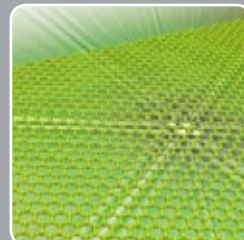
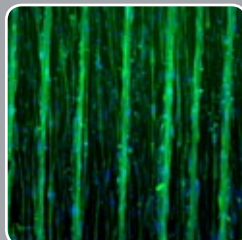
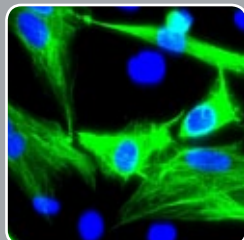
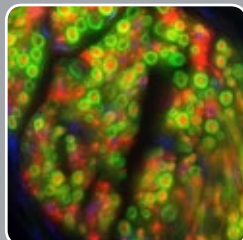




Annual Report 2008



creating advanced materials
materials synthesis · energy conversion · energy storage · bionics

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01

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 nano-technology 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 and highly efficient energy storage materials.

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.

ACES is 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.

ACES was established in 2005 and is funded by the ARC with \$12 million in federal funding over five years.

ACES also receives support from the NSW Department of State & Regional Development to achieve technology transfer to NSW and Australian industry.



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

02

From the Executive Research Director

The review of our ACES Centre by an ARC appointed panel during 2008 caused us to collect, collate and reflect on the extensive information and insights gained in our progress to date. The site visit required the organisation, coordination and participation of the complete ACES team: Researchers and support staff, University administrators, and the ACES End-Users Committee and our International Advisory Board. It was a tremendous effort by the whole team and I am very pleased to report that as a result of the review, ARC funding of ACES has been extended to 2013.

I would like to thank everyone for their tremendous efforts and contributions.

The review process highlighted some very positive elements of ACES. Firstly, I find myself in the fortunate position of working alongside some of the most highly talented individuals in the world in their chosen field of endeavour – I consider that an incredible privilege. This is combined with the fact that we find ourselves with a stable level of core funding and excellent research facilities

in a supportive environment filled with opportunity and excitement. I am well aware that many high calibre Australian researchers may never have that privilege.

And so... our privileged position brings with it a high level of responsibility.

Entrusted by our peers to carry out research in this critical area, we must continue to deliver high quality science that leads to:

- ▶ Significant advances in **knowledge**.
- ▶ A national **resource** for commercial interests and other government research agencies.
- ▶ A better **understanding** of the impact of scientific research in the community.

During 2008 ACES delivered in each of these areas.

Knowledge – Our researchers produced 93 refereed publications and gave 39 invited conference presentations. The work of ACES researchers was highly cited during the past 12 months. We continue to discover new materials, fabrication protocols and concepts that

will enable the implementation of new technologies in **Energy** and **Medical Bionics**.

Training – 36 PhD students and 30 research fellows are currently engaged in ACES research programs. Several of the research fellows have gained highly competitive ARC Funded Fellowships.

ACES provides a multidisciplinary, multifaceted research environment with domestic and international research collaborations involving each of our students and Research Fellows. Our researchers are provided regular opportunities to present their work on the international stage. The ACES environment also allows them to obtain formal training and other experiences well beyond the scope of their personal research project.

A National Resource – Recognised as the national centre for Electromaterials Science, ACES provides a first port of call for numerous industry enquiries – many leading to collaborative research activities as detailed in the End-Users Section of

this Report. ACES also acts as a technical resource for DSTO and CSIRO - providing innovative approaches, expertise and state-of-the-art experimental facilities in the area of Electromaterials Science.

Understanding Impact – Our task in this area is made somewhat easier by the fact that energy and health rank highly on most peoples “concerned list” and advances in both of these areas are critically dependent on breakthroughs in Electromaterials Science.

ACES researchers have embraced numerous media opportunities (print, TV, radio coverage) in 2008 – always keen to explain the impact of the science in which we are engaged.

ACES also provides an educational resource for schools and the general community. For example, we are actively engaged with the Wollongong Science Centre in establishing a “NanoMaterials and Energy” Exhibit (see Outreach section of the Report). ACES researchers also participate in a variety of outreach events.

Returning to the 2008 review of ACES

– I was pleased with the quality of our written documentation and proud of the way my colleagues represented ACES during the site visit. However, after the

review I was concerned that the most valuable assets and characteristics of ACES are hard to capture in such a process. The unwavering, day-to-day dedication and enthusiasm of these highly talented individuals is hard to capture and convey in a snapshot. Their ability to identify, capture and exploit the unexpected as it emerges in the laboratory is also difficult to articulate – though we tried.

Yet these two “measures” are perhaps the most critical to the success of ACES.

Of course, researchers respect the need for key performance measures that can be counted but that need has not, in my experience, bounced anyone out of bed in the morning.

It is the unknown, the unplanned, the unpredictable nature of research that drives us all. It is the ability to capitalise on our unexpected findings that produces our most significant outputs.

I hope we have captured some of that excitement in the following pages.

Best Wishes,



Gordon



03

From the International Advisory Board

The International Advisory Board reviewed the 2008 progress of the ARC Centre of Excellence for Electromaterials Science (ACES) on 4th February 2009. Those in attendance were: Dr (Dame) Bridget Ogilvie (Chair), Prof Siegmund Roth, Prof Richard Kaner, Prof Judy Raper, Dr Greg Smith, Dr Albert Mau and Dr Ian Sare. The Board was unanimously impressed by the quality and quantity of outcomes achieved by the Centre.

Key Performance Measures

In general the performance of the Centre has exceeded the 2008 targets. In particular, there were 93 refereed publications of which 74 (79%) had an impact factor greater than 2 (in fact, 34 had an impact factor greater than 4), 13 postgraduate students recruited, 8 postgraduate completions, 4 national/international workshops, 39 invitations to international conferences, 60 visits to leading international laboratories, 877 media reports, 93 international visitors, 4 patents lodged, and 5 new organisations recruited to collaborate with the Centre.

ACES Programs

P1 Electromaterials: This program was set up to provide materials for Programs 2, 3 and 4.

The move to the new building and facilities at the Innovation Campus has facilitated better cell fabrication and characterisation, resulting in better devices.

New Building Blocks - For example, new porphyrins that have been synthesised have resulted in patentable technology, while bucky balls have enhanced electron conductivity in solar cells and batteries.

Nanostructures, Nanodispersions and Fabrication – 2008 progress has been built on work done in 2007 on fibre spinning and further developments in inkjet printing. There will be a quest for better equipment such as a 3D-printer to produce enhanced nanostructures. Work on graphene by Dan Li and Ric Kaner has been published. There is now developmental work going on to scale up the synthesis of graphene dispersions to 20 litre quantities. ACES novel carbon nanowebs are of interest to Cap-XX and collaborative work with them on supercapacitors is on-going. The Monash University team has developed gold-polypyrrole composites for solar cells.

To enhance fabrication facilities, inkjet printing instrumentation will be developed. Purchase of equipment will be considered. Paul Calvert from the USA is helping ACES to develop 3-D printing of cells.

ACES work is being benchmarked with published work. For example, Dan Li's graphene sheets have 4 orders of magnitude higher conductivity than previously reported graphene. For

graphene and carbon nanotubes, 50% of the time has been spent on optimising results. This is due to batch to batch variation in commercial carbon nanotubes, although graphene is not such a big problem. NCRIS characterisation facilities will ensure quality control of materials that ACES-IPRI supplies to partners. Postdocs are producing routine materials in addition to new materials development.

P2 Energy Conversion: This program has two streams of activity; namely flexible solar cells (at Monash and UOW), and actuators (at UOW).

Actuators – The milestone to produce low voltage actuators of 5 times better output than previous results is ambitious. ACES current achievement is 2.5 times. To achieve the required further enhancement, gel materials and fibres have been considered and they need to be small. The work on DNA gels is a collaborative venture with Korean workers, and the actuation is due to a pH response. To make the gels conductive, carbon nanotubes composites with gels have been considered. Polypyrrole actuators have also been developed but are not stable although the actuation results are good. Tough gels have been under development in 2008. In addition, simulation work on bending actuators has aided development of these actuators to achieve a 5 times improvement in the speed of response. To overcome variability of materials for actuators, much time has been spent on standardising production methods and formulations.

