, was open to all High Schools in the Illawarra Region whose students had to address the question: “what new Bionic parts would you develop for humans, why and how?”. They were asked to either write an essay or create a poster. Individual or Group Entries were accepted.



Dr Benny Kim (ACES/IPRI) explaining the workings of a supercapacitor



Prof. Liu (ACES/ISEM) with some of the researchers and students in attendance at the in house workshop.



Professor Graeme Clark (centre) with ACES Executive Director Professor Gordon Wallace (left), and Science Centre Director Glen Moore.

The competition certainly fired the imagination of both student and teachers and gained good media coverage. Winners were awarded their prizes by Prof Graeme Clark. The individual and group winners were also invited to enjoy a morning tea with staff and students from ACES/IPRI and participate in a guided tour of the IPRI laboratories. The winning entries were on public display for the day at the Science Centre.

An extension of the Bionics 2020 competition was conducted at Sydney Grammer School. On 20 November, Prof Geoffrey Spinks gave a talk entitled "Our Bionic Destiny", attended by approximately 100 students (from years 7-12) and parents. Entries in this second Bionics 2020 competition (from years 7, 8, 9 & 10) showed insightful knowledge of Bionics.

Getting science and research into the news and how to ensure it is accurately reported, was the subject of the ACES Media Seminar held at IPRI in Wollongong on 18 September. The seminar, organised by ACES Communications Coordinator Leanne

Crouch, was attended by 40 ACES staff and students and covered many aspects of dealing with the media. Invited to present at this workshop were Bernie Goldie, Manager of the University of Wollongong's Media Unit and the Deputy Editor of the Illawarra Mercury Newspaper, Carol Johnstone. They provided insights into the traditional role of the media and to the global social media revolution. Participants were also made aware of the broad range of media options: from the internet, to multimedia to podcasts, to Wikipedia, Facebook and Twitter as opportunities for scientists and researchers to broadcast their message to a global audience.

A similar event was held in Melbourne on 9 November for ACES. This was done in conjunction with Monash University's Centre for Synchrotron Science who hosted a Workshop for students and staff from ACES/Monash and 7 PhD students from ACES/IPRI.

Talks from ACES staff included a session on grant writing by Prof Maria Forsyth (ACES/Monash); tips for getting science and

research into the media and how to ensure it is accurately reported by Leanne Crouch (ACES); a session on commercialising Research by Chris Gilbey (Director of Strategic Development: ACES); and an insight into intellectual property laws by PhD student Tim Khoo (ACES/Monash).

Participants were later taken on a tour of the Australian Synchrotron before being presented with a number of sessions introducing the capacities of the Synchrotron, and its relevance to ACES research.

In addition to the above workshops and special events, there have been active seminar programs at both Monash and Wollongong, with regular (one-per-week) external and internal speakers on a wide range of topics for students and research workers, as well as internal seminar series at both nodes for students to present to their peers. This has also enabled visiting staff from Monash to present to Centre members at Wollongong and vice-versa, resulting in effective exchange of ideas and education. In addition, in Wollongong monthly program



Bionics for 2020 Competition winning group from Macquarie Fields High School; 'the Awesome Foursome' and 'Aussie Pride' are pictured with their science teacher Rebecca Toll and the UOW Dean of Science, Professor Will Price.

meetings are held in both the materials and bionics programs to discuss current research problems and to offer possible solutions.

Further significant progress has been made in the educational outreach area with the completion of the new animated DVD called "Nanostructures for Electromaterial". The DVD covers the topic of electromaterials, their applications, benefits and impact on society, by addressing how nanostructured nanomaterials are used in applications for advancing the cochlear ear implant and for nerve and muscle growth. The DVD has been distributed to high schools throughout the country and it has also been placed on the ACES, IPRI and UOW websites.

In August 2009 there was the formal opening of the first stage of an education exhibition, *Nanomaterials for Energy*, at the Wollongong Science Centre. The iDome is the centre piece first stage of this Wollongong Science Centre exhibit and is a partnership between ACES and the Wollongong Science Centre. Seven modules are featured in the segment and include

graphical and animated molecular visualisation modules, providing a 180-degree view of nanotechnology and the advanced electromaterials used by ACES as well as a virtual tour (360-degree view) of ACES / IPRI laboratories at the Innovation Campus.

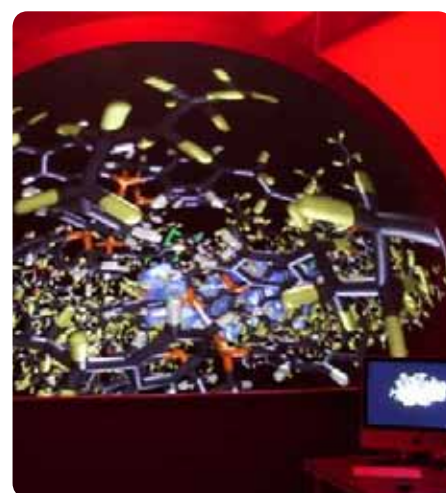
Progress is being made towards implementation of stage 2 of the exhibit which will add to the range of items on the iDome facility and build around it a variety of informative packages using a number of different media. ACES is currently looking at further sponsorship/joint partnership to enable a project manager to be employed. This will focus on the use of new materials in energy conversion such as in solar cells or artificial muscles, energy storage in new types of batteries and capacitors, and medical bionics.



Timothy Khoo (ACES/Monash PhD student) and Prof. Maria Forsyth at Monash University's Workshop.



At the Monash Centre for Synchrotron Science.



iDome exhibit at Wollongong Science Centre.

International Profile

ACES continues to attract research scientists from around the globe and participates in a number of active international research collaborations. During 2009, ACES produced 98 refereed publications, with some 40 of these involving international collaborators. The Centre has established an international research network that will help realise our scientific ambitions.

This section reports on:

- ▶ International Symposia (4) hosted/co-hosted by ACES
- ▶ International collaborations: listed country by country
- ▶ International invited presentations given by ACES researchers

International Symposia Hosted/Co-Hosted by ACES

(i) Nanostructured Electromaterials Symposium (Wollongong, 4-6 February 2009)

The latest developments in electromaterials and how they can be applied to the way we live and work were presented and explored at the 2009 Electromaterials Symposium.

The symposium focused on nanostructured electromaterials and their applications in the areas of energy and health. International experts from Ireland, Canada, USA, UK, Japan and Korea spoke on the application and performance of these electromaterials in areas as diverse as corrosion protection, chemical sensors, fuel cells, batteries, biosensors, artificial muscles and medical bionics.

Prof. Siegmund Roth (Max Planck Institut für Festkörperforschung, Germany) and Prof. Richard Kaner (University of California, Los Angeles, USA) discussed carbon nanotubes and graphene, describing how they can be characterised and processed into useable formats for practical applications.

Prof. Rose Amal (University of NSW) described how the development of highly efficient photocatalytic nanoparticles and systems for water and air purifications, self cleaning surfaces and clean energy can address the energy, water and environment

issues facing our society. Prof. John Madden (University of British Columbia) discussed electrodes attractive for use in storage of electrostatic energy, actuation and solar cell harvesting, while Dr Gerry Sweigers (CSIRO Molecular and Health Technologies) described "bio-inspired" catalytic solar water splitting research.

In the health area Prof. Mario Romero-Ortega (University of Texas at Arlington, USA) described his recent studies on the use of nerve growth factors to guide sensory nerves to specific target areas. Ultimately, this should lead to the improvement of the neural control of robotic prosthetic devices used by amputees.

Post doctoral researchers from ACES also presented highlights from their research on dye sensitised solar cell technologies, conducting platforms for muscle and nerve regeneration, and biocompatibility studies of carbon nanotubes. The final session focused on end-users of electromaterials science and included presentations from Defence Science and Technology Organisation, Australia, Aqua Diagnostic Australia, The HEARing CRC and Hearworks Pty Ltd, Cap-XX Pty Ltd, Boston Scientific and CSIRO Energy Technology, Australia. For the full report see <http://electromaterials.edu.au/news/2009febsympreport.pdf>

Our heartfelt thanks to the sponsors who supported the 2009 ACES Symposium: The Hearing Co-operative Research Centre, the Co-operative Research Centre for Polymers, CSIRO and BlueScope Steel.

(ii) 3rd Congress on Ionic Liquids “COIL3” (Cairns 31 May – 4 June 2009)

Prof Doug MacFarlane and Dr Jenny Pringle (ACES) organised the 3rd Congress on Ionic Liquids. Ionic Liquids have become of intense interest in the electrochemistry and electromaterials fields as electrolytes in batteries, solar cells, electrowinning and nanomaterials synthesis. The meeting is the main international gathering held every two years in the Ionic Liquids area and attracts researchers from a wide variety of fields - around 400 delegates attended from 35 countries, of which 150 were students. The conference consisted of 42 invited presentations from top researchers in the field and around 350 posters. Major sponsorships were received from Merck, the Air Force Office of Scientific Research, CSIRO, Monash University and ACES.

(iii) International Symposium on Renewable Energy Storage and Conversion Technologies (Wollongong, 18-20 November 2009)

This International Symposium was jointly hosted by the Institute for Superconducting and Electronic Materials (ISEM) and ACES, and supported by the UOW Energy Futures Networks and the Korean World Class University Centre for Next Generation Battery, South Korea. This symposium provided the 100 participants, the opportunity to discuss a wide range of new scientific findings in the area of renewable energy storage and conversion technologies. It also served as a high level platform for all participants to establish new collaborations.

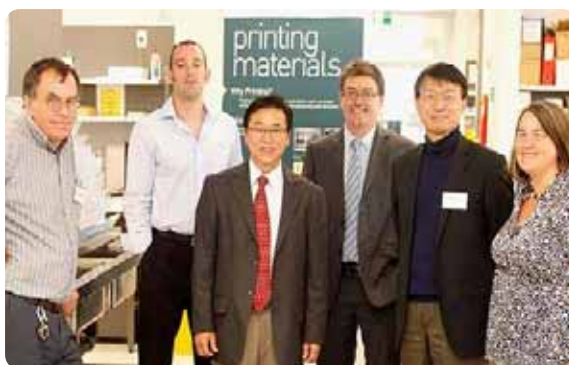
(iv) Printing of Bio-Systems and Electronics: the Next Generation of Bionics (Wollongong, 3-4 December 2009)

The use of printing in producing electronics devices has grown in recent years, and the development of new materials for bionics is a rapidly developing field. The workshop explored the convergence of these two exciting fields and the opportunities thereby created to enable the printing of bionic devices. Interest was demonstrated in the audience mix which included, 5 international, 12 national and 9 industry representatives.

Prof. James Yoo from Wake Forest Institute for Regenerative Medicine, USA, spoke about the use of inkjet printers in the development of functional tissues for clinical applications. Other international speakers included visiting US printing expert Prof Paul Calvert, Prof Gyoujin Cho (Suncheon National University, Korea), Dr Jan Sumerel (Fujifilm Dimatix, USA) and Prof Niyazi Serdar Sariciftic (University of Linz, Austria). The workshop was sponsored by ACES, the Australian Research Network for Advanced materials (ARNAM), Fujifilm Dimatix and Labcyte Inc.



At the 3rd Congress on Ionic Liquids



Speakers at the Workshop included ARC Professorial Linkage Fellow, Prof Paul Calvert, Prof James Yoo and Prof Gyoujin Cho, and Dr Jan Sumerel, seen here with Prof. Gordon Wallace and Dr Marc het in Panhuis.



Hands-on demonstrations were a hit at the Printing of Bio-systems and Electronics workshop, Dec 2009.

Collaborations by Country

Canada

Professor Doug MacFarlane visited the Department of Chemistry at the University of Waterloo Canada in July 2009 for collaborative discussions.

China

Collaborations with Shanghai Jiao Tong University continued to strengthen. In August 2009, Dr Jun Chen (ACES) visited Shanghai to review the progress of the on-going DEST Inter-Linkage Project. Dr Chen also visited East China University of Science and Technology in order to further build up collaboration from 2010 based on conducting polymer composites.

Prof. HK Liu (ACES) spent 2 weeks in China (28 June until 14 July) visiting various collaborators at Shanghai University, East China University of Science and Technology, Institute of Physics, the Chinese Academy of Science, and Northeastern University.

Dr. Z.P. Guo (ACES) visited East China University of Science and Technology and Fudan University from 29 June to 10 July. The collaboration with the Shanghai University has resulted 3 papers in 2009 (see journal article 113 and refereed

conference papers 3 & 4 in publications section). The collaboration with Fudan University has resulted one paper in 2009 (journal article 130 in publications section).

PhD student Peter Sherrell spent 3 weeks at Shanghai Jiao Tong University, in September, using their advanced microwave reduction system to synthesise carbon-platinum composites, under a DEST Inter-Linkage Project. Whilst visiting China, Peter gave an oral presentation on "Optimisation of Carbon Nanoweb Architectures for Nano-Energy Applications" at the International Conference of ChinaNano2009 held in Beijing (1-4 September).