Solar Cells – The emphasis is on plastic solar cells. Monash has developed a PEDOT counter electrode to replace Pt/ITO. In electrolyte development, ionic

liquids have been used for porphyrin dyes. A 3% efficiency was achieved using a plastic crystal electrolyte. Monash solar cell fabrication facilities are better than UOW's and so UOW will be sending materials to Monash for solar cell fabrication. There has been a LIEF grant success to equip Monash with fabrication facilities and UOW with characterisation equipment. Monash has also been successful in obtaining funding from the Victorian Government to set up a solar cell consortium (VICOSC). 2008 has been a year of growth and new significant results are expected in 2009.

P3 Energy Storage: Efforts in this Program were directed towards lithium batteries and advanced metal batteries.

Lithium Batteries – Lithium batteries currently have 2 main issues of concern; namely safety and cycle life. The safety aspects include fire and explosion. As for cycle life, 1000 cycles are required for commercial batteries whereas research testing has only considered up to 100 cycles. Research and development needs to address properties of the anode, cathode and electrolyte. Work on the anode in 2008 included use of new mesoporous carbon-tin nanocomposites that resulted in significant improvement in specific capacity; achieving 960 mAh g⁻¹. Work on the cathode involved the use of vanadium oxide that offered a solution to the stability issue, while the use of ionic liquid electrolytes with this cathode also solved the safety issues.

Advanced Metal Batteries – The focus was on developing Metal/Air batteries where oxygen from the air is reduced at the anode metal catalyst such as platinum. However, platinum supply is limited and

the cost is high. Significantly, ACES have now developed a PEDOT polymer substitute for the platinum anode material. Future work will also consider magnesium and aluminium anode materials.

P4 Bionics: Research efforts were focused on the cochlear implant, and spinal cord and peripheral nerve regeneration. The aims of the research on the cochlear implant are to increase the number of electrodes in the implant and to improve the contact between the nerves and the implant. Program 1 electromaterials have been used in these developments.

Cochlear Implant – NT-3 delivery to encourage nerve growth was explored, as was also the use of electro-stimulation in *in vivo* tests. The issues of safety and stability were also studied. *In vitro* work has shown that the use of NT-3 in conjunction with electro-stimulation gives better results than without electro-stimulation.

Spinal Cord and Peripheral Nerve Regeneration – Polypyrrole surfaces with wet spun biodegradable fibrous microstructures developed in Program 1 were studied here as nerve renewal conduits. Linear migration of nerve growth along the fibrous microstructure was demonstrated. This exciting work has extended into the wet-spinning of polypyrrole fibres, whose micro and nanostructure can be altered by using different dopants such as the sulphonated polyaniline PMAS.

P5 Ethics: The 2008 activities were on 2 fronts; namely research on democratic participation and public engagement in emerging technologies; and research on medical bionics, selfhood and perception.

Social and ethical issues with respect to technology were examined, especially in relation to the Bionics Program.

Dr Greg Smith noted that there was now more noticeable synergy in ACES as a result of more program management rather than managing project by project. This is a good outcome. Dr Ian Sare and Prof Siegmund Roth agreed that synergy is demonstrated and the value of an integrated Centre is shown.

Education and Training

The Education Committee has continued to be very active in its mandate of providing education and training for both members of the Centre and the broader community through a range of activities. The primary focus this year has been to broaden the range of training activities for post-graduate students and early career researchers, as well as to provide opportunities for external participants and other interested parties. 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 sphere of activity has been the close integration of Centre activities at the University of Wollongong node with the University's Nanotechnology undergraduate degree. In addition, completion of Phase 1 has been achieved for an Educational Exhibition in the area of Electromaterials and their impact on society in collaboration with community based Science Centres.

International Profile

ACES continues to attract research scientists from around the globe and participates in a number of active international research collaborations. During 2008, ACES produced 93 refereed publications, with 30 of these involving international collaborators. The Centre has established a vibrant international research network.

The International Consortium of Organic Solar Cells (ICOS), which links 6 international solar cell research groups and 7 groups from Australian universities and the CSIRO, was created with funding from a DEST International Science Linkages grant (A\$1.4 million p.a.) in 2007. ACES researchers at both Monash University and the University of Wollongong play a leading role in this world-class Consortium, which provides access to a wide variety of materials and facilities for the development of organic solar cells.

In 2008, as well as visits to all the international ICOS partner laboratories, ACES researchers developed a three-way collaboration on porphyrin solar cells with researchers at Imperial College London and the University of Otago. This has led to significant new insights into dye-sensitised solar cells.

Outreach

ACES have been very active in outreach during 2008 with the following media reports: 30 print, 807 websites, 28 radio, and 12 TV.

End Users/ Industry

ACES has cultivated an open and vibrant research environment that ensures close interaction with other Australian and international scientists. These collaborative activities are undertaken under agreements that cover:

- ▶ Appointments as Visiting Research Fellows, or
- ▶ Specific collaborative research agreements, or
- ▶ Commercial research agreements.

The ACES approach ensures high visibility for its research activities and the opportunity to establish partner engagement at the early stage of research. This approach ensures strategic input from a commercial as well as a technology perspective. The high profile, open engagement approach encompasses end-user driven intentions and has proven highly effective in developing externally funded programs with a range of organisations, both private and public sector – a critical measure of success.

Dr Ian Sare questioned whether a basis exists to bridge the gap between technology and industry. For example, variability and scale-up issues need to be addressed and may need chemical engineers to develop them. The technology level needs to be moved up in order to attract industry. ACES are looking for commercialisation opportunities via the appointment of a Director of Commercial Development, and extra resources will need to be found.

Prof Siegmund Roth noted that for commercialisation to be achievable, the budget will need to be doubled. The usual lead time for commercialisation is about 20 years. However, engineers could be of help after 5 years.

Final Comments From The Chair

In 2008, ACES once again performed at a high level, reflected in renewal of its core support from the ARC until 2013, and I anticipate the increased coherence of the different groups will see its reputation continue to grow.



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

International Advisory Board for ACES



04

Highlights of the Core Funded Activities

ACES researchers produced 93 refereed publications in 2008. Many of these involved collaborations external to ACES and with research partners from all parts of the globe. ACES has truly become an international venture. In 2008, we have benefited from the synergism arising from such collaborative activities.

I trust you will enjoy this sample of ACES research highlights for 2008.

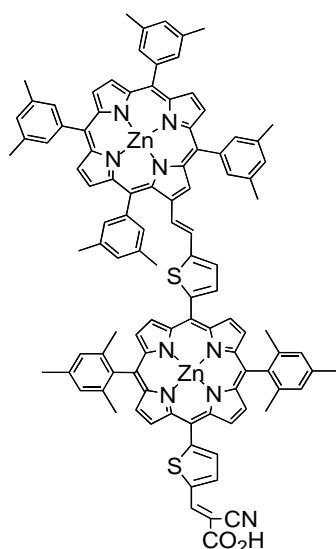
Program 1: Electromaterials

The Electromaterials research hub has enabled us to build on integrated, iterative "supply chain" linking research in Energy Conversion, Storage and Bionics.

This iterative human chain has proven to be the source of continuing innovation. For example:

NEW BUILDING BLOCKS

In this third year of the Centre, new materials are still under development for Programs **P2-P4**, with an increasing demand for the materials developed in the previous two years. For example, the successful development of the use of porphyrin dimers in dye-sensitised solar cells (**P2**) has led to the synthesis of new dimers such as **1**. The development and functionalisation of new electrode materials such as graphene has spurred the synthesis of a variety of electroactive functionalities such as the fullerene derivative **2**. In addition, the experience previously gained in the synthesis of a wide variety of functionalised polythiophenes has been applied to the development of functionalised sexithiophenes **3** for incorporation into biodegradable polymers for the **P4** program.