For three weeks in July Prof. H.L. Wang from Beijing Normal University and his student spent time working with Prof Hugh Brown (ACES) in Wollongong on gels. Dr Sureyya Saricilar (ACES) then visited Beijing Normal University in December 2009, spending 3 weeks with Professor H. L. Wang.

Dr Yimei Yin, from Shanghai Jiao Tong University, visited ACES for three months and worked with Dr Jun Chen on the collaboration project on nanostructured active composite materials for SOFC application. This visit was supported by the ARC discovery project, DP0877348.

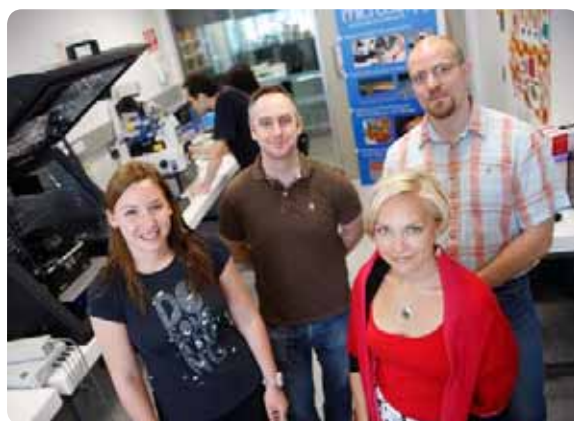
Dr Yong Kong from the Department of Applied Chemistry, College of Chemistry and Chemical Engineering at Jiangsu Polytechnic University, Changzhou, China visited ACES for 6 months to carry out research on making all-polymer batteries composed of biocompatible materials.

Two 12 month collaborative visits with ACES/ISEM were completed in 2009. Mrs. Limei Fan, from the University of Electronic Science & Technology of China, completed her visit with ACES in April and Dr Xianjun Zhu from the Central China Normal University in June.

ACES/ISEM hosted many international visitors from China. On 29 January they hosted Mr Jiangfeng Wu, Manager, DLG battery (Shang Hai) CO Ltd, and Dr. Yao Chen, the General Manager of DLG battery (Shang Hai) CO Ltd, who returned again in May (15 May). They also hosted Prof Yu Chen Zai from the Northeastern University (30 April – 1 May) and A/Prof. Yun Long Xu from East China University of Science and Technology (Shanghai) for 2 months (Feb – April).

Finland

Suvi Haimi and Aliisa Pali from the Regea-Institute for Regenerative Medicine, University of Tampere, Finland, and Jani Pelto, a fellow from VTT Technical Research



Finnish visitors Suvi Haimi, Aliisa Pali, and Jani Pelto, carried out atomic force microscopy experiments with Dr Michael Higgins

Centre of Finland, visited IPRI in November. As well as presenting lectures on their research, they also carried out atomic force microscopy experiments with Dr Michael Higgins on the collaborative project: "The effects of polypyrrole based polymers and electric environment on adipose stem cell attachment, viability, and proliferation".

France

PhD student Torben Daeneke (ACES) worked with collaborators in France (Strasbourg) and Switzerland (Lausanne), for 10 weeks commencing in June.

ACES PhD student, Shannon Little, spent September at the Centre de Recherche Paul Pascal in Bordeaux, France, on a collaborative project with Nicholas Mano's research group to produce a high power density biofuel cell. Whilst in France, Shannon attended the International Symposium on Functional Nanomaterials, presenting a poster on "Carbon NanoWeb Electrodes for Enzymatic Direct Electron Transfer".

Germany

Dr Udo Bach gave a presentation and had a meeting at Bosch headquarters in Stuttgart on 15 June. The discussion centred on the

joint application to the Victorian Consortium for Organic Solar Cells and included a lab visit.

Prof Leone Spiccia spent time in July visiting the research group of Prof Metzler-Nolte; Dr Gasser; Dr Schatzschneider (Bochum University) in Germany.

Dr Udo Bach visited Prof Baeuerle at the University of Ulm, Germany, holding discussions about collaboration on dye-synthesis on 15 September.

ACES PhD student, Ben Mueller, spent a week working on AFM-Raman measurements of graphene in Prof. von Klitzing's department at the Max Planck Institute for Solid State Physics in Stuttgart, Germany, in November. Prof von Klitzing won the Nobel Prize in Physics in 1985.

Dr Udo Bach visited Prof. L. Schmidt Lab -Mende at the Ludwig Maximilian University in Munich on 6 December.

Hong Kong

Dr. Jiazhao Wang (ACES) visited the Hong Kong University of Science & Technology, in July for two weeks, to initiate the collaborative project entitled "Production of Carbon Nanotube and CNT Application as Catalyst Support and Advanced Material for Energy Storage". This project is being

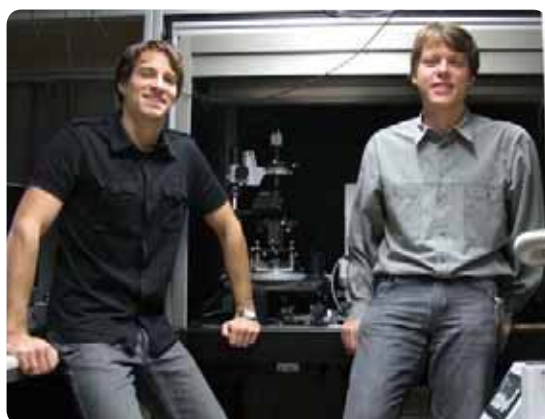
funded by Hong Kong under the Innovation and Technology Support Programme (ITP/026/08NP).

Ireland

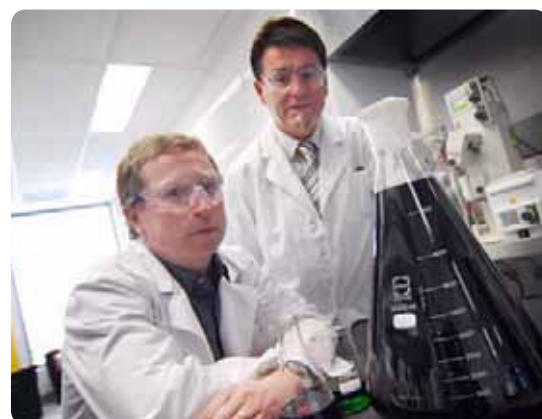
Prof Tony Killard, from the National Centre for Sensor Research at Dublin City University (DCU) carried out research at ACES in October. He combined his expertise in electrochemical sensors with Prof Calvert and IPRI on conducting polymer nanomaterials in the project to allow printed sensors and biosensors to be integrated into electronic devices creating "miniaturised smart systems".

Dr Robert Byrne, a post-doctoral researcher from the National Centre of Sensor Research at DCU, was awarded a STTF Fellowship to work with Prof David Officer on synthesis and characterisation of photochromic terthiophenes. He spent several weeks working in Wollongong during February.

A series of visits by PhD researchers from Ireland is building upon these already strong research links. Students Emer Lahiff and Silvia Scarmagnani worked in the ACES labs in February. Silvia worked on the functionalisation and characterisation of polymeric microspheres and polyaniline nanofibres with spiropyran photochromic.



Ben Mueller (right) in Prof. von Klitzing's department at the Max Planck Institute for Solid State Physics in Stuttgart, Germany.



Prof. Tony Killard (left) from Dublin City University undertaking research at the Innovation Campus with Prof. Gordon Wallace.

These followed visits from Elaine Spain to Wollongong in December 2008 to work with Dr Lynn Dennany on a biosensor for mastitis detection and by Martina O'Toole, also in December 2008, to work with Dr Rod Shepherd on ink jet printing.

Ms Eimear Ryan, a PhD student from the National University of Ireland, was awarded a 2009 Endeavour Research Fellowship to visit ACES for 5 months. She worked with Dr Simon Moulton, using conducting polymers to deliver anionic drugs that are insoluble in water.

Deirdre Sheridan, administrative assistant at Dublin City University, visited Wollongong for 2 weeks in November to train and participate in the administrative operations of ACES; taking special interest in the organisation of international symposia.

Dr Scott McGovern travelled to Dublin City University, in March to work with collaborators on the WANDA Linkage Project. Development of the image recognition program was undertaken for use in the WANDA robotic fish. Testing was undertaken on the software in 'real world' environments to ascertain the best regime for use of the program (lighting, colour

detection, etc). These interactions have led to plans to incorporate a range of sensors on the fish.

Scott again visited Ireland in September to attend the International Symposium on Functional Nanomaterials, held on the 10-11 September, at DCU. A highlight was the successful Irish launch of the robotic fish called "WANDA" by Scott and DCU collaborators. In particular, a demonstration of WANDA's object recognition and detection capabilities using wireless video-imaging software was presented. This led to discussions with potential industry partners, including IBM and Foster-Miller, on future collaboration ACES research.

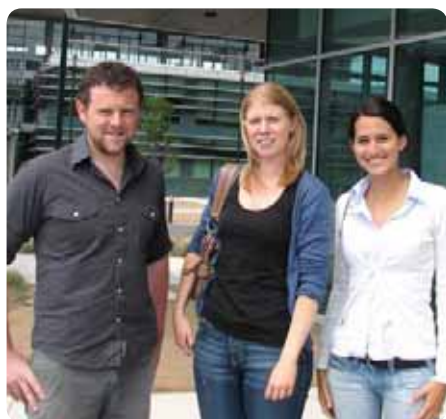
Dr Michael Higgins gave invited talk at the International Symposium on Functional Nanomaterials, on "Dynamic Polymer Interfaces for Controlling Protein and Cellular Interactions" and showcased work being carried out within the Bionics Research Program of ACES, in September 2010. The aim of the symposium was to act as a platform to present the latest advances in cutting edge nanomaterials research. Two ACES PhD students, Shannon Little and Robert Breukers, presented posters.

Robert Breukers worked with Prof. Dermot Diamond and Dr Robert Byrne at NCSR for 1 month (August -September). His research focused on the synthesis, polymerisation and characterisation of spiropyran functionalised terthiophenes for use in sensors.

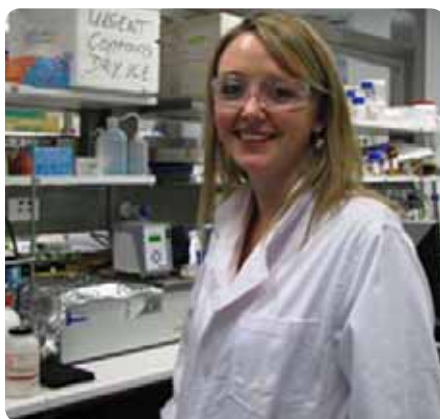
Dr Lynn Dennany (ACES) worked with Prof Forster at DCU in September to obtain energy transfer and electron transfer data utilising TCSPC and low temperature emission data on Ru porphyrins covalently attached to fullerene molecules. The studies have provided useful information on the quenching pathways of a ruthenium porphyrin attached to a fullerene molecule. Whilst visiting Lynn gave a Seminar Series Presentation "Tuning electron and energy transfer in polyelectrolytes".

Japan

ACES has a fruitful on-going collaboration with Prof. Shogo Mori (Shinshu University, Japan), Prof. Akihiro Furube and Dr. Ryuzi Katoh (AIST, Tsukuba) in Japan. This collaboration is mainly focused on evaluating the efficiency limiting factors of porphyrin-sensitised TiO₂ solar cells by using various transient optical and electrical



Robert Byrne, Emer Lahiff and Silvia Scarmagnani from DCU in Ireland, outside AIIM building in Wollongong.



Ms Eimear Ryan, a PhD student from the National University of Ireland worked at IPRI with Dr Simon Moulton, using conducting polymers to deliver anionic drugs.



Deirdre Sheridan, administrative assistant at Dublin City University, pictured with Phil Smugreski (ACES)

probes. The partners from Tsukuba joined this collaboration in 2009 bringing experimental skills in femtosecond pump-probe measurement, which is one of the best set-ups in the world.

With this collaboration there are 3 main sub-projects:

- ▶ Investigation of the injection efficiency in porphyrin dimer-sensitised TiO_2 solar cells. For the first time efficient injection in a dimer-sensitised solar cell has been demonstrated (*J. American Chem Soc*, 2009). A further two publications are in preparation to be submitted in 2010.
- ▶ The injection limitations in various porphyrin-sensitised solar cells depending on molecular structure. A clear correlation between injection efficiency studied using fs-TAS and the device efficiency has been observed hence a paper is currently in preparation.
- ▶ As a follow up to the paper published in *Chemical Communications* in 2008, the effect of a zinc atom versus free-base porphyrin on the recombination dynamics in the porphyrin-sensitised solar cell has been undertaken in 2009.

Our Japanese collaborators have attended and presented talks at both the ACES Symposium held in February 2009, and the



Irish launch of the robotic fish called "WANDA" by Dr Scott McGovern and collaborators from the NCSR

ACES Solar Cell Characterisation Workshop held in November 2009. In addition ACES PhD student, Matt Griffith, has recently been awarded a Prime Minister's Award which will allow him to spend 6 months in 2010 with Prof. Mori in Japan.

Korea

Links between ACES and Korean researchers were bolstered by a number of visits, collaborative projects, grants and awards. ACES Executive Director Prof Gordon Wallace was appointed to join eminent world scientists in a newly-formed international collaborative research project named "World Class University". Supported by a \$1 million grant from the Korean Ministry of Education, Science and Technology, Prof Wallace will collaborate with researchers and students at Hanbat National University to prepare a variety of electrode materials for use in energy conversion and energy storage systems.

In January, NSW Minister for Science and Medical Research, Jodi McKay, announced that ACES would be the first funding recipient of a joint technology program between the NSW Government and the

South Korean province of Gangwon. The \$100,000 grant will promote research in new technologies.

Mr Hwi Won Kang, a Senior Research Engineer from PARU Co. Ltd, Suncheon, South Korea, worked with ACES/IPRI researchers for 3 months, starting in January, on gravure printing of solar cells. In addition, Gwangyong Lee, an under graduate student in the Printed IC Lab, Department of Chemical Engineering at Suncheon National University, focused on Ink-jet printing of electronic devices, with the view to prepare a novel electrode with enhanced performance and low production cost for solar cell and supercapacitor applications.

In February, a visit to Wollongong by Prof Ko Jang Myoun and Jeong Ho Park from Hanbat National University, marked the start of a collaboration to prepare a variety of electrode materials to be used in energy conversion or energy storage systems. This visit is the first in a series of transfers of staff and students between the two institutions.

There were also many visits by ACES researchers to Korea. Prof Gordon Wallace and Dr Byung Kim visited Korea in March and April 2009 to build further on the



UOW Vice-Chancellor Gerard Sutton, NSW MP Noreen Hay, NSW Minister for Science and Medical Research Jodi McKay, ACES Director Gordon Wallace, UOW Deputy Vice-Chancellor (Research) Judy Raper pictured at the announcement that ACES received funding for a joint technology program with Gangwon.

collaboration between ACES and Korean partners and national institutes, following the announcement of the World Class University partnership in February. Prof Wallace returned to Korea in July to visit Korean universities and research institutes where he provided a number of presentations and discussions, including:

- ▶ presentation on recent ACES findings in the Bionics area at a mini symposium organised by Prof. Seon Jeong Kim
- ▶ presentation at the newly formed department for "Printed Electronics" at Suncheon University, where ACES has a number of collaborative projects with Prof. Cho
- ▶ presentation on Organic Bionics to Prof. Park Yungwoo's research group at Seoul National University; and collaborative research discussions with Prof. Park (Gangwon) on the use of novel TiO₂ structures for energy storage
- ▶ Keynote address at a World Class Universities event aimed at building research and commercial collaborations

An additional visit in November to Korea by Prof Wallace, Prof Leon Kane-Maguire, Prof David Officer and Dr Jun Chen built upon these growing collaborative links. These four

ACES researchers and Dr Byung Chul Kim conducted a two day 'Conducting Polymer School' at Hanbat University in Daejeon.

New Zealand

In February, four ACES researchers, Drs Pawel Wagner, Attila Mozer and Sanjeev Gambhir and PhD student Robert Breukers, attended the fourth MacDiarmid Institute Conference - Advanced Materials and Nanotechnology 4. They presented lectures ranging from the use of functionalised polythiophenes as scaffolds for cell growth and in solar cells to the synthesis and use of porphyrin monomers and dimers in solar cells.

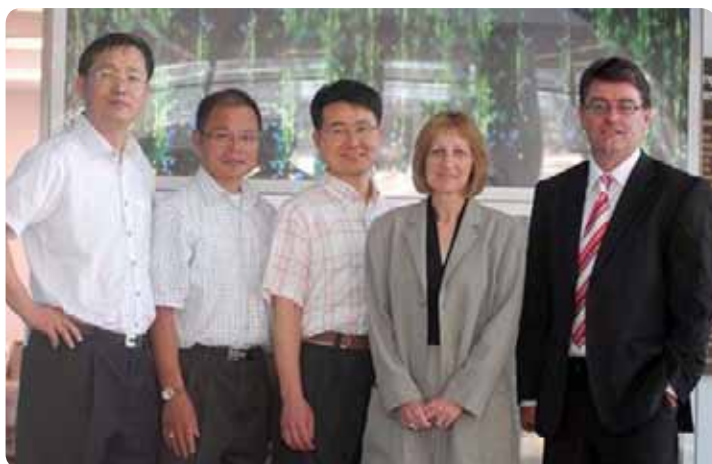
As part of the International Consortium on Solar Cells (ICOS) research program, Drs Wagner and Mozer met with Professor Keith Gordon (University of Otago) and PhD student Mr. Samuel Lind to discuss Wollongong-Otago ICOS research projects on dye-sensitised solar cells. This resulted in a very successful visit by Sam Lind to the ACES laboratories later in July to further the joint research. This has resulted in a *J. American Chemical Society* paper with

Japanese collaborators on porphyrin-based solar cells, also involving collaboration with Imperial College researchers.

Other interactions with Prof Gordon, linking material synthesis/characterisation and device construction at the ACES with quantum mechanical calculations and Raman spectroscopy at the University of Otago for solar cells and light emitting diodes, continue to be very productive. Some of this work is funded by a New Zealand Royal Society Marsden grant and a Foundation for Research Science and Technology International Investment Opportunities Fund (IIOF) grant. Prof David Officer (ACES) met with Prof Gordon in New Zealand in November to discuss the research for this and other grants.

Phillipines

Ms Karen Santiago, from the University of Santo Tomas, Philippines spent 2009 in ACES working with Dr Toni Campbell on long term controlled release of a drug from a biodegradable substrate, where the drug was loaded by ink-jet printing techniques.



Prof Gordon Wallace and Deputy Vice-Chancellor (Research) Prof Judy Raper with (from far left) Professor Ko Jang Myoun (Hanbat University, Korea), Dr Byung Kim (IPRI) and Jeong Ho Park (Hanbat University) after the announcement that the Korean government had invited Gordon to join the project "World Class University".



Dr Attila Mozer (ACES) spent one week in October at the National Metal and Materials Technology Center (MTEC) in Bangkok

Singapore

Dr Atilla Mozer (ACES) visited the A*Star Institute of Materials Research and Engineering (IMRE) in Singapore on 12-13 March, and attended the IMRE-ICOS Photovoltaic Workshop. He gave a lecture on "Transient Optical and Electrical Probes: Overview of Charge Transport and Lifetime Measurements at the Intelligent Polymer Research Institute". Dr Jenny Pringle (ACES) also presented a lecture entitled "PEDOT Electrocatalysts for Dye-Sensitised Solar Cells" at the IMRE-ICOS workshop.

Dr Udo Bach (ACES) visited Bosch in Singapore on 18 September 2009 where he had discussions about involvement of Bosch as commercial partner for ASI and VSA applications. Udo gave a presentation on behalf of the Victorian organic solar cell consortium.

Switzerland

Prof Leone Spiccia (ACES) visited a number of research groups during July including Prof Graetzel (EPFL).

Naomi Lewcenko (ACES) attended the European Materials Research Society Conference in Strasbourg from June 8 - 12 and also visited Prof Graetzel at EPFL in Lausanne, Switzerland.

Dr Udo Bach (ACES) visited Prof Michael Graetzel at the Swiss Federal Institute of Technology, Switzerland on 4 September. He also visited Prof J. Moser at the Swiss Federal Institute of Technology, Switzerland to discuss a potential collaboration on laser spectroscopy on 7 September.

Thailand

Dr Atilla Mozer (ACES) spent one week in October at the National Metal and Materials Technology Center (MTEC) in Bangkok. Attila is a partner investigator on a collaborative project funded by a Thai Government, MTEC Director's Initiative

grant, which is focused on developing advanced organic electronic devices. He contributes to the grant by using advanced spectroscopy techniques to characterise solar cell materials.

The main objective of this first visit was to overview solar cell activities at MTEC focused on inverted inorganic / organic hybrid solar cells. He then toured the most prestigious research institutes in Bangkok: MTEC, NANOTECH, NECTEC - all part of NSTDA (National Science and Technology Development Centre).

United Kingdom

To follow up on her sabbatical in Warwick in 2008, Prof Maria Forsyth (ACES) visited Warwick University and the University of Birmingham. PhD student Paul Bayley (ACES) spent from March to May working with colleagues at the University of Warwick and University of Leicester, whilst Dr Patrick Howlett (ACES) visited the University of Birmingham in May. Whilst in the United Kingdom, Dr Patrick Howlett (ACES) also attended the Conference on the Corrosion Chemistry in Pits, Crevices and Cracks at Manchester College in Oxford.

Professor Doug MacFarlane (ACES) visited the University of Surrey, Department of Chemistry in October.

USA

In January, Dr Pawel Wagner (ACES) visited the laboratories of Profs Marder, Kippelen and Brédas in the Centre for Organic Photonics and Electronics and the School of Chemistry and Biochemistry at Georgia University of Technology, where he presented a seminar entitled "New materials for organic solar cells".

Dr Pawel Wagner also visited Prof George Malliaras' laboratories at Cornell University, meeting Dr Lee-Fun Lim. Discussions took place about how the superb CNS

semiconductor device fabrication and characterisation facilities could be utilised in conjunction with the ACES conducting polymer development program. Dr. Lim provided a batch of specially designed ITO-coated glass plates for electronic devices to test back in Wollongong.

In March, Dr Scott McGovern attended the SPIE Smart Materials and Structures Conference, San Diego USA, March 2009, where he gave an invited talk "Organic bionics" on behalf of Professor Gordon Wallace. Scott also accepted the SPIE Smart Structures and Materials Lifetime Achievement Award on behalf of Prof Gordon Wallace.

Links with the University of Texas at Dallas were expanded during 2009. In May, Joselito Razal (ACES) attended the San Francisco MRS Conference where he presented a talk on Nanostructure-Mediated Skeletal Muscle Regeneration Using Multiwall Carbon Nanotubes and Polypyrrole Platforms. He also visited the University of Texas at Dallas (UTD), where he learned the technical skills of spinning carbon nanotube (CNT) sheets and yarns, and UTD provided open-access to samples of spinnable CNT forests. Joe also visited University of Texas at Arlington, to further collaborative discussions.

Mr. Suriya Ounnunkad, an ACES PhD student, gave an oral presentation at the world's largest annual nanotechnology meeting, NSTI Nanotech Conference & Expo 2009 in May, at Houston, Texas. His talk "A novel carbon nanotube-biomedical polymer composite platform for bioelectrochemical applications" highlighted his research into carbon nanotube nanocomposite materials. Suriya also visited Prof. Thomas Randall Lee at the University of Houston.

Dr Philip Whitten (ACES) continued to develop on an existing collaboration with Prof Ric Kaner at UCLA with a visit for

4 weeks in June after receiving an UIC International Links Grant Scheme Award from UOW. Whilst at UCLA, he continued his collaborative research in the area of self-assembled arrays of conducting polymer nanofibres and also presented a seminar to Qebing Pei's group at UCLA. Phil's visit to UCLA was followed up with a visit to ACES by Veronica Strong from Ric Kaner's lab in August, also courtesy of the International Linkage Grant Scheme Award.

Dr Whitten also attended two Gordon Research Conferences for Polymers presenting a poster on "Flash Welding of Polyaniline Nanofiber Mats and Their Actuation".

Prof Doug MacFarlane (ACES) visited the University North Carolina, Centre for Bio Engineering in July for collaborative research discussions.

Dr Attila Mozer (ACES) visited our ICOS solar cell consortium partners at Georgiatech (Prof. Seth Marder, Prof J.-L. Bredas, Prof. Ken Sandhage and Prof. Bernard Kippelen) and discussed collaboration between the parties. A two year collaboration agreement with leading organic solar cell company Konarka

Technologies Inc. was also signed, as a result of which a post-doctoral position will be funded to perform advanced laser spectroscopy investigations, in Wollongong, on Konarka solar cell materials.

Prof Leone Spiccia (ACES) delivered an invited talk at the SPIE conference on Optics and Photonics (San Diego) in August and also visited the research team of Prof Casey (UC Davis).