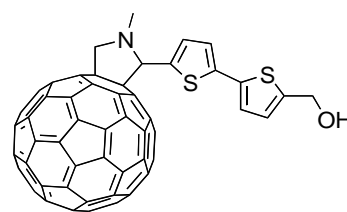
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NANODISPERSION AND FABRICATION

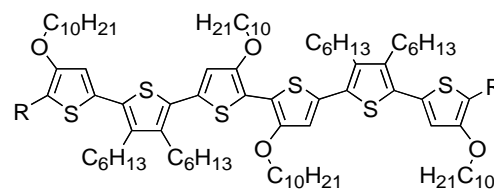
The nexus between functionality and processability/fabrication is one that is at least partially overcome by advances in nanotechnology. The ability to create stable functional nanodispersions with physical properties (particle size, viscosity, surface tension) that make them amenable to subsequent processing is critical to the realisation of practical applications as we develop novel nanostructured electromaterials.

During 2008, ACES researchers have supplied such nanodispersions to our international collaborators, enabling significant progress in the ink jet printing of new chemical sensing materials (**Electrochimica Acta 2008**). Supply of such nanomaterials has also enabled fundamental studies into the dynamic character of polyaniline to be carried out (**J. Phys. Chem. 2008**).

We continue to discover biologically derived or biocompatible polymers that are highly effective dispersants for carbon



2



3

nanotubes and provide physical properties amenable to subsequent processing. For example, using biologically derived systems such as gellan gum and chitosan, mechanical reinforcement is achieved from carbon nanotubes via a continuous flow wet-spinning method. (**Adv. Funct. Mat. 2008**). Using the biocompatible polymer SIBs, a nanostructured conducting platform containing polypyrrole has been produced by electrospinning (**Chem. Commun. 2008**).

Our ability to produce stable graphene dispersions (**Nature Nanotech. 2008**) has been used to advantage to fabricate graphene-based electrodes that have been shown to have useful electrochemical properties and to be non-cytotoxic (**Adv. Mat. 2008**). Layer-by-layer deposition techniques have been used to produce novel graphene-polymer composites. Air brush spraying methods have been further refined to allow thin, uniform layers of graphene to be deposited. For example, on plain glass

slides, sprayed graphene layers of ~50% transmittance with a sheet resistivity of ~3 k Ω have been produced.

NANOSTRUCTURED CARBONS

Building on our ability to fabricate robust aligned carbon nanotubes as well as nanoweb electrodes, we have developed protocols that enable additional functionality to be introduced to these structures. For example, the addition of platinum nanoparticles provides a highly electrocatalytic surface for methanol reduction (**Chem. Materials 2008**), while the addition of polypyrrole caps to aligned carbon nanotube tips provides a highly efficient nano-container for incorporation and release of the nerve growth factor NT-3 (**B. Thompson PhD Thesis**).

Program 2: Energy Conversion

The focus of the Energy Conversion Program remains the development of (flexible) dye-sensitised solar cells (DSSCs) and of improved performance artificial muscles. The exploitation of novel nanostructured electrodes to enhance performance is of primary interest.

PLASTIC SOLAR CELLS

Following the establishment of internationally competitive solar cell fabrication and characterisation facilities at both Monash and UOW in 2007, the focus in the solar cell program has been on gaining a better understanding of the factors that lead to higher efficiency solar cells, in particular using porphyrins as dyes.

Highlights have been:

- Understanding, via an international collaboration, the key factors (Fig. 1) that lead to lower solar cell efficiency of porphyrin dyes compared to ruthenium dyes (**Chem. Commun. 2008**).

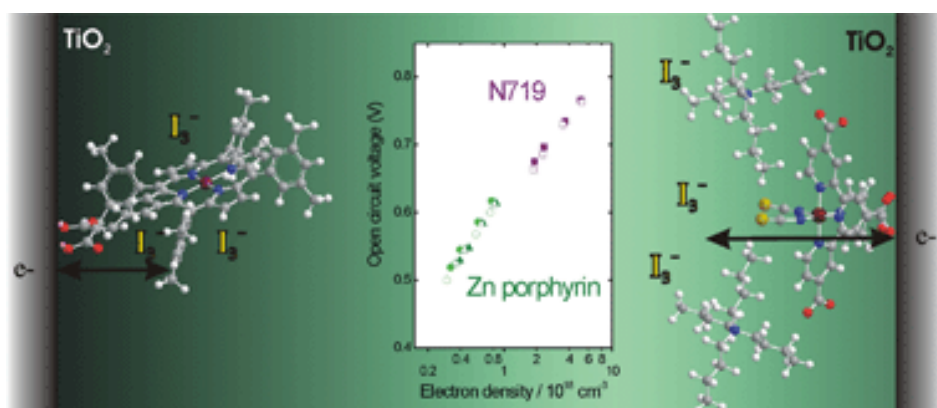


Figure 1. Cartoon showing V_{oc} and structural differences between porphyrin and ruthenium dyes.

- ▶ Achieving a world record for conducting polymer based DSSCs.
- ▶ Demonstrating a new cell architecture using porphyrin dye mixtures (**Aust. Prov. Patent application 2008**).
- ▶ Demonstrating, for the first time, significant light harvesting using porphyrin dimers as the dye.
- ▶ Increasing the efficiency of porphyrin-sensitised solar cells using new surface treatment agents.
- ▶ Increasing the efficiency of porphyrin-sensitised solar cells using light soaking.
- ▶ Developing a DSSC with mixed ruthenium complex / infra-red absorbing organic dyes.
- ▶ Developing a monolithic DSSC with PEO/PVDF polymer electrolyte and carbon anode replacement for the Pt anode.
- ▶ Developing a DSSC with a core-shell structured NiO / Al₂O₃ photocathode.
- ▶ Integrating infrared-absorbing organic dyes into the DSSC photocathode.

These results provide an excellent basis from which to undertake exciting new developments in dye-sensitised solar cells in 2009.

ELECTROMECHANICAL ACTUATORS

Significant progress has been made during 2008 on the development of improved actuator materials (in association with Program 1). In particular, several novel hydrogel materials have been fabricated that promise large actuation response (**Angew. Chem. Int. Ed. 2008; Langmuir 2008**). In addition, several new nanofibrous materials have been developed for high-speed actuators (**Sensors & Actuators B; Advanced Materials 2008**). We have also demonstrated the first wet spinning of conducting polypyrrole fibres (**Synthetic Metals 2008**). In parallel, we have pursued the application of actuators as positioning systems for chemical sensors (Fig. 2) (**Sensors and Actuators B, 2008**) and as propulsive elements for a robotic fish.

Program 3: Energy Storage

The goal of the Energy Storage Program is to exploit novel nanostructured electromaterials to generate enhanced energy storage devices, including flexible wearable structures.

LITHIUM BATTERIES

Highlights in 2008 include:

- ▶ New mesoporous carbon-tin (MC-Sn) nanocomposite anode material showing extremely good cycling stability, with the specific capacity of Sn in the composite electrode of 960 mAh g⁻¹, which amounts to an impressive 97% of the theoretical value (**J. Mat. Sc. & Tech. 2008**).
- ▶ High capacity thin film cathode materials based on LiV₃O₈ developed and shown to have high cycle life with ionic liquid electrolytes (Fig. 3) (**Chem. Mat. 2008**).
- ▶ Carbon nanotube-based electrode materials developed and tested in battery structures. These show excellent capacity and cycle life (**J. Power Sources 2008**).

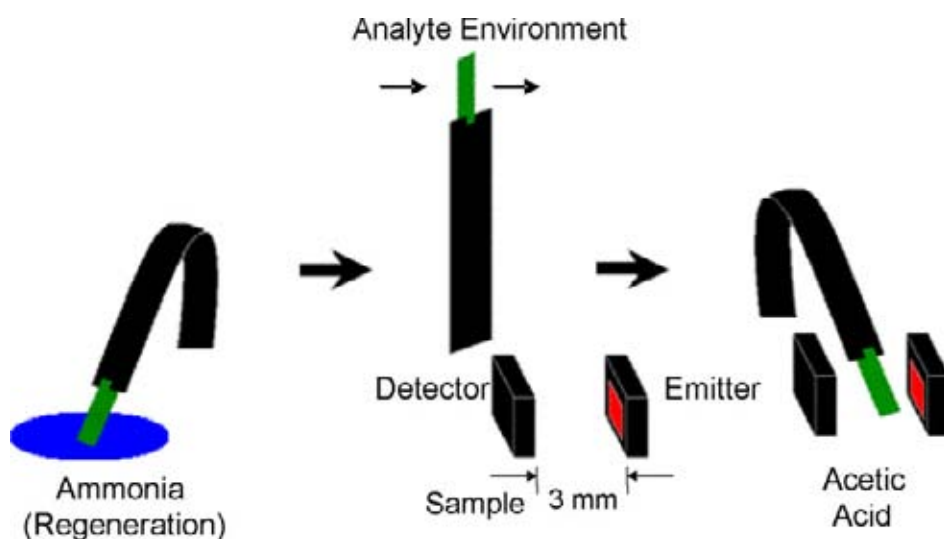


Figure 2. Example of bending actuator used for positioning a sensor element.