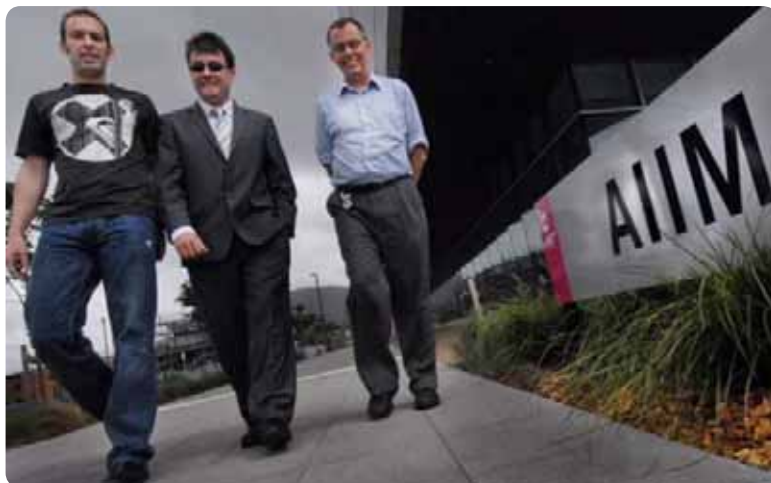
Dr Udo Bach (ACES/Monash) visited Prof C. Drain at the City University of New York USA on 15 September, holding discussions about collaboration on dye synthesis.

ACES hosted Assoc Prof Mario Romero-Ortega (University of Texas at Arlington) during February where he was an invited speaker at the February international symposia talking about described his most recent work on the use of nerve growth factors to guide sensory nerves to specific target areas. Discussions were also held about a collaborative project on nerve segregation using a 3D implantable nerve conduit and planning the next stage of preliminary experiments.

Further collaborative links were developed with Prof Paul Calvert, from the Department of Materials and Textiles at Massachusetts Institute of Technology, Dartmouth. An ARC Linkage International Award for Prof Calvert has allowed Paul to be in ACES to commence research on inkjet printing bio-functional materials.

Inkjet printing technology offers a way to create three-dimensional biological structures for studying cell interactions and artificial organs. Paul is assisting the ACES team to develop new machinery to allow the printing of active materials such as drugs, biopolymers and electronic conductors generating systems where electronics and cells can 'communicate'. This should ultimately feed into existing devices such as pacemakers and implantable insulin pumps, and future goals such as better nerve-driven artificial arms and electronic sight.

PhD student, James Vincent Scicolone, from New Jersey Institute of Technology spent 3 months in ACES from September, investigating with Dr Simon Moulton, the use of electrospaying and spray drying to form nanoparticles that contain drugs for controlled release.



Collaborative links were developed with Prof Paul Calvert (ARC Professional Linkage Fellow).

Invited International Presentations

In 2009, 39 invitations were received by ACES researchers to address international conferences.

January 2009

Dr Udo Bach participated in a podium discussion by Australian Consulate and DVC international (Monash) to Water and Energy Forum Conference called (Australia Week) in LA on 14 January.

Dr Udo Bach gave an invited talk to Nano fabrication group called (DNA – directed nano fabrication) on 21 January, at the Molecular Foundry (Lawrence Berkeley National Labs).

March 2009

Dr Udo Bach gave an invited Presentation on (Dye-Sensitized Solar cells – Towards tandem solar cells) to COPE researchers: Towards Tandem DSC's in Atlanta on 2 March.

Dr Scott McGovern attended the SPIE Smart Materials and Structures Conference, San Diego USA, March, where he gave an invited talk "Organic bionics" for **Professor Gordon Wallace**.

April 2009

Prof Gordon Wallace gave an invited lecture "Nanostructured Organic Electrodes" at the 60th Annual meeting of the International Society of Electrochemistry (ISE2009_Beijing).

Prof David Officer presented at the 3rd International Conference on the Industrialisation of DSC (DSC-IC 2009), Nara in Japan, 22-24 April. He invited talk was on "Porphyrin-sensitised Titanium Dioxide Solar Cells".

May 2009

Prof Maria Forsyth was invited to give a presentation on 'Coatings and Cathodic Protection - Corrosion mitigation in the Field' at the 17th Joint technical Meeting in Milan in May.

June 2009

Prof Maria Forsyth was an invited speaker at the 3rd Congress on Ionic Liquids (COIL-3), Cairns, June. Her talk was 'NMR Transport Measurements in Ionic liquids'.

Prof Doug MacFarlane gave the Chairman's Opening Remarks at the 3rd Congress on Ionic Liquids (COIL-3), Cairns, June.

Prof David Officer was invited to present at 'Nanophotonics Down Under 2009: Devices and Applications', held in Melbourne from 21 - 24 June. David's talk was "Towards Artificial Photosynthesis: Light Harvesting with Nanostructured Porphyrins".

Prof David Officer addressed the 3rd Congress on Ionic Liquids (COIL-3) at Cairns, Australia on "Organic Dye-sensitised Solar Cells: The Effect of Ionic Liquid Electrolytes".

Professor Gordon Wallace addressed the 3rd Congress on Ionic Liquids (COIL-3) at Cairns, Australia on "Ionic Liquids: The Elixir of Life for Organic Conducting Polymer Based Electrochemical Devices".

July 2009

Prof Maria Forsyth participated and chaired a session on Intergranular Corrosion at the Corrosion Chemistry in Pits, crevices and Cracks, Manchester College, Oxford 16- 20 July.

Prof Doug MacFarlane gave an invited talk "Plastic Crystal proton Conductors for Fuel Cells" at the Solid State Ionics 17 in Toronto July.

Prof Doug MacFarlane gave an invited talk "ionic liquids" on a Webinar at Cytec's Welland plant, Canada 6 July.

August 2009

Prof YiBing Cheng gave an invited talk at the 2nd Photonics and OptoElectronics Meetings, Wuhan, China 8-10 August.

Dr Jenny Pringle attended the 42nd IUPAC meeting in Glasgow, Scotland from 2-9 August, giving an oral presentation on "Synthesis of Conducting Polymers in Ionic Liquids for Photovoltaic Applications."

Dr Jun Chen gave an invited talk at the ISE Annual Conference in Beijing (17-22 August).

Dr Attila Mozer gave an invited address "Efficient photo-induced charge injection in Zn-Zn porphyrin dimer-sensitised TiO₂ solar cells: towards 3-dimensional light harvesting" at the SPIE conference in San Diego.

Prof Leone Spiccia attended and delivered an invited talk at the SPIE conference on Optics and Photonics, San Diego.

Dr Udo Bach participated to the eMRS - Symposium A (Dye-sensitized Solar Cells) in Strasbourg on 6 August.

Prof Gordon Wallace was an invited keynote speaker at the Royal Chemical Society 42nd IUPAC Congress: Chemistry Solutions 2-7 August, Glasgow, United Kingdom. The topic of Gordon's keynote address was "Nanostructured Organic Electrodes: the Impact on Medical Bionics" and the address was delivered by **Assoc Prof Stephen Ralph**.

September 2009

Prof Doug MacFarlane gave the plenary lecture at the Opening of the Centre for Molecular Systems Science at the University

of Kyushu, Global Centre of Excellence September 2009: "Ionic Liquids Applications in the Chemical- and Bio- Sciences".

Prof Graeme Clark gave the opening address for Virtual Conference organised by The Ear Foundation, Nottingham on 29 September.

Dr Michael Higgins gave an invited talk at the International Symposium on Functional Nanomaterials, on "Dynamic Polymer Interfaces for Controlling Protein and Cellular Interactions" in Ireland, September.

Prof YiBing Cheng gave an invited talk at the 3rd GCOE International Symposium: Catalysis as the basis for the innovation in materials science, Sapporo, Japan, 14-15 September.

Prof David Officer addressed the audience at the International Conference Stuttgart Nanodays'09, held 14-15 September on "Nanostructured Carbon Electrodes".

October 2009

Prof Maria Forsyth was an invited speaker, 216th ECS Meeting with Euro CVD 17 and SOFC-XI at the Centre of Electrochemical Surface Technology (CEST) in Vienna, 4 – 9 October. Her talk was on 'Insights into the nature of Ionic Liquid surface film formation on reactive metals'.

Dr Patrick Howlett presented his work on 'Novel Electro-materials and Electro-interphases: from Energy to Sustainable Infrastructure' at the 216th ECS Meeting with EuroCVD 17 and SOFC-XI: Vienna, Austria. Austria Centre Vienna, October 4 - 9.

Maria and Patrick were also Invited Panel Members at the Round Table: The Future of Ionic Liquids in Electrochemical Surface Technology, CEST, 9 Oct, Wiener Neustadt, Austria. (Ionic Liquids, Surface Interactions & Applications).

Prof Doug MacFarlane gave the Plenary Lecture "Polymerisation and Device Applications of Conducting Polymers in Ionic Liquids" at the International Symposium on Ionic Liquids and Polymers, Washington DC, in October.

Prof Doug MacFarlane gave an invited talk "Plastic Crystal proton Conductors for Fuel Cells" at the 1st Latin American Chemical Congress, Havana, in October.

Prof Doug MacFarlane presented an invited talk at the 3rd International Conference on Electroactive Polymers in Jaipur in October.

Prof Leon Kane-Maguire gave an invited presentation "Multifunctional Materials for Advanced Monitoring Systems" at the European Commission - Australian Scientists Workshop, Brussels, Belgium, 13 October.

Prof David Officer gave an invited seminar at the Korea-Australia International Collaboration Seminar at the Kangwon Fine Chemicals Centre, Kangwon, Korea on 27 October. His seminar was on "Porphyrin-sensitised Titanium Dioxide Solar Cells".

Prof David Officer gave his invited address "Light Harvesting with Nanostructured Porphyrins: Towards Artificial Photosynthesis" at the 104th National Korean Chemical Society Meeting, held at the Daejeon Convention Center, Daejeon, Korea, 29-30 October.

Prof Gordon Wallace gave his invited address "Organic Conductors for Regenerative Medical Bionics" at the 104th National Korean Chemical Society Meeting, held at the Daejeon Convention Center, Daejeon, Korea, 29-30 October.

November 2009

Prof Doug MacFarlane gave the Plenary Lecture "Ionic Liquids and Global Sustainability" at the International Symposium on Green and Sustainable Chemistry, Tottori, Japan, November.

Prof Doug MacFarlane gave the Plenary Lecture "Advanced Applications of Ionic Liquids in Chemical Processing, Electrochemical Devices and Biosciences" at the Regional Conference on Ionic Liquids, Kuala Lumpur November.

Prof YiBing Cheng gave an invited presentation on "Synthesis and Application of Submicron-sized Mesoporous TiO₂ Spheres for Dye Sensitized Solar Cells" at the International Symposium on Advanced Ceramics and Technology for Sustainable Energy Applications (ACTSEA-2009), Taipei, Taiwan, 1-4 November.

ACES National Linkages

ACES participates in a number of active national research collaborations, some of which are outlined below. During 2009, ACES produced 98 refereed publications, with 36 of these involving collaborators external to ACES.

ACES currently enjoys an important national linkage, with Professor Rose Amal's (Assoc. Director ARC Centre of Excellence for Functional Nanomaterials) group, 'Particles and Catalysis Research Group' at **University of NSW**, in the area of characterisation of metal oxide nanostructure for solar cells application, where two new projects were initiated in 2009. One-step flame-made TiO_2 particles have been investigated for use in dye-sensitised solar cells. A second study into the effect of rutile to anatase fraction on charge transport and recombination has been carried out. Investigations were also carried out into the application of aligned TiO_2 nanotubes for use in solar cells. To date a maximum efficiency of around 3% has been achieved. Initial studies into the use of WO_3 nanostructures for use dye-sensitised solar cells are underway.

Studies continued on the porphyrin-based organic solar cell collaboration between Prof Paul Dastoor, in the Centre for Organic Electronics (CoE) at the **University of Newcastle**, and Prof David Officer (ACES). Two visits were made to the CoE by post-doctoral researcher Dr Lynn Dennany to investigate the use of ruthenium porphyrins, developed in an ARC Discovery project, as sensitisers in polymer solar cells. Further work will continue in this area in 2010 following the promising results obtained.

ACES PhD student Benjamin Müller has been collaborating with Dr Joselito Quirino and Prof Pavel Nesterenko in the group of Prof Paul Haddad at the Australian Centre for Research on Separation Science, **University of Tasmania** to work on Capillary Zone Electrophoresis (CZE) and Open Tubular Capillary Electrochromatography (OT-CEC) of graphene oxide and chemically converted graphene. In 2009 Ben has made 2 week long visits to Tasmania. CZE allowed us to separate graphene oxide (GO) and

chemically converted graphene (CCG) dispersions depending on their sheet size and on their charge carried.

ACES/ISEM has collaborated and hosted numerous national visitors in 2009. As a result of the collaborations two papers are in preparation with: (i) Dr. Young-Hee Cho from the **University of Queensland** who visited ACES 12-13 November, and (ii) Dr. Alexey Glushenkov, from the **Australian National University** in Canberra who visited 22-24 July.

ACES has established a collaboration with Margaret Morris (**University of NSW**) and Terry O'Brien (**University of Melbourne**) to design and synthesise polymer micro- and nano-spheres for the delivery of the anti-epilepsy neuropeptide (NPY). The polymers prepared at ACES are to be implanted into animals at University of Melbourne.

The development of conducting spheres for drug delivery is a collaboration with Frank Caruso's group at the **University of Melbourne**. Frank's group have developed a layer-by-layer method where by oppositely charged polymers are sequentially deposited onto SiO_2 spheres templates, and ACES are



Ben Mueller (front) with his collaborators at University of Tasmania.

designing and assessing the introduction of conducting layers into this process. Dr Simon Moulton spent a week with Frank's group in 2009 as part of this collaboration.

Dr Michael Higgins (ACES) is collaborating with Prof. Hans Griesser, at the Ian Wark Research Institute, **University of South Australia**, on "Nanoscale dynamics and protein surface interactions of thermoresponsive polymer coatings". This collaboration has involved 3 visits to ACES; two by Hans and a visit by his PhD student Martin Cole, where they used the ACES AFM facilities for characterisation studies. A publication is currently in preparation.

The collaboration with Prof Alan Bond's group from **Monash University** strengthened with two visits to his laboratory by PhD student Mr Suriya Ounnunkad to work on Fourier Transformed AC Voltammetry, a new electrochemistry technique revolutionised by the Bond laboratory. Using the technique to study carbon nanotube composite nanostructured electrodes, interesting results obtained from the studies have lead to two publications soon to be submitted. Ongoing research from these initial studies is planned for 2010 and beyond.

Prof Doug Mac Farlane has collaborations with Dr Anita Hill **CSIRO Manufacturing and Materials Technology** and Dr Mike Horne and Dr Theo Rodopoulos from **CSIRO Minerals**.

In addition, every year ACES hosts numerous visitors - from international, national and enduser groups. For a complete list of visitors to ACES in 2009 see appendix 1.

Outreach 2009

In 2009 ACES was involved in many outreach activities, which are summarised below:

- (i) ACES in the media
- (ii) ACES community engagement activities
- (iii) ACES 'Hands-On'
- (iv) ACES public communications/presentations/competitions
- (v) ACES involvement in other community activities

(i) ACES in the Media

ACES formalised a targeted Communications Strategy and Media Relations Strategy aimed at increased awareness, understanding and support among various stakeholders and the community of the outcomes and benefits of the scientific research credentials of ACES. This included the creation of a Communications & Media Officer Position dedicated to these activities.

As a result, ACES featured more prominently in the media in 2009. There were a total of 101 media interest stories published (appendix 2); with 41 articles in print, 34 articles online/web, 16 radio interviews and 10 TV appearances.

As well as generating substantial interest in the media, new initiatives in the area of social media and networking were started in September, via the University of Wollongong's Research Office UOW Facebook and Twitter sites (to date UOW has 363 Facebook fans and 282 Twitter followers). Since September 12 stories about ACES/IPRI were posted on Facebook and 29 messages were tweeted concerning ACES/IPRI.

In addition, media demonstrations and community lab tours were held; and an events calendar developed for staff and

students across the nodes to keep them updated on training, education and other events among the group.

Several of those outreach activities are highlighted below.

21 January 2009

Story in the Diamond Valley Leader on how scientists are working with a team at ACES/IPRI to trial the use of "carbon nanotubes" to connect cochlear implants with the human brain.

27 January 2009

Follow-up Drive Time (ABC radio) report about a new research initiative, funded by a \$100 000 grant from the NSW Department of Science and Medical research, in which ACES/IPRI will collaborate with Korean nanotechnology researchers to develop new materials for batteries. This research will have a major impact on devices such as mobile phones and digital cameras.

10 March 2009

The *Illawarra Mercury* followed up on the opening of the Australian Institute for Innovative Materials, including an overview of research at IPRI and profiles of two PhD students, Brianna Thompson and Peter Sherrell, in its story "Minister launches cutting-edge campus at Wollongong". *ABC Illawarra Radio* provided a report on the opening during its Morning Show with Steve Parsons, including airing an interview with Kim Carr, Minister for Innovation, Industry, Science and Research. "*Minister opens AIIM building and praises collaborative partnerships*", was written by Nick Hartgerink from the UOW media unit.

18 March 2009

The Korean *DaeJeonToday* Newspaper ran a news story on Prof Gordon Wallace's visit to Korea in March, during which he attended

a ceremony for the "World Class University" project where he was presented with a letter of appointment.

18 March 2009

Professor Doug MacFarlane (ACES/Monash) was interviewed about the development in fuel cell technology using Gore-Tex that he and researchers at Monash University have been exploring. The interview appeared in the March 2009 edition of *Mobile Tex*. *Mobile Tex*, which features news and information on the global transport textiles industry, including the automotive, aerospace, rail and marine sectors.

6 April 2009

A radio interview with Prof Graeme Clark, first broadcast on ABC radio's Conversation Hour program, was repeated on Monday 6 April.

9 April 2009

A *Perspectives* article published in *Science* on 9 April, entitled "Electrode-Cellular Interface" was contributed by Prof Gordon Wallace; Prof Graeme Clark and Dr Simon Moulton. "A 'stacked' bionic materials store promises a medical revolution", was written by Bernie Goldie, UOW media unit.

15, 18 April 2009

After a landmark case, which saw a grandmother being posthumously awarded damages in an asbestos case, there has been discussion in the media about the possible dangers of nanotechnology. Prof Gordon Wallace was asked to comment on the new call for stricter regulations on nanotechnology. Gordon said he supported discussion over stricter regulations on the importing, manufacturing, supplying and selling nanotechnology materials, as well as labels on all products that contain nanoparticles, called by the ACTU. He also would welcome further study into

the potential health risks associated with nanotechnology, and that staff doing research in the field use the same safety standards that apply to all new chemistry research. The story was reported in the *Illawarra Mercury* by journalist Courtney Trenwith 'UOW professor welcomes nanotech study'.

23 April 2009

The *Catalyst* Program on ABC TV featured a story on solar prints which featured the research being undertaken by Dr Udo Bach, who is a Research Fellow with ACES at Monash University. The team of researchers including Dr Udo Bach and Prof Yi-Bing Cheng, have developed a solar cell which is thin, flexible and can be produced on a mass-scale using the same technology used to print polymer banknotes.

29 April 2009

The Higher Education liftout in **The Australian** newspaper profiled ACES Executive Director Professor Gordon Wallace talking about his work in the fields of bionics and polymers. The article titled "Polymers Rescue Bionic Man From Fantasy World" by Jane McCredie also featured a photo of Gordon outside the AllM Facility in Wollongong.

30 May 2009

"Wollongong uni nerve centre for spinal repairs" - Angela Thompson's story in the *Illawarra Mercury* describes how researchers at ACES/IPRI have claimed a seat at the cutting edge of medical bionics, taking a 'giant step' towards repairing spinal injuries.

1 August 2009

The Illawarra Mercury ran a special 16-page feature celebrating the first year of operation of the Innovation Campus, administrative home for ACES. The feature included messages of support from

UOW Vice-Chancellor Professor Gerard Sutton and Minister for the Illawarra David Campbell as well as articles on the cutting edge research being undertaken at ACES/IPRI including the partnership with the Wollongong Science Centre and the new iDome exhibition.

11 August 2009

The IQ Education Supplement in the *Illawarra Mercury* featured an article previewing Prof Graeme Clark's public lecture. The article included an interview with Prof Clark who spoke highly about the research being currently undertaken at ACES and the importance of initiatives such as the 'Bionics for 2020' High School Competition, which provide vital encouragement for young minds. The lecture was also promoted via ABC Illawarra Radio, i98FM and Wave FM radio and the *Lake Times* Newspaper.

The *Illawarra Mercury* also featured an article on the 'Bionics' Competition, including an interview with UOW Dean of Science and ACES Chief Investigator Prof Will Price who said he was delighted with the quality of the entries received from schools, including a number from outside the local area.

10 September 2009

Irish Times, ran a news story on "A Robot Fish Called WANDA", a collaborative research project between ACES and DCU.

14 September 2009

Story in *Illawarra Mercury* titled "Two researchers within ACES have been named as recipients of ARC (Australian Research Council) Future Fellowships".

1 October 2009

On-line and in *The Illawarra Mercury*, an article on visiting Professorial Linkage Fellow Prof Paul Calvert, a world-renowned materials scientist from the University

of Massachusetts Dartmouth in the US, currently carrying out collaborative research at ACES/IPRI.

27 October 2009

The University of Wollongong's Community Connections Feature which appeared in the *Illawarra Mercury* and *Wollongong Advertiser* featured an article on IPRI community lab tours and a profile on ACES/IPRI PhD student Cameron Ferris.

8 December 2009

ACES/IPRI PhD student, Matthew Griffith, has been named as one of 20 postgraduate students in Australia to receive a \$63,500 Prime Minister's Australia Asia Endeavour Award. Story in *Illawarra Mercury*.

21 December 2009

Prof Gordon Wallace interviewed about current research in the area of medical bionics, including comments on the bionic eye design for the future.

(ii) ACES Community Engagement Activities

March 2009

ACES/IPRI moved into their new facility at the Innovation Campus, which was opened officially in March by Kim Carr the Federal Minister for Innovation, Industry, Science and Research. Local dignitaries and University members were given the opportunity to participate in a 45 minute tour of the laboratories. Since the opening, the Illawarra community have shown a great interest in finding out 'what happens in those buildings on the Innovation Campus'. Consequently, IPRI has opened its doors to the public to showcase its work.

29 March 2009

Assoc. Prof. Robert Kapsa (ACES) presented his work on 'Development of Advanced Polymer Systems for Regenerative Bionics Applications: *Molecular Chemistry Meets the Molecular*

Biology of the Cell: Building Regenerative Systems for Muscle and Nerve' at the Bernard O'Brien Institute for Microsurgery, Melbourne.

April 2009

Two upcoming artists in residence within the School of Art & Design, Faculty of Creative Arts at UOW, Janet Burchill and Jenifer McCamley, along with Jacky Redgate Visual Arts Coordinator and Derek Kreckler Senior Lecturer, were hosted at ACES for an afternoon. They were interested in the aesthetics of the electromaterial research, especially energy conversion and electronic textiles. They were also shown the iDome interactive display in the Science centre.

5 April 2009

Assoc Prof Robert Kapsa (ACES) gave the Lion's Australia: Step Ahead Australia Spinal Cord Fellowship Presentation at the Melbourne Exhibition Centre. His talk, "Spinal Cord Injury: New Ways of Treating an Old Problem," was keenly listened to by the 250 seniors of the Lions Club executive and a number of individuals affected by spinal cord injury.

29 April 2009

The Australasian Gene Therapy Society Conference was held with around 450 registrants. ACES sponsored the keynote speaker Prof Jeffrey Chamberlain to talk about his work on 'Adeno-Associated Virus mediated gene transfer as a therapy for Duchenne Muscular Dystrophy'. Assoc Prof Rob Kapsa (ACES) presented a talk and two posters.

25 May 2009

ACES played a large role in the Illawarra Innovation Showcase which is part of the National Innovation Festival, as follows:

- ▶ Community Tours of the IPRI/ALIM Building
- ▶ Launch of the "Bionics for 2020" high school competition by Prof. Will Price
- ▶ Presence at the Illawarra Innovation Showcase Expo
- ▶ Involvement in the Seminar Presentation Series (Prof. Gordon Wallace spoke on organic bionics)



ACES/IPRI moved into their new facility at the Innovation Campus, which was opened officially in March by Kim Carr the Federal Minister for Innovation, Industry, Science and Research.

- Innovation Week Lecture, by Paul Bourke, was co-sponsored by ACES. Paul talked about visualisation techniques for science, including the iDome.

The involvement of ACES in the showcase was reported on WIN TV news, ABC Illawarra Radio, the Illawarra Mercury article on "*Science Centre drawcards just about out of this world*" and the Illawarra Mercury and the University of Wollongong media unit article "*iC opens its doors for Innovation Week*".

7 July 2009

ACES hosted 8 undergraduate students undertaking the Advanced Science program at the University of Western Sydney. They were given an overview of ACES activities followed by a half day laboratory tour. After the tour the students were effusive in their thanks and Dr Robyn Crumbie, the subject coordinator, wrote: "I personally found the visit very worthwhile and impressive".

29 July 2009

Significant inroads into the development of the latest materials for "smarter" medical bionic devices were announced at a special demonstration held at ACES. The *Illawarra*

Mercury and *WIN Television* reported on and aired the demonstration, and Prof Gordon Wallace was also interviewed on ABC Radio.