ADVANCED METAL BATTERIES

- ▶ As part of metal-air battery research, the first ever Pt-free air electrode has been developed (**Science – 2008, Aust. Prov. Pat. App 2008**). The electrode is based on a nanolayer of the conducting polymer PEDOT (Fig. 4) and is capable of an electrocatalytic action equivalent to Pt.

BIOCOMPATIBLE BATTERIES

An innovative approach showing great promise for biocompatible (and preferably bioabsorbable) batteries, required for use *in vivo* with bionic devices, is our recent development of a new class of organic/inorganic batteries employing a magnesium (or Mg alloy) anode, a conducting polymer cathode and an ionic liquid electrolyte (**Electrochim Acta 2008**).

POLYMER CAPACITORS

In a collaboration with Prof Jang Myoun Ko's group at Hanbat National University (Korea), a number of new polymeric materials have been developed for use as capacitor electrodes.

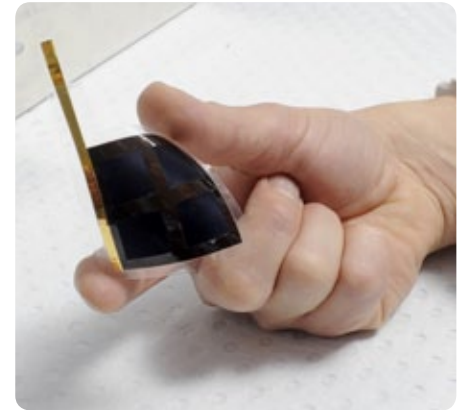


Figure 4. PEDOT/Air electrode

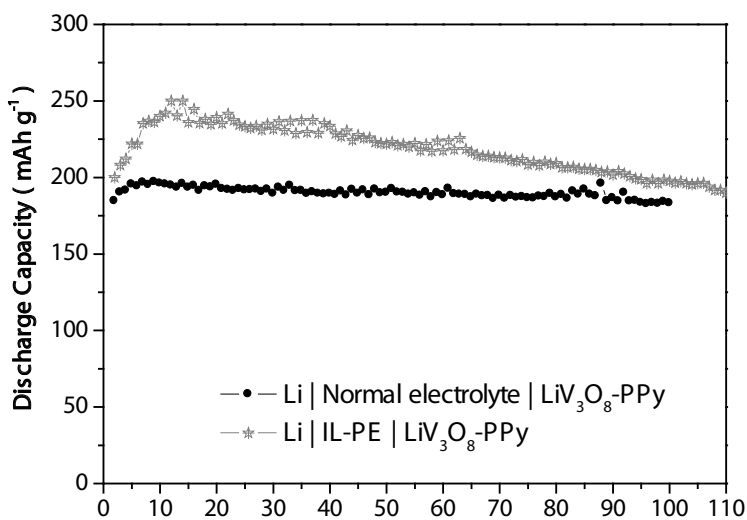


Figure 3. Capacity vs Cycle number on LiV₃O₈ Cathode

Program 4: Bionics

The Bionics Program is focused on the generation and application of novel conducting materials that safely and effectively transfer electrical energy between electronic circuitry and cell systems within the body. In particular, the Program aims to develop devices and methods by which tissues composed of excitable cells (muscle and nerves) can be stimulated to restore structure or function in muscle and nerve that have been damaged due to trauma or accelerated degenerative processes. Over the past year, research into the development of an improved cochlea implant has targeted the evaluation of carbon nanotubes' safety when used as a component of high resolution electrodes and for further delivery of neurotrophins to preserve the auditory nerves in deafened ears. The nerve regeneration program has explored the potential for nano-and micro-structured conductive surfaces to promote directional growth of axons to provide a functional link across a damaged section of peripheral nerve and spinal cord.

NERVE CELL GROWTH STUDIES ON CONDUCTING POLYMERS

Directed axonal growth was demonstrated on conducting polymers using a hybrid biodegradable polymer microfibre/polypyrrole cell growth platform (Fig. 5), and on polypyrrole-covered carbon nanotubes. These studies showed for the first time that the extent and direction of axonal outgrowth from a live neural explant can be controlled by direct electrical stimulation.

The release of the neurotrophin NT-3 in previous studies to stimulate the growth of spiral ganglion neurons was expanded to utilise the controlled release of another neurotrophin, BDNF, both on its own and in conjunction with NT-3 release (Fig. 6). These studies have led to the design of novel structures that include conducting polymers to promote a controlled neuroregenerative environment for the support of nerve repair in peripheral nerve and the spinal cord.

DEVELOPMENT OF ADVANCED ELECTRODES WITH CARBON NANOTUBES

Electrode structures suitable for investigations that separate the effects of direct electrical stimulation from those encountered by controlled release of growth factor have been produced and applied *in vivo* for the release of NT-3 into the cochlea of guinea pigs (**Richardson et al., 2008 – In Press**). In parallel studies, electrode structures based on aligned carbon nanotubes and newly-discovered Carbon Nanowebs have been incorporated into designs for advanced cochlea implant electrodes with high current density capacities.

Carbon nanotubes (CNTs) have recently been found to present health issues in certain formats. Their potential use in delivering high density electrical stimulation in bionic devices such as the cochlea implant necessitate that more understanding be gained regarding the specific CNT formats that present health risks, so that they can be utilised to improve electrode function. An intensive long-term *in vivo* study is well under way to determine the safety of aligned CNTs embedded in a solid gel matrix.

These systems are being developed in conjunction with high-resolution electrode arrays with increased numbers of individual electrodes for use in deafened animal models to generate new-generation high density electrode systems for bionic implants.

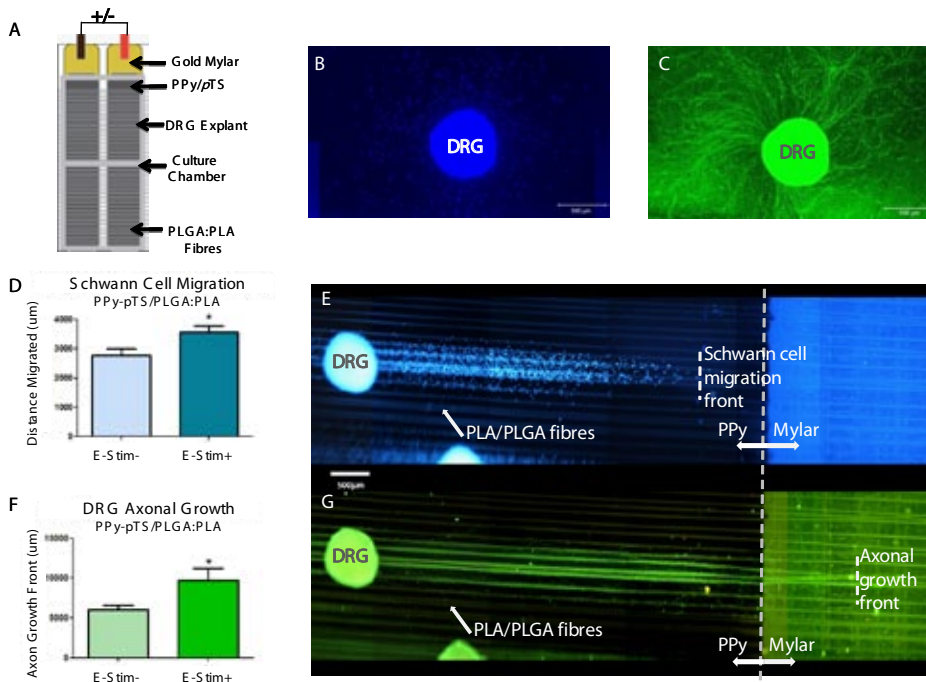


Figure 5: Hybrid PPy/pTS -PLA:PLGA (75:25) "Wet Spun" polymer fibres scaffolds (A) were prepared for growth of Dorsal Root Ganglia explants. DRG grown on plain PPy/pTS surfaces showed radial axonal growth (B) and radial migration of Schwann cells (C) on stimulated and unstimulated polymers. In contrast, DRG grown on the hybrid scaffold fibres showed axonal growth (green) and Schwann cell migration (blue DAPI labelled cell nuclei) in a linear path from the DRG body. Electrical stimulation (E-Stim+, D and F) significantly increased the extent of Schwann cell migration (C & D) as well as the axonal growth front (E & F) compared to unstimulated DRG (E-Stim-, D and F).

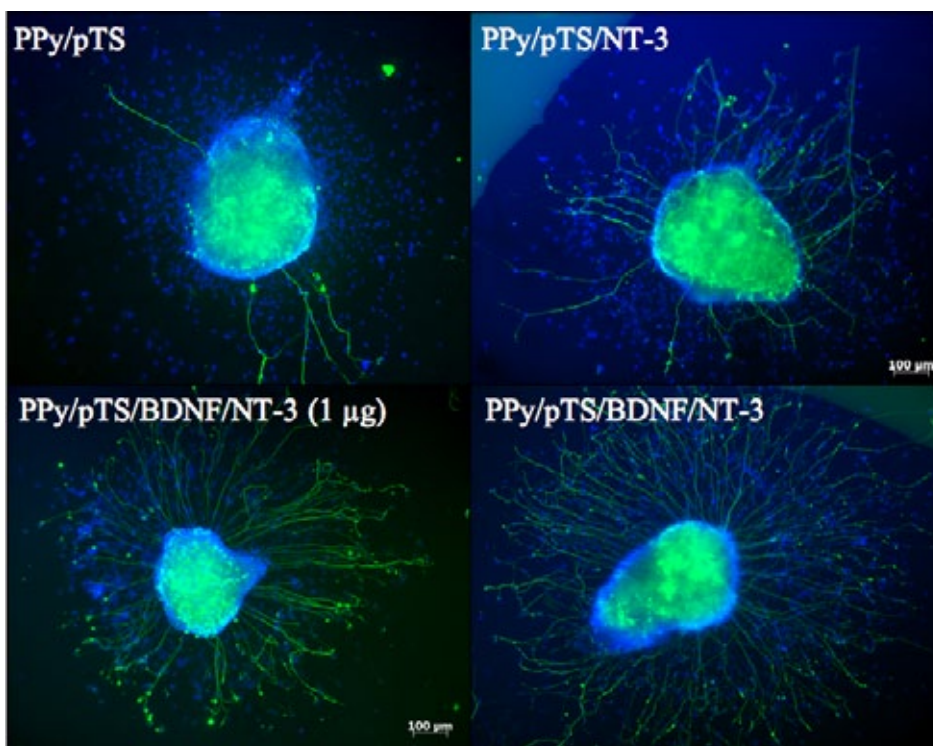


Figure 6. Images of auditory nerve explant growth on different polymer films (only stimulated films shown)

Program 5: Ethics

The highlight for the Ethics Program in 2008 related to its research on public engagement with nanotechnology, and the development of defensible and democratic public policy on research and regulatory issues relating to rapidly developing nanotechnologies. This research was presented at the International Conference on Nanoscience and Nanotechnologies in Melbourne (**'Processes for public deliberation on the ethics of enhancement technologies and bionics' Feb, 2008**) and led to a media interview (**ABCScience online**), interest by CSIRO, the Commonwealth Office of Nanotechnology and the NSW Committee on State Development's Nanotechnology Inquiry. Internationally, it led to involvement in the Gordon Research Conference on Governing Emerging Technologies (**Big Sky Montana, August 2008**) and development of research links with the University of British Columbia's W. Maurice Young Centre for Applied Ethics on science regulation, deliberative democracy and public attitudes.

05

Education and Training

The core education and training activity in 2008 involved PhD students of the Centre. Thirteen new PhD students were recruited and there were eight completions. There are currently 36 PhD students enrolled in the Centre (Appendix I).

The Education Committee has continued to be very active in its mandate of providing education and training for both members of the Centre and the broader community through a range of activities. The goals for 2008 were to continue the training programs for staff and research students in the area of ethics and regulation in Nanotechnology, and to provide further workshops in the area of characterisation of nanomaterials, as well as a range of other specific training and education programs through seminar programs and short courses. The primary focus this year has been to broaden the range of training activities for post-graduate students and early career researchers, as well as to provide opportunities for external participants and other interested parties. 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 sphere of activity has been close integration of Centre activities at the University of Wollongong node with the University's Nanotechnology undergraduate degree.

In addition, completion of Phase 1 has been achieved for an Educational Exhibition in the area of Electromaterials and their impact on society in

collaboration with community based Science Centres. This is in fulfilment of a Year 3 milestone.

Specifically, during 2008 the following major events have been organised and successfully run:

Workshops held in 2008

- ▶ NMR Workshop at Monash, 19 February 2008.
- ▶ Full ACES Centre Meeting at Monash, 20 February 2008.
- ▶ 3rd International Electromaterials Science Symposium - "Advanced Materials for Batteries, Energy and Solar Cells" at Monash, 21-22 February 2008.
- ▶ Gel workshop at IPRI UOW, 2 May 2008.
- ▶ Theory/Modelling Workshop at Monash, 14 May 2008.
- ▶ Australian Symposium on Ionic Liquids 3 (ASIL-3) at CSIRO Clayton, 15 May 2008.
- ▶ Seminar on Commercialisation and Venture Creation, UOW (May 2008)
- ▶ IPRI Open Day, UOW, 6 June 2008.
- ▶ Asia-Pacific Nanobionics Symposium, iC Campus, UOW, 22-25 June 2008.
- ▶ Ethics and Bionics Workshop at St Vincent's Hospital Melbourne, 15 July 2008.
- ▶ International Workshop on Preparation and Characterisation of Battery Cells, iC Campus UOW, 24-25 July 2008.
- ▶ Energy Forum, IPRI, as part of the 17th International Conference on Photochemical Conversion and Storage of Solar Energy (IPS17), 27 July to 1 August 2008 in Sydney.
- ▶ SPM Symposium and Workshop, iC Campus UOW, 28-30 August 2008.
- ▶ ACES Centre meeting at iC Campus UOW, 18 Sept 2008.

- ▶ Seminar on Science Society and Public Engagement, Nov 2008, Wollongong – organised through Wollongong's Social Innovation Network.
- ▶ Workshop on Ethics in Science and Engineering, Monash, Dec 2008.
- ▶ Workshop on Electron Spin Resonance Spectroscopy (ESR), UOW, Dec 2008.

In addition, there have been active seminar programs at both Monash and Wollongong, with regular (one-per-week) external 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.

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

Nanotechnology Students win scholarships to attend ICONN 2008

ACES provided scholarships to four undergraduates from the Bachelor of Nanotechnology degree, UOW, to attend the International Conference of Nanotechnology and Nanoscience (ICONN2008) held in Melbourne in February. The four students, Dennis Antiohos, David Marshall, Shane Ellis and Tom Higgins, were selected via a competition amongst all senior undergraduate students in Nanotechnology.

Coordinator of the Nanotechnology degree, Prof. Will Price, said that it was a fantastic opportunity for the students to see and hear the latest research and development in this emerging area. The students also had the opportunity to attend specialist workshops and talk to industrial companies planning to employ graduates in Nanotechnology.

HOPE meeting

JAPAN FEBRUARY 2008

On 24-28th February, the first HOPE Meeting was held in Tsukuba, Japan. Brianna Thompson, an ACES PhD student, was chosen by the Australian Research Council Nanotechnology Network and the Australian Academy of Sciences as one of five Australian students to attend the conference. The aim of the meeting was to gather high quality research students in the field of nanoscience and nanotechnology from the Asia-Pacific region, and introduce them to Nobel Prize winners and other outstanding researchers in the field.