In addition to the demonstration, a 30 minute lab tour for local businesses and science teachers from local high schools was held. Teachers also previewed the new animated DVD developed by the Centre called "Nanostructures for Electromaterial". This educational outreach DVD has since been distributed to high schools throughout the country and placed on the ACES, IPRI and UOW websites.

19 October 2009

A focus group was held in Wollongong on the subject of bionics. This was a collaborative activity between the Department of Innovation, Industry, Science and Research and ACES. The focus group was one in a series, where the aim is to gain a better understanding of the publics' knowledge, concerns and aspirations towards biotechnology and nanotechnology (in particular, applications of these technologies). Prof Susan Dodds facilitated the discussion. Prof Gordon Wallace

attended the focus group as an expert in bionics, to engage in the discussion and answer any questions.

December 2009

On 8 December, ACES PhD student Cameron Ferris presented a lecture on his journey towards his PhD for 30 Careers Advisors from the Illawarra. His talk, "Cells, gels and nanotechnology" highlighted Cameron's experiences of the nanotechnology undergraduate degree at UOW, the research he is undertaking for his PhD, and a general background about the scope of the research being done here at ACES.

ACES also hosted 20 Careers Advisors from High Schools in the Sutherland Shire on 10 December. Cameron Ferris again gave a short presentation. Each group (4) was then aligned with other ACES PhD students and given a tour of the laboratories, where the students showcased their research. Feedback was very positive.

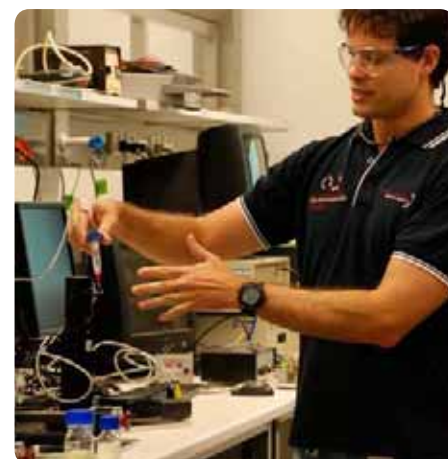
On December 17, IPRI hosted a community tour of the laboratories for interested members of the public.



Prof Will Price launching "Bionics for 2020" high school competition



ACES hosted 8 undergraduate students undertaking the Advanced Science program at the University of Western Sydney



(ii) ACES Hands-On

ACES/St Vincents researchers delivered a Masterclass for the University of Melbourne International Advanced Medical Science class. This class was made up of 35 second year medical students from Universitas Indonesia. The lecture covered potential therapies for the most lethal progressive childhood disorder, Duchenne Muscular Dystrophy, which affects 1 in 3,500 new-born male children. The 35 students, along with a further ten, second year medical students from the University of Melbourne were also provided with a Laboratory Skills workshop, given by ACES/St Vincents researchers, that took place during the periods, 20-31 July and 10-21 August. During the laboratory workshop the students received training in basic biological laboratory skills required for their Advanced Medical Science year.

A significant challenge for the Centre is to recruit top quality postgraduate candidates. As a first step in addressing this challenge, ACES gave two keen high school students interested in cutting edge science and research the opportunity to have hands-on experience.

Year 12 Illawarra Grammer School (TIGS) student Vaughan Patterson gave up part of his school holidays to get two days hands-on experience with nanomaterials. He produced a magnetic liquid called 'ferrofluid', a material originally laboriously produced in the 1960's by NASA, but the ferrofluid produced by Vaughan, using clever chemistry makes these nanoparticles within 2-3 hours. When put near a magnet, the ferrofluid shows amazing transitions, such as forming spikes, as pictured.

(iii) Public Communications/ Presentations/ Competitions

12 May 2009

On 12 May, *Future Materials* arranged a Sydney Executive series forum entitled "Enabling Technologies – Intelligent Materials" at which Prof Gordon Wallace (ACES) and Phil Aitchison (CAP-XX) were guest speakers, showcasing the success of their organisations utilising novel technologies.

22 May 2009

Prof Graeme Clark delivered the The Libby Harricks Memorial Oration 2009 in Sydney, giving an address entitled "The Bionic Ear: from an idea to reality". The aim of the Libby Harricks Memorial Oration is to create greater public awareness of hearing problems and to highlight the work done on behalf of the Deaf and Hearing Impaired community by voluntary groups throughout Australia.



Vaughan Patterson (centre) with a magnetic liquid he produced called 'ferrofluid' (inset)



18-19 June 2009

Prof Gordon Wallace presented a lecture entitled "Taking the speed humps out of the biofunctional materials highway" at the 3rd Annual 'Excitable Cells' Meeting, at the Melbourne Museum. The meeting linked associates from neuroscience, laboratory to bedside, as well as engaging other disciplines such as engineering, biochemistry and biomaterials science. Dr Michael Higgins and Dr Simon Moulton also gave talks about their research carried out in ACES.

9 July 2009

ACES Communications Officer Leanne Crouch attended the National Nanotechnology Communications Meeting in Canberra, which was hosted by Department of Innovation, Industry, Science and Research. The meeting involved presentations by various research and industry representatives as well as discussions over a national framework for communicating nanotechnology in the media and within the broader community. Some of the key outcomes of the meeting included an agreement to undertake forums to educate the media on the science of nanotechnology, as well as forums to educate key scientists on how to work

with the media; the provision of a weekly news summary on nanotechnology issues to participants who request it (ACES has subscribed to this service) and co-operate with other agencies on joint community engagement activities.

28 July 2009

Prof David Officer (ACES) participated in the Green Jobs Illawarra Renewable Energy Forum at Rydges Hotel in Wollongong, where he presented an invited lecture on solar energy entitled "Renewable Energy: Powering Australia and the Planet".

19 August 2009

A growing partnership between IPRI and the Wollongong Science Centre & Planetarium is providing a number of opportunities to engage communities and schools in research being undertaken on their doorstep.

A new exhibition was launched during National Science Week. The 'iDome' allows people to get a 180-degree view inside the IPRI laboratories, including a guided tour of the labs by senior researcher Dr Simon Moulton and demonstrations and animations of the research being carried out. There are plans to install a live video feed into

the exhibition so that people can watch scientists' conducting this amazing research as it happens.

The partnership also led the sponsorship of a free Public Lecture, by Bionic Ear pioneer and ACES Chief Investigator, Professor Graeme Clark. Graeme's lecture, titled "Big thinking, small technologies", took the audience through some of the implications of nano-bio-technology, including how it may help with spinal cord repair, drug delivery and the development of a visual prosthesis – the bionic eye - and his collaborative research with IPRI and the University of Wollongong.

Sponsored by ACES, UOW's Faculty of Science, Wollongong Science Centre and supported by RACI, the lecture was attended by more than 120 people including community members, local high school students and science teachers, University staff and students and recipients of cochlear implants and their relatives and resulted in positive feedback. The event also gained widespread media publicity in the region. In particular, WIN TV News reported on the lecture, including interviews with Prof Clark and the mother of four-month old Felix Williams, who was due to receive bilateral cochlear implants within the next month.



(L to R): Dr Simon Moulton, Professor Mark Cook, Professor Gordon Wallace and Dr Michael Higgins at 'excitable cells' workshop in Melbourne.



Prof Graeme Clark with Joanne Williams and four-month old Felix Williams, who is due to receive bilateral cochlear implants in September 2009.

20 August 2009

Prof Graeme Clark was invited to attend a parliamentary symposium, hosted by Dr Brendan Nelson, in Canberra, on infant and early childhood deafness.

27 August 2009

Dr Simon Moulton (ACES) presented a lecture, "The role of Nanotechnology in Bionic Research", to the Southern Highlands & Tablelands Regional Group of Engineers Australia- Sydney Division.

7 September 2009

Dr Simon Moulton described the ACES bionics research in a lecture, "Latest Research in Medical Bionics" to the audience of the University of the Third Age (U3A). U3A consists of retired people, who appreciate the stimulation and enjoyment of learning together.

22 September 2009

Prof Graeme Clark gave a lecture on the "Issues in Nanotechnology", to 4th year students at La Trobe University.

2 October 2009

At the October Wollongong Innovation Campus Networking Function, Prof David Officer gave a short presentation on the

current and future Australian Institute of Innovative Materials research facilities and associated ACES research program.

3 November 2009

Maria Forsyth (ACES) was the key note speaker at Deakin University's Inaugural ITRI annual symposium in Geelong. Her talk was about "Novel Electro-materials and Electro-interphases: from Energy to Sustainable Infrastructure".

Public Lecture Series: Campus to Corporation to Customer Lecture Series (C2C2C)

ACES initiated a lecture series that ran throughout 2009 entitled 'Campus to Corporation to Customer' (C2C2C). This free series of lectures featured Australia's leading venture capitalists, financial and legal minds and entrepreneurs providing personal insights and experiences into the opportunities, risks and rewards associated with commercialising innovation. This series opened the minds of ACES researchers to the highs and lows when striving for commercialisation of their research.

The inaugural lecture on 25 June featured Roger Buckeridge from Allen & Buckeridge. The lecture focused on the challenges associated with migrating innovation into the marketplace; the pitfalls, the risks and rewards, and the temperament required to minimise the risk of failure and maximise the potential for success.

On 4 September, Lindley Edwards, CEO Venture Bank, gave the second lecture. She is a specialist adviser in merger, acquisition, divestments, fund raising, strategic consulting and licensing for growth public and private companies.

The third presentation on 1 October was by intellectual law specialist Noric Dilanchian, the Managing Partner of Dilanchian Lawyers & Consultants in Sydney. Noric talked about innovation and the timing of when it was best to engage 'the team' to plan the way forward.

Victor Bivell, Editor and Publisher with Eco Investor Magazine, provided an insightful presentation on 11 November titled 'The Whole of Commercialisation Approach to Innovation'. In the 15 years Victor spent as a venture capital editor, one of the sayings about commercialisation he came across that is pertinent to commercialisation is that "what ever you may think it is going to take, double the money and triple the time".



Lindley Edwards, CEO Venture Bank



Intellectual law specialist Noric Dilanchian



Victor Bivell, Editor and Publisher with Eco Investor Magazine

(iv) ACES involved in community engagements

Funds for Heart Foundation

ACES staff took out the 'iC Treadmill Challenge' 2009, an Innovation Campus Health initiative in conjunction with the National Heart Foundation's National Heart Week. Members of the team decked out in red, ran their way to victory during the five hour Challenge and raised funds for the Heart Foundation.

Jeans for Genes

The team at ACES donned their jeans and donated money for the annual Jeans for Genes Day on 17 August, raising money for the Children's Medical Research Institute and to support research by scientists

into areas like cancer research, cell transformation, cell signalling, embryology and gene therapy.

Team supports 'Sizzle for a Cause'

ACES staff and students supported the 'SIZZLE FOR A CAUSE' fundraising event held at the Innovation Campus in Wollongong on 25 September. The team helped to help raise money and awareness for the Prostate Cancer Foundation.

U-MO-W team show support for men's health

Students and researchers at ACES/IPRI raised \$570 for Movember's men's health partners – The Prostate Cancer Foundation of Australia and Beyond Blue – the national depression initiative.



ACES staff taking the 'iC Treadmill Challenge' 2009

Prizes and Awards

March 2009

1. In March, Prof Graeme Clark (ACES), presented the inaugural **Bill Wheeler Scholarship to Tom Higgins**, who was undertaking the final honours year of a degree in nanotechnology. The scholarship supports research on any aspect of nanobionics carried out by Honours degree students in science or engineering at the University of Wollongong.

Bill Wheeler was a very community-minded person who devoted time to the Rotary Club of Kiama and to disadvantaged children. He took a special interest in the further development of the cochlea implant for deafness and the new research at ACES on spinal cord repair.

2. **Prof Gordon Wallace** was honoured with the Lifetime Achievement Award for 2009 by the International Society for Optical Engineering. Announcement of the award was made at the annual SPIE Smart Structures and Materials/Non-destructive Evaluation Symposium, held in San Diego, USA.

3. **Prof Graeme Clark was presented an Honorary Doctorate by Zaragoza University.** The University of Zaragoza

is the only public university in the historic region of Aragón, Spain. Founded in 1542, it is one of the oldest universities in the world with over 40,000 students in its 22 faculties and ranks among the top public universities in Europe.

4. **Scots College names building after Prof Clark.** The Graeme Clarke Centre (Science, PDHPE and Mathematics) at Scots College has been named after Prof Graeme Clark (ACES). Scots College is an independent day and boarding school for boys, located in Bellevue Hill, Sydney.

27 April 2009

Shulei Chou, a PhD student in ACES, has been awarded a highly-competitive Electrochemical Society (ECS) summer fellowship to study at Canada's Dalhousie University. He will receive a US\$5,000 award and will spend from June with his summer fellowship host, Prof Jeff Dahn. ECS is a very large society covering many disciplines in chemistry, materials, engineering and solid state science. ECS has a world-wide membership, including most universities in North America, many

from Asia, Europe, South America and Australia. The ECS awards are given to only five candidates each year.