Throughout her visit, Brianna met and participated in discussion groups with Alan Heeger and Hideki Shirakawa (Nobel Prize winners for the discovery of conducting polymers) and Sumio Iijima (who discovered carbon nanotubes), all fathers in the field of organic conducting materials. In addition, Brianna heard talks from Leo Esaki, Robert Laughlin and Heinrich Rohrer who are also Nobel Prize winners in the field of nanoscience and nanotechnology.

UniQuest Research Commercialisation Workshop

BRISBANE 16-18TH APRIL 2008

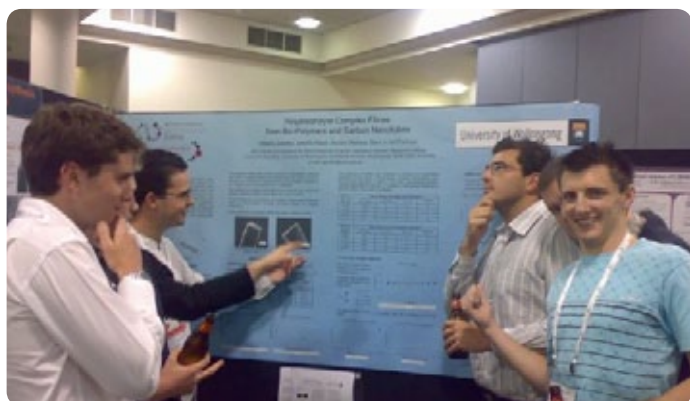
Six PhD students from ACES, Shannon Little, Charles Mire, Satyen Desai, Alberto Javier Granero Rodriguez, Sina Naficy and Javad Foroughi, attended the UniQuest Research Commercialisation Workshop at the Novotel Twin Waters in Brisbane on 16-18th April. The workshop focused on promoting the commercial opportunities arising from current research being undertaken at

the University of Wollongong. Topics such as intellectual property (IP) rights as well as the process of "pitching" to prospective venture capitalists were also discussed, with a significant portion of the program being aimed at "hands-on" and workgroup/discussion based exercises. The workshop was a great success and provided real insight for these students into the processes required to bring promising research to the point of being a successful commercial venture.

Workshop on Gel Electrolytes

2 MAY 2008

Across various Programs within ACES there is a growing interest in gel electrolytes. The purpose of this workshop was to discuss and compare the various chemistries possible and also the properties that gel electrolytes produce. Prof Hugh Brown, Engineering UOW, talked about tough gels and Prof Doug MacFarlane, Ionic Liquids group Monash, spoke about ionic liquid gels. Following these talks, attendees had the opportunity



Pictured left: ACES students at ICONN

Pictured right: Dr Greg Smith (SciVentures)

to partake in a general discussion about the properties and technical requirements of their specific applications.

Commercialisation from Research Outcomes

4 MAY 2008

Dr Greg Smith from SciVentures Investments Pty Ltd, also a member of the ACES International Advisory Board, visited the ACES/ IPRI node on 4 May and gave an insightful seminar to staff on 'Commercialisation & Venture Creation from Research Outcomes'. Greg co-founded the venture capital company, SciVentures Investments Pty. Ltd., which manages the SciVentures Pre-Seed Fund that is licensed under the Federal Government's "Backing Australia's Ability" program.

The seminar covered a variety of topics which included the present competitive global environment for research and commercialisation; approaches to commercialisation of R&D; the critical role of intellectual property; management of the intellectual property portfolio and tools

available to do so; the steps involved in the start up/ spin out route and licensing techniques and strategies. Open and frank discussions helped the participants to understand the complexities of being able to realise commercialisation and venture creation from the benchtop research outcomes we achieve.

Theory/Modelling Workshop

14 MAY 2008

A workshop entitled "Theoretical Approaches to the Field of Ionic Liquids: Advances and Perspectives" was held at CSIRO Minerals for 25 delegates. The purpose of the workshop was to get more insight into outstanding problems of molecular simulations of ionic liquids. The workshop featured scientists applying various approaches of computational chemistry: from molecular dynamics to *ab initio* theory.

The audience was made up of post-graduate students of Monash University and the University of Canterbury (NZ),

together with international visitors including Prof. F. Endres (TU-Clausthal, Germany).

Fruitful discussions arose during the talks and as a result scientific collaborations are in progress.

3rd Australasian Symposium on Ionic Liquids (ASIL-3), Clayton

15-16 MAY 2008

The 3rd in a series of symposia on the properties and applications of ionic liquids attracted around 100 participants from academia and industry, including ACES members from all nodes. Participants from 6 other countries were also present.

Keynote and invited speakers included:

- ▶ Professor Ken Seddon from the Queen's University Ionic Liquids Laboratory, Belfast,
- ▶ Professor Robin Rogers from the University of Alabama/QUILL,
- ▶ Professor Jim Davis, University of Sth Alabama,
- ▶ Professor Frank Endres, TU Clausthal,

- ▶ Dr Nolene Byrne from University of Arizona,
- ▶ Professor Andy Edgar from the University of Leicester.

These speakers and the local participants covered a very broad but nonetheless detailed insight into the current state of the ionic liquids field. A lively poster session allowed students and young postdoctoral researchers to present their work. Congratulations to Shahana Chowdry who won The Best Student Poster Prize and Dr Bronya Clare who received the Endres Prize.

The event was co-hosted by ACES along with the CSIRO Divisions of Minerals, Energy Technology and Materials Science and Engineering. Major sponsorship was received from Merck and the Australian Journal of Chemistry.

Ethics and Bionics Workshops, St Vincent's Hospital and Monash University, Melbourne

15 JULY AND 12 DECEMBER 2008

Two workshops were held by ACES on Ethical issues surrounding the use of nanotechnology during 2008. These were organised by Prof Sue Dodds and Dr Renee Kyle.

The first was an Ethics and Bionics one-day Program on July 15 at St Vincent's Hospital, Melbourne. The aim of the workshop was for staff involved in the Bionics and Ethics Programs of ACES to exchange information on the kinds of research being conducted in each program, and to identify where possible collaborations might be pursued. ACES members from UOW, St Vincent's and the Bionic Ear Institute participated in discussions where a number of ethical issues were passionately discussed. The topics ranged from the distinction between wearable and implantable devices; implications for devices' success,

marketing of bionic devices and similar nanotechnologies; and how such devices/technologies are defined and understood by the public.

Some of the members then talked about their research and what ethical issues they faced, including the role of the media in communicating their research to the general public, and how nanotechnology has the potential to be misrepresented by the media as a 'cure' for diseases. In conclusion, the group agreed on a number of outcomes that could be implemented into the ACES Program to address such issues.

The second ethics workshop was for post-graduate students and early career researchers at the Monash node of the Centre. This was held on Friday 12 December and addressed the fact that scientists and engineers are increasingly faced with numerous ethical issues during the course of their work. These issues occur at all stages of the research and development process, from professional standards and ethics in basic research, extending to the effects of innovation

on society. Facilitated by the ACES Ethics Program, this workshop aimed to encourage critical discussion of those ethical issues that arise in practice of scientific research and engineering as well as the practical application of that work.

Scanning Probe Microscopy (SPM) and Hands-On Workshop '08

28-30 AUGUST 2008

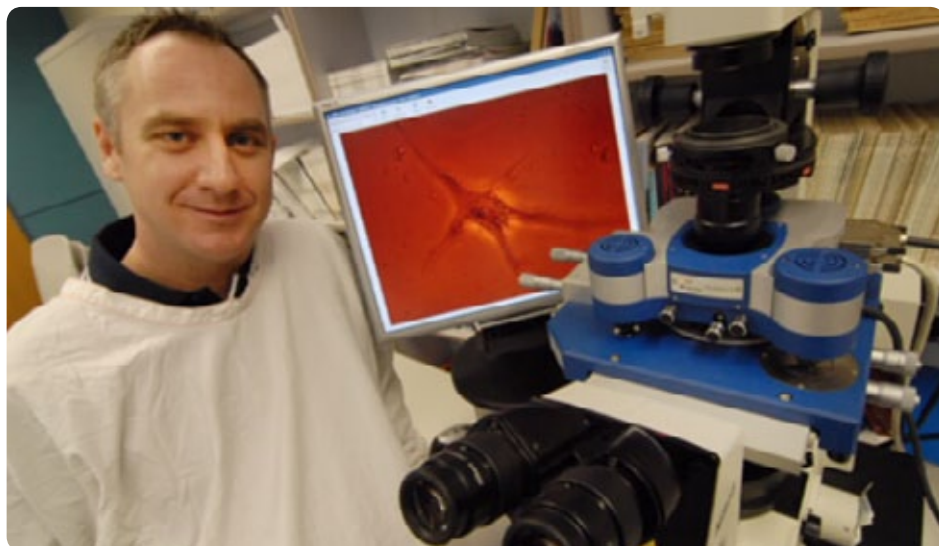
A three-day workshop was hosted by ACES at the Innovation Campus, Wollongong. The program included international and Australian leaders in the field and extensive hands-on sessions with state-of-the-art instrumentation within ACES. The workshop generated an overwhelming response from the Australian SPM and nanotechnology community, with approximately 100 registrants.