May 2009

1. **Dr Joselito Razal** (ACES), received an ARC Early Career Researchers Award, and was one of only six Australian Postdoctoral Fellowship holders in the country selected by the Australian Research Council to participate in a special event held recently at Canberra's *Science at the Shine Dome*. This is an annual three-day event held in Canberra (May 6-8) by the Australian Academy of Science. It provides a unique opportunity for young scientists to hear about the research findings of colleagues across a wide range of disciplines and to mix with Academy Fellows and symposium speakers, as well as their peers and participate in career development workshops.

Joe's APD for 2009 -2011 (DP DP0987503, \$235.8k) was on **Wet-Spinning Novel Multi-Functional Bio-Synthetic Platforms**. The project will deliver new advanced materials for novel biomedical devices such as nanostructured electrodes and tunable drug delivery



Prof Gordon Wallace (left) and Prof Graeme Clark, pictured with Tom Higgins the inaugural Bill Wheeler Scholarship recipient.



Summer Fellowship Award winner Shulei Chou (foreground) pictured with his PhD supervisors (from left) Prof Hua Kun Liu, Prof Shi Xue Dou and Dr Jiazhaio Wang.

systems. It will also develop a very versatile and low-cost technology that is well-suited for overcoming some of the current limitations in exploiting nanomaterials in nanoscience and biomedical industries.

2. UOW Cares Program won the category of Outreach and Community Relations category in the 2008 Association of Commonwealth Universities PR, Marketing and Communications Awards, 15 May. ACES communications and media officer, **Leanne Crouch**, was recognised for her contribution and passion for this novel program.

11 June 2009

Congratulations to **Prof Gordon Wallace and Geoff Spinks** (ACES) who were part of the winning team in this year's annual Trailblazer competition organised by the University of Wollongong. This competition rewards innovative ideas and early-stage research which have the potential to benefit the community, industry or business.

Along with Dr Bridget Munro and Prof Julie Steele from Health and Behavioural Sciences, they won the open section for their project titled "Controlling lymphoedema in an intelligent fashion – lymphoedema

support device for breast cancer patients". Lymphoedema is a substantial problem suffered post-operatively by breast cancer patients. Insufficient lymph flow can lead to swelling of the arm, disfigurement, pain and reduced function. The UOW researchers devised a wearable sleeve that can provide enhanced lymph flow.

Congratulations also goes to ACES researcher **Dr Grant Mathieson** (ACES) who was named runner up in the same category for his project "The Flexalex Cistern." **Dr Philip Whitten** (ACES) was also selected as a finalist in the competition for his entry titled "Novel hydrogel production".

19 June 2009

ACES staff recognised at the University of Wollongong's Staff Awards for Excellence

Research Excellence for Emerging Researcher Award: Recipient **Dr Simon Moulton**. This Award is in recognition of Simon's strong research track record, both nationally and internationally, as well as his leadership role in the Bionics Program within ACES. Simon is also highly respected

both for his ability to grasp challenging multidisciplinary issues, serving as an excellent mentor for younger researchers.

Research Excellence for Senior Researchers Award : Highly Commended **Prof Geoffrey Spinks**. Geoff is one of Australia's pre-eminent materials engineers and has made exceptional research contributions to materials science. Geoff has been the driving force in ACES widely acclaimed actuator (or "artificial muscle") research, which is being successfully applied in areas such as the Cochlear bionic ear implant, an electronic Braille screen, rehabilitation garments and robotics.

Vice Chancellor's Award for Excellence in Community Engagement Highly commended was 'The Welcome to Wollongong Team' of which ACES communications and media officer **Leanne Crouch** was a member. The team were recognised for facilitating better interactions and relationships between international students and the Illawarra Community. Activities conducted as part of the Welcome to Wollongong initiative included a formal civic festival, a mini



Dr Joselito Razal (centre) is pictured at the *Science at the Shine Dome* 2009 with the President of the Australian Academy of Science, Prof Kurt Lambeck, and the CEO of the Australian Research Council, Prof Margaret Sheil.



Pictured at the Trailblazer awards announcement with Professor Judy Raper (Deputy Vice-Chancellor of Research) are the winners.

international festival as well as developing and maintaining a website www.w2w.uow.edu.au.

8 July 2009

Congratulations to **Javad Foroughi**, a PhD student in ACES, who was announced as one of only three young scientists selected to represent Australia at the Asia Nanotech Camp (ANC 2009) held in Taiwan from 28 September to 12 October. Initiated by the Asia Nano Forum, the Asia Nanotech Camps foster young nanotechnology leaders in Asia, and provide a platform for young researchers to communicate and learn from each other.

Congratulations also go to ACES PhD student, **Dillip Kumar Panda**, who was selected to attend the "Chemistry and Physics of Materials for Energetics. This announcement allows Dillip to attend A European School in Materials Science" at the University of Milano-Bicocca in Milano, Italy from 14-19 September. This school will be focused on renewable sources and new materials.

13 July 2009

Success for ACES researcher **Dr Anita Quigley**, who has received the highest recognition at the annual "Research Week" activity hosted by St Vincent's Hospital, Melbourne, which showcases activities occurring within the SVHM Campus.

Anita was awarded the Senior Investigator Award in the Scientific Research Category and her abstract, describing the work recently published in *Advanced Materials* on electrical neurostimulation: "Hybrid Biodegradable-Conductive Polymer Platforms for Stimulation of Neural Growth", was selected as the 'Outstanding Abstract' by a panel of senior scientists. Congratulations to Anita and her co-workers of this work from ACES, Joe Razal, Brianna Thompson, Simon Moulton, Magda Kita and Lizzie Kennedy.

15 July 2009

A team involving researchers from ACES has had its paper awarded the Best Conference Paper Prize at the 6th International conference on Informatics in Control, Automation and Robotics held in Milan, Italy. The paper beat out 129 papers to win the title. Congratulations to all those

involved. In addition to being published in the fully refereed conference proceedings, the paper titled 'FROM BENDING TO LINEAR MOVEMENT: A Linear Actuation Mechanism Based on Conducting Polymer Actuators', authored by **Elise Burriss, Gursel Alici, Geoff Spinks, and Scott McGovern**, will appear in a selected papers book to be published by Springer-Verlag.

8 September 2009

Prof Graeme Clark was awarded the Otto Schmitt Award for exceptional contributions to advancements in medical and biological engineering at the opening session of the World Congress on Medical Physics and Biomedical Engineering in Munich, Germany. The award, regarded as one of the world's major scientific prizes, is made every three years by the International Federation for Medical and Biological Engineering which represents research organisations from more than 50 countries.

The award was presented to Prof Clark at the opening session of the World Congress. In his acceptance speech 'The Multi-channel Cochlear Implant- Past, Present and Future', Prof Clark highlighted how the success of the bionic



UOW Vice-Chancellor Gerard Sutton with Research Excellence for Emerging Researcher Award recipient Dr Simon Moulton



UOW Vice-Chancellor Gerard Sutton with Research Excellence for Senior Researchers Award (Highly Commended) recipient Prof Geoffrey Spinks

ear resulted from multi-institutional and wide-ranging interdisciplinary research – in neurophysiology, neurobiology, biophysics, bioengineering, electrical engineering, surgery, psychophysics, speech science, and audiology. He believes the trinity of early diagnosis, hearing aids or cochlear implants, and auditory verbal education will help many more children to achieve their true potential.

September 2009

Professor Maria Forsyth (ACES) received a Vice-Chancellor's Award for Postgraduate Supervision 2009 Commendation from Monash University. The award recognises staff who have demonstrated not only commitment to teaching or research student supervision, but, also innovative and exciting approaches that serve as a model for how research and education can be brought together.

October 2009

A discovery grant (DP 1092610 \$240.5k, APD) was awarded to Dr Orawan Winther-Jensen (ACES) for funding 2010-2012. Her work will centre on **photo-enhanced water oxidation using novel structures and conjugated polymers**. The proposed solar water splitting cell will facilitate an efficient, low-cost and renewable production of hydrogen. Hydrogen is considered to be the ultimate fuel since only water is produced as a product of combustion.

26 November 2009

Matthew Griffith, a PhD student in ACES/IPRI was named as one of 20 postgraduate students in Australia to receive a \$63,500 Australia Asia Endeavour Award. This prestigious Prime Minister's award provides scholarships for the "best and brightest" university students from Australia and Asia to undertake international research in China, India, Indonesia, Japan, Malaysia, Singapore, Republic of Korea, Taiwan, Thailand, or

Vietnam. It is hoped that the awards will build a new generation of leaders with strong ties to Australia and to our region.

Matt will be using the opportunity to develop his research in nanotechnology applied in solar energy at IPRI at his host university in Japan, ShinShu University.

Recipient of an Australia Asia Endeavour Award, Matthew Griffith (centre), is pictured with some of the colleagues from ShinShu University in Japan who will host him so he can develop his research further.

December 2009

To cap off a great year, ACES/IPRI Honors student, **Tom Higgins**, who was this year awarded the inaugural Bill Wheeler Scholarship to support research on nanobionics, was awarded the University of Wollongong University Medal. The medal is awarded for achieving the best academic record in Science in 2009.



Dr Chyrisse Heine, Prof Graeme Clark, Rebecca French, and Dr Tony Paolini were delighted to hear of Prof. Clarke's award.



Matthew Griffith received a \$63,500 Australia Asia Endeavour Award



Tom Higgins, the inaugural Bill Wheeler scholarship holder, was awarded the Wollongong University Medal for achieving the best academic record in Science in 2009.

Industry/ End-User Liasion

Key Achievements in 2009

- ▶ Development of the ACES Strategic Plan
- ▶ Establishment of a Director of Commercial Development position
- ▶ Development of a suite of ACES technology brochures
- ▶ Recruitment of a new Chief Operating Officer
- ▶ Creation of a Communications Officer position
- ▶ Redevelopment of the ACES website
- ▶ Development of standard IP management contracts and promotions at UOW for roll-out to other ACES partners in 2010.
- ▶ Funding for the AIIM-PD Facility at UOW.
- ▶ Extended funding for the ANFFL facility at UOW.

ACES Strategic Plan

In mid-2009, a consultant (Perceptic Pty Ltd) was engaged to develop a detailed 3 to 5 year Strategic Plan for ACES, concentrating on fundamental research, commercial research, intellectual property development and management, and commercialisation directions. A plan has been provided for consideration.

The key recommendations of the Strategic Plan will be evaluated by the ACES Executive Committee in early 2010 and

recommendations approved by the Centre Executive will be implemented in 2011.

It is anticipated that implementation will commence with the participation of they key service provider within Perceptic, Mr Chris Gilbey, the Director of Commercial Research and a new role of Business Development Manager.

Establishment of the Director of Commercial Development

In early 2009, two attempts were made to identify a suitable Director of Commercial Development, with advertisements placed in commercial media. Only one applicant was found to have the suitable skills, experience and cultural fit, but unfortunately, pulled out of the process after they had been offered the position. It was then decided that full-time employment of the Director of Commercial Development would be unwise in 2009, given that the Strategic Plan was being developed. It is anticipated that the position will be re-advertised in 2010 so that the key recommendations of the Strategic Plan can be implemented. In addition, NSW State Government funding is currently being sought through the NSW Science Leveraging Fund to support this position.

In the interim, UOW has seconded its Director of Commercial Research/ Executive Officer of Research Development, Dr Troy Coyle, to the role. Key outcomes to date from this secondment include:

- ▶ development of a suite of one-page technology promotion brochures
- ▶ input to the development of the Strategic Plan
- ▶ Development of the IPRI Patent and Patent Application Portfolio, which will be rolled out to other parties in 2010
- ▶ Development of IP management processes and contracts for Visiting Fellows, Visiting Students and Collaborators, which can be rolled out to other parties in 2010
- ▶ Development of standard templates for ACES confidentiality agreements (particularly useful for students involved in ACES presentations) and commercial research subcontracting (to allow UOW to be the lead in negotiations with industry and then subcontract the ACES parties). These documents have been circulated to the other parties and are currently being negotiated. As ACES is not its own entity, all members have to sign individual agreements, so acceptance of a template will speed this process up.
- ▶ Negotiation of two IP licences (still in process), three Collaboration Agreements, five Confidentiality Agreements, one ARC Linkage Agreement and five Fellow Agreements.

Development of a suite of ACES technology brochures

Recognising that there were a range of technologies evolving that require commercial investment and proof-of-concept funding, technology fliers have been developed for the following technologies:

- ▶ Graphene
- ▶ Self- Powered Sensing and Delivery Devices
- ▶ Novel Nano-Carbon Electrodes
- ▶ Printing of Functional Electromaterials
- ▶ Fabrication of Novel Nano-Materials

This initial suite will be built upon in 2010 and already drafts exist for Precious Metal Recovery, Batteries and Solar Cells.

Recruitment of a new Chief Operating Officer

In November 2009, the ACES Chief Operating Officer, Dr Chee Too, retired. Dr Toni Campbell has been appointed as his replacement in this role. Toni has a PhD in Chemistry (2000) from IPRI at the University of Wollongong and has worked as a research fellow in ACES/IPRI since 2001. As Toni progressed through her post doctoral years she participated in developing projects with collaborators as well as designing and completing or supervising the experimental work. A significant number of the projects have involved participation with external collaborators, both national and international.

The focus of her time within IPRI was not restricted to research. For the past 6-7 years she had a principal coordination role in relation to core communications within IPRI and ACES. Toni was the Technical Director of Communications within ACES and advised the Communications Officer on any technical aspects of the research that needed to be presented in the public arena.

Development of the Communications Officer position

The Communications Officer position was developed in January 2009 with the core aim of maintaining communication strategies for ACES in order to raise the profile of the Centre and showcase the ground-breaking research being undertaken. The role includes communicating with end-users and other target audiences, developing promotional material, maintaining the ACES website and quarterly e-newsletter and generating media opportunities.

The ACES Communication Strategy 2009-2012 was developed and implemented mid-year, identifying End-Users as one of five target audience groups along with objectives, strategies and communications tools designed to keep end-users informed, updated and engaged, as well as attract potential partners for collaborative activities and commercial opportunities that will benefit the Centre. Tools included face-to-face meetings, website, brochures, fliers,

newsletters, invitations to presentations and key Centre events and tours of the laboratories. To make it easier for members of ACES, a data collection sheet was developed and distributed.

Feedback on the format and content of the newsletter was sought from the ACES End-Users Committee. It was clear there needed to be a change made to the format, content and distribution of the e-newsletter, including focusing on a particular theme for each edition; simplifying the email version of the newsletter into key points and links to the website, and growing the distribution list.

The ACES Media Strategy implemented during the year resulted in substantial media attention. This included articles in international newspapers, national television reports including the Catalyst Program, Channel 9 National News and SBS National News, national radio segments and website mentions.

In addition, the Communications Office was appointed to the ACES Education & Communications Committee, which initiated several outreach activities during 2009 including targeted communications and visits planned for regional high schools, a new "Bionics for 2020" Competition for high school students, involvement in National Science Week and the National Innovation Showcase and the launch of an interactive exhibition.

Redevelopment of the ACES website

A 'Marketing Communications' Plan was developed as part of the overall ACES Strategic Plan. This Plan takes into consideration current issues faced by ACES including conquering the tyranny of distance between the different ACES nodes; presenting ACES as an authoritative source; building a sales funnel of end-users; qualifying leads; driving tactical public relations activities; and presenting a central brand identity - by leveraging the value of the internet.

ACES will need to enable communication to take place in a way that mirrors the way that individuals are now using the web. It will need to effectively communicate through social networks and use tools that are being used by the future target stakeholders. The market is not the ACES peer group of scientists but includes businessmen, journalists, investors, public servants and students.

Development of standard IP management contracts and promotions at UOW for roll-out to other ACES partners in 2010.

The Director of Commercial Development has conducted an audit of IPRI Intellectual property and developed a promotional brochure outlining all available patents and patent applications of potential interest to end-users (Appendix 3). In 2010, a similar review will be undertaken of the other partners. These documents are intended to be publicly available and so are written in a way that protects confidential information, while still allowing anticipated partners to review the IP.

A suite of template agreements has been developed for Visiting Fellows and Visiting Students with varying scenarios based on who owns the IP that they develop initially (the Fellow/Student or their Employer/Institute). These will be provided to other partners for use in their own institutions.

Finally, a standard confidentiality and sub-contracting agreement has been developed to ensure smooth negotiations for projects where all partners must sign off on contracts. It is intended that these also become attachments to the new Centre Agreement.

Funding for the AIIM-P&D Facility at UOW

In 2009, funding was obtained via the Education Investment Fund to develop the \$50 million "Australian Institute for Innovative Materials (AIIM) -- Processing and Devices" Facility (AIIM P&D). This new building will be developed alongside the existing Australian Institute for Innovative Materials (AIIM Building) at UOW's Innovation Campus. This facility will significantly assist ACES IP to progress to commercial development. Already, UOW has hosted several forums and meetings with various end-users, including a specific forum with Korean partners. The concept of the new AIIM P&D facility is that it will enable projects to extend through proof-of-concept and device development stage and partners could either invest through secondment of people to the facility, funding research projects or jointly developing specialised materials processing capabilities.

Management Arrangements

The Governance/Organisation Chart for ACES is shown below (Chart 1).

The Centre Executive (Table 1) met 8 times in 2009 to review the progress of the Centre as well as the procedures used to facilitate the dissemination of research findings and to maximise the use of skills within the Centre and externally.

The International Advisory Board (IAB) (Table 1) met on 4 February 2009. The board provided valuable advice on scientific and commercial opportunities relevant to the Centre, as well as monitoring the Centre's progress. Members of the IAB also provided regular comment and guidance to the Director.

The End-Users Committee (EUC) (Table 1) provided advice on strategies used to engage End-Users and identified new collaborative opportunities. Anita Hill (CSIRO) joined the EUC in 2009. The EUC met twice in 2009.

The Education Committee (Table 1) initiates and implements strategies to attract and engage high calibre research students. Chaired by Professor Will Price, it met regularly during 2009.

Director Commercial Development (Table 1): In 2009 UOW has seconded its Director of Commercial Research/ Executive Officer of Research Development, Dr Troy Coyle, to the role.

Staff of ACES: A list of current staff and affiliations are provided in Appendix 4.

ACES Students: In 2009, 9 new PhD students were recruited to the centre, with 6 PhD completions. A complete list of students and graduates is provided in Appendix 5.

The Intellectual Property Register is provided in Appendix 3.



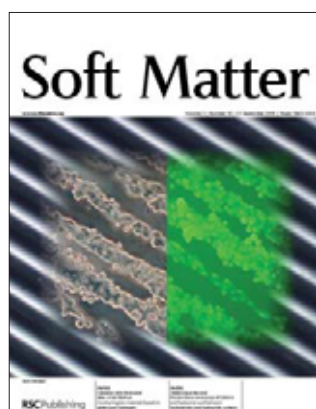
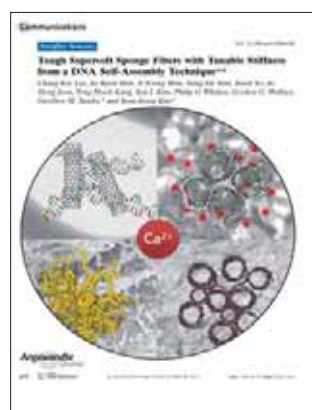
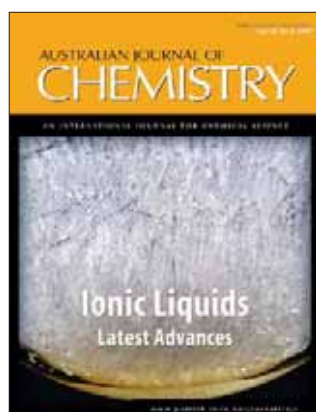
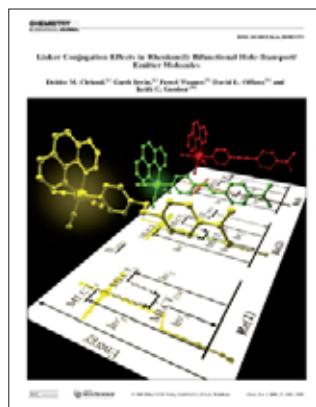
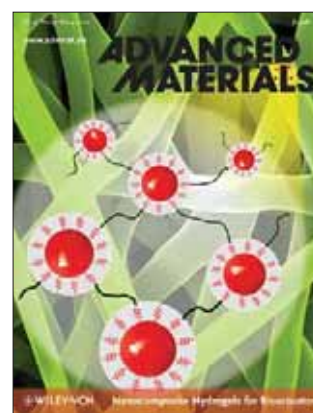
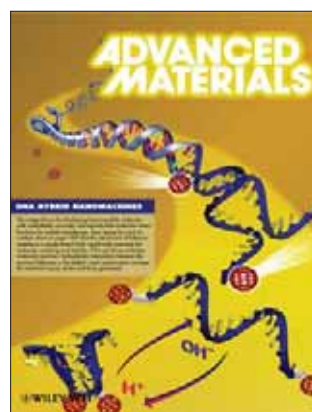
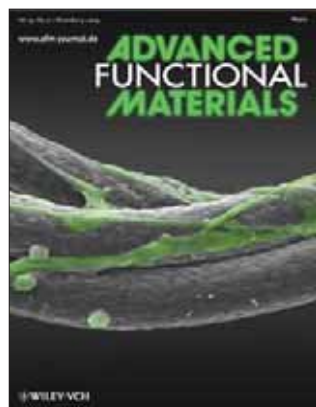
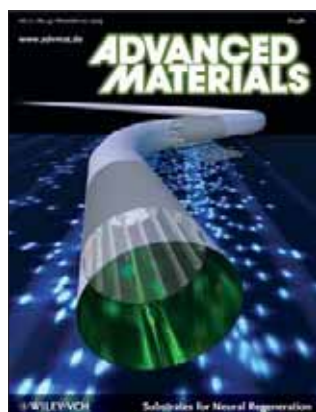
Chart 1. ACES Governance/Organisation Chart

Table 1: Members of ACES Management		
Centre Executive	International Advisory Board	End-Users Committee
Executive Director: Prof. G. Wallace	Dr (Dame) Bridget Ogilvie (Chair, AC, DBE, FAA, FRS, FMedSci)	G. Smith (Chair, SciVentures)
Associate Director: Prof. M. Forsyth	Prof. R. Baughman (University of Texas at Dallas)	P. Aitchison (Cap-XX)
Selected Senior Researchers: Prof. L. Kane-Maguire Prof. D. MacFarlane Prof. G. Clark Prof. D. Officer A/Prof. R. Kapsa Prof. G. Spinks Prof. S. Dodds	Prof. R. Kaner (University of California)	E. Evans (BlueScope Steel)
Chief Operating Officer: A/Prof. C. Too (Jan - Sept) Dr T. Campbell (Oct - Dec)	Prof. K. Kaneto (Kyushu Institute of Technology, Japan)	A. Hill (CSIRO)
Business Development Officer: Director Commercial Development Dr Troy Coyle (UOW)	Prof. Thomas W.H. Kay (St Vincent's Hospital, Melb.)	P. Murphy (IWRI, UNISA)
Communications Officer: Leanne Crouch	Dr. A. Khan (Monash University)	J. Nicholson (Visiocorp)
Education Director: Prof. W. Price	Dr. A. Mau (CSIRO)	J. Patrick (Cochlear)
Early Career Researchers Representative: Dr A. Mozer	Prof. N. Ogata (Chitose Institute of Science and Technology, Japan)	R. Shaw (Rio Tinto)
	Prof. J. Raper (DVC Research, UOW)	T. Truong (DSTO)
	Prof. S. Roth (Max Planck Institute, Stuttgart)	
	Dr. I. Sare (DSTO)	Education Committee
	Dr. G. Smith (SciVentures)	Prof. W. Price (Chair)
		Dr T. Campbell (UOW)
		Ms. L. Crouch (UOW)
		Dr A. Minett (UOW)
		Dr J. Pringle (Monash)
		Ms S. Shekibi (Monash)

2009 ACES Publications

The target for 2009 was 50 publications with 50% of journal articles in journals with an impact factor greater than 2. The Centre has exceeded this target, publishing 98 refereed publications. Of the 98 journal articles 68 (69%) were published in journals with an impact factor greater than 2 and 37 (38%) in journals with an impact factor greater than 4.

In addition ACES research has graced the covers of 11 journals in 2009.



Book Chapters

Conjugated Polymer Actuators: Fundamentals Spinks, G.M., Alici, G., McGovern, S., Xi, B., Wallace, G.G. Biomedical Applications of Electroactive Polymer Actuators Edited by Federico Carpi, Elisabeth Smela, Wiley, Great Britain (2009), 195-228.

Actuated Pins for Braille Displays Spinks, G.M., Wallace, G.G. Biomedical Applications of Electroactive Polymer Actuators Edited by Federico Carpi, Elisabeth Smela, Wiley, Great Britain (2009), 265-278.

Journals

- B. B. Xi; P. G. Whitten; A. Gestos; V. Truong; G. M. Spinks; G. G. Wallace, *Electrochemical pneumatic actuators utilising carbon nanotube electrodes*, Sensors and Actuators B Chemical 2009, 138, (1), 48-54. **IF:2**
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