The workshop provided a valuable forum where the latest advances in SPM research, including new approaches to SPM nanometrology, nanoscale properties

of novel interfaces/nanomaterials, and designs of emerging nanodevices were presented. Importantly, the workshop also enabled students and early career researchers (who were given free registration) the opportunity to meet and discuss with leaders in the SPM and nanotechnology research field. The final day of the workshop featured a free "hands-on" SPM training session especially for students.

ACES Full Centre Meeting

In-house meetings were held in February (Monash) and September (Wollongong) during 2008. These less formal gatherings allow all ACES researchers to exchange new ideas and current challenges in their own projects in a friendly open event.



Pictured: Dr Michael Higgins demonstrating ACES new SPM capabilities

06

International Profile

ACES continues to attract research scientists (Appendix II) from around the globe and participates in a number of active international research collaborations. During 2008, ACES produced 93 refereed publications, with 30 of these involving international collaborators. The Centre established an international research network that will help realise our scientific ambitions.

The International Consortium of Organic Solar Cells (ICOS), comprising 6 international solar cell research groups and 7 groups from Australian universities and the CSIRO, was created with funding from a DEST International Science Linkages grant (A\$1.4 million p.a.) in 2007. ACES researchers at both Monash University and the University of Wollongong play a leading role in this world-class Consortium, which provides access to a wide variety of materials and facilities for the development of organic solar cells.

In 2008, as well as visits to all the international ICOS partner laboratories, ACES researchers developed a three-way collaboration on porphyrin solar cells with researchers at Imperial College London and the University of Otago. This has led to significant new insights into dye-sensitised solar cells.

International Symposia Hosted/ Co-hosted by ACES

1st Asia-Pacific Nanobionics Symposium

IC CAMPUS, UNIVERSITY OF WOLLONGONG, 22-25 JUNE 2008

ACES hosted the first Asia-Pacific Nanobionics Symposium at the University of Wollongong's new Innovation Campus in June. The symposium attracted over 150 delegates from the USA, China, Japan, Italy, Ireland, Korea, Singapore, France, New Zealand and all states of Australia. Several delegates from non-university sectors were also present; including Cochlear, Continence Control Systems International, eDAQ Pty Ltd, Krestal Capital, SciVentures and Nippon Telegraph and Telephone Corporation, Japan.

Vice-Chancellor Professor Gerard Sutton, in his welcome, said the symposium created history by being the first event held at the new campus and that the symposium represented a partnership between research, industry and commerce, which are three key aspects the Innovation Campus will bring together. The CEO of the Australian Research Council, Prof Margaret Sheil, gave the opening address before the keynote address and public lecture by Prof Graeme Clark which took the audience into a world where restoration of our senses is a distinct possibility.

World class researchers discussed how 'Nanobionics' is an area that could potentially bridge the gap between the

traditional science areas of engineering-based nanotechnologists and the biological-medical field of bionics.

The symposium was supported by iC Central, the Australian Academy of Science, the Australian Research Council, the NSW Office for Science & Medical Research and the Australian Research Council Nanotechnology Network who subsidised the attendance of students and early career researchers.

International Workshop on Preparation and Characterisation of Battery Cells

IC CAMPUS, UNIVERSITY OF WOLLONGONG, 24-25 JULY 2008

In July 2008, ACES conducted an international workshop in the field of batteries. Delegates (43), including guests from industry, CSIRO, ANSTO and international collaborators, were privileged to hear leading national and international speakers from Australia, China, Singapore, Japan, Korea, Taiwan and Hong Kong discuss recent advances in research, development, and practice in batteries. The range of topics discussed included advances in the lithium ion battery, flexible electrodes, polymer electrodes, novel cathode materials and advanced electrodes for energy storage, with the focus on the nanostructure of the materials.

17th International Conference on Photochemical Conversion and Solar Energy Storage

SYDNEY CONVENTION CENTRE, SYDNEY, 27TH JULY – 1ST AUGUST 2008

In mid-2008, ACES co-hosted the 17th International Conference on Photochemical Conversion and Storage of Solar Energy (IPS17) in Sydney, bringing together the best international solar researchers, industry personnel and funding bodies to provide a catalyst for the rapid exploitation of cutting edge solar energy research as well as the opportunity for industry involvement in the direction of new energy technologies.

Having the IPS-17 Conference in Sydney presented the opportunity to invite the plenary and invited speakers, and other delegates of IPS-17, pioneers and world leaders in solar energy conversion, to participate in an **Energy Forum Meeting** hosted by ACES at the University of Wollongong on the Sunday the IPS-17 conference started. Twenty conference delegates were bused to both the IPRI laboratories on the main UOW campus and the Innovation Campus to showcase IPRI and ACES research, the new IPRI laboratories at the Australian Institute for Innovative Materials (AIIM), to facilitate interaction and discuss worldwide trends in research and funding opportunities.

International Conference on Electronic Materials 2008

HILTON HOTEL, SYDNEY, 27TH JULY – 1ST AUGUST 2008

ACES organised the Symposium Q on Polymeric Materials and Organic Electronics at ICEM 2008 in Sydney. This MRS-type conference was attended by over 1000 delegates including a number of ACES student researchers. These students participated in a conference event, the Global School for Advanced Studies organised by Professor Bob Chong of Northwestern University, in which both Australian and international students were asked to develop a joint research project on solar cells.

Collaborations by Country

AUSTRIA - ACES was invited to be an international member of a sister organisation in Austria, the K1 Centre for Electrochemical Surface Technology (K1-CEST). The partnership agreement is currently being settled. Once this takes place it is planned that exchange of personnel will be able to take place freely between the two Centres.

CANADA - A visit to Wollongong in July by Prof John Madden from the University of British Columbia (UBC) marked the start of joint work to create photovoltaics that incorporate photosynthetic proteins. These light harvesting proteins will replace porphyrins and other dyes in dye-sensitized solar cells. The joint venture attracted CND\$450,000 funding from the National Sciences and Engineering Research Council of Canada Special Research Opportunity grant and will involve exchange of researchers between ACES and UBC.

Collaborative work with Prof. Savadogo from the Université de Montréal for a fuel-cell project (ARC LP) is continuing.

CHINA - ACES continued to consolidate linkages in China during 2008, including the establishment of a jointly funded Research Fellow with the Institute of Chemistry at the Chinese Academy of Sciences.

In April, Associate Prof Chee Too (CI ACES) and Dr Jun Chen (RF, ACES) visited Prof Zi-Feng Ma of Shanghai Jiao Tong University (SJTU) to kick off a three-year DEST ISL Australia-China project on "Nanostructured Electromaterials for Direct Alcohol Fuel Cell". Project milestones and exchange visits of personnel were discussed. SJTU is ranked fourth in China and the Chinese Government has invested RMB 3 billion on constructing the campus that provides tertiary education for over 40,000 students.

Collaborative links with Shanghai Jiao Tong University were further strengthened by an extended visit of an ACES PhD

student (Weimin Zhang) to Prof Ma's laboratories to examine new electrodes developed at ACES for use in fuel cells.

Professor N. Yanna, also from Shanghai Jiao Tong University, received a Chinese Government Award to visit ACES, and completed his year-long stay in March 2008. Two joint papers on lithium rechargeable batteries were published in refereed journals in 2008.

Further collaborative studies in the electrocatalysis area involved a 12-month stay at ACES by Aijian Zhang (from East China Normal University) to develop new electrodes for electrochemical reduction of carbon dioxide. Prof Wallace and Dr Jun Chen visited East China Normal University and met with Prof. Lu who is the supervisor of Aijian Zhang.

Dr Jian Wu (RF) participated in the 2007-08 Scientific Visits to China exchange program on a 21-day exchange for her project which aims to develop new materials and technologies based on conducting polymers and carbon nanotubes. The proposed applications of



Aijian Zhang (2nd from right), from East China Normal University, with some of her fellow students she met during her stay at ACES.

conductive polymer-coated fabrics are many, including static dissipation, military applications, strain gauge performance and energy storing fabrics. Dr Wu visited Prof Yongfang Li and Prof Daoben Zhu at the CAS Institute of Chemistry at Tsinghua University in Beijing as well as the School of Materials Science and Engineering at the Beijing University of Science and Technology. Dr Wu's visit to these Chinese institutes helped to establish a relationship between ACES and Prof Li and his group at the CAS Institute of Chemistry. This collaboration will allow Dr Wu to develop contacts and provide a market in China for 'wearable strain gauges'. The collaboration aims to improve the capacity to exploit new technologies in China and build productive industry, science and technology alliances between China and Australia.

In November, Prof Wallace and Dr Chen visited the Institute of Chemistry (Chinese Academy of Sciences) in Beijing – a wonder world of chemistry with over 800 PhD students. ACES/IPRI has established a joint postdoctoral Research Fellowship

with the Institute of Chemistry to work in the area of new electrodes for biofuel cells.

Dr Jiazhao Wang (ACES, RF) received a travel award and visited the Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences Guangzhou. Dr Zaiping Guo (ACES AI) also received a Tianshan scholarship award and visited the Applied Chemistry lab at Xinjiang University.

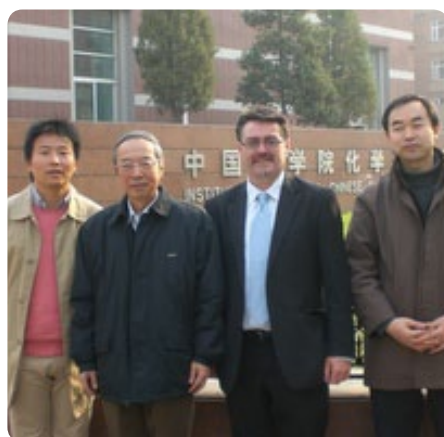
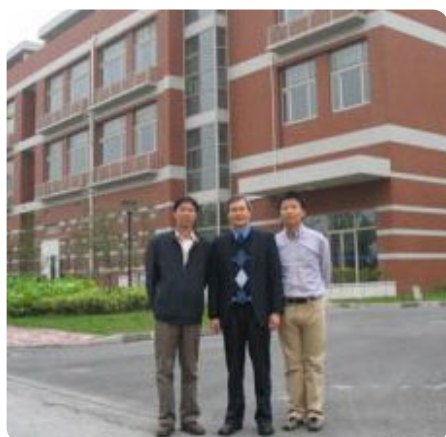
In June, Prof Hua Kun Liu was offered an Honorary Professorship and visited both the Electrochemistry Lab at Hubei University and the Materials Technology Lab at Shanghai University. During the year, ACES hosted Prof Chunqi Feng from Hubei University working on 'Advanced materials for lithium batteries' and Prof Ying Li from Shanghai University, who received an Australia-China grant. In addition, three kinds of nanoparticles, made under magnetic field at the Shanghai University, are currently being investigated by ACES. The

preliminary results were presented at the 'International Battery Workshop' in July 2008.

Ms Limei Fang, a PhD candidate from the University of Electronic Science and Technology of China, received funding through the China Scholarship Council and visited ACES for a 12 month period beginning in May 2008.

Prof Yong Yang (Xiamen University), Prof Jun Chen (Nankai University) and Prof Yuping Wu (Fudan University), who are experts in the lithium rechargeable batteries field, supported the International Battery Workshop hosted by ACES in presenting invited talks.

DENMARK - The collaboration between ACES and the Technical University of Denmark (DTU), established in 2007, was expanded this year by a visit by Dr Jun Chen (ACES) for four weeks in September. The visit was funded by the Australian Government Department of Innovation, Industry, Science and Research's International Science Linkages – Science Academies Program under



Pictured left: Outside the Fuel Cell Research Building at SJTU, (left to right): Prof Zi-Feng Ma, Associate Professor Chee Too, Dr Jun Chen

Pictured right: in Beijing visiting the Institute of Chemistry (Chinese Academy of Sciences), (left to right): Jun Chen, Daoben Zhu, Gordon Wallace and Lanqun Mao,

the 'Scientific Visits to Europe' program. During his visit, Dr Jun Chen established collaborative research with the Danish Polymer Centre on the linkage project "Electroactive Nanoporous Polymers for Catalytic Application". He also gave oral presentations at DTU, Risø National Laboratory (Denmark) and the University of Copenhagen.

FRANCE - To extend research on carbon nanotube biocomposites, in collaboration with Dr Philippe Poulin at CNRS Bordeaux, Dr Simon Moulton (ACES/IPRI) was one of over a hundred leading Australian scientists awarded a scientific grant to undertake important international collaborative research under the International Science Linkages – Science Academies Program 2008-2009. This will allow Simon to travel to and work at CNRS in 2009 to follow up on his previous stay at CNRS Bordeaux early in 2007 and the visit to ACES by PhD student Lucy Viry, from CNRS Bordeaux in late 2007. Simon will also visit Prof

Eric Anglaret at University Montpellier II in order to develop aligned carbon nanotube biomaterial structures.

Solene Pelleau from the University of Nantes visited Monash University for three months to work on the magnesium batteries project under the supervision of Dr Bjorn Winther-Jensen, investigating a range of new electrolyte compositions using galvanostatic and impedance techniques.

GERMANY - Dr Andrew Minett visited research collaborators and presented talks at institutions in Germany during 2008. He visited Professor Siegmur Roth at the Max-Planck-Institut fuer Festkoerperforschung, and Sineurop Nanotech GmbH (both in Stuttgart), to discuss carbon nanotube electrode formation.

INDIA - ACES personnel continued to develop a number of collaborations with Indian groups, including CSIR Chennai, Bombay Atomic Research Centre and the University of Delhi.

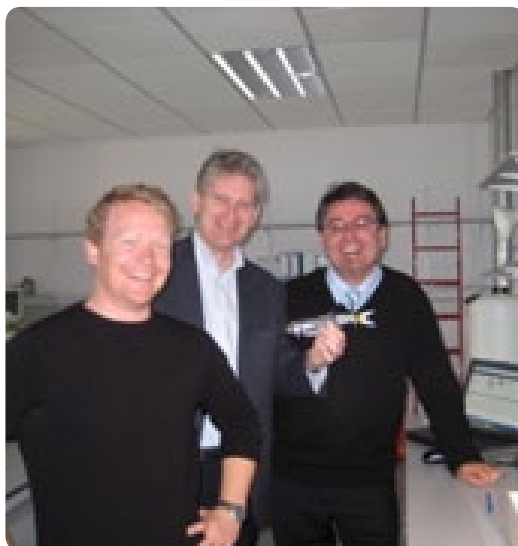
Professor Doug Macfarlane presented an invited talk at the 3rd International Conference on Electroactive Polymers in Jaipur in October.

IRELAND - Our highly active collaborative research program with Dublin City University (DCU) continued to grow in 2008. Supported by an ARC Linkage International Grant, a number of exchange visits resulted in: the development of novel micro-fluidic control systems; further advances in the autonomous low powered mobile sensing fish; an application of ink-jet printed materials as sensors; development of new photo-electrochemical systems to be used as sensors; and the use of functionalised antibodies as sensing materials.

In March, Dr Scott McGovern and Prof Gordon Wallace from ACES visited Dublin City University as part of on-going collaborative studies supported by an ARC Linkage Grant. The work involves the use of new electromaterials in the development of novel fluid movement

Pictured left: Dr Scott McGovern (left), Prof Dermot Diamond (centre) and Prof Gordon Wallace (right) at DCU

Pictured right: Prof David Officer presenting at the International Symposium on Solar Cells



and sensing systems. The team aims to develop an autonomous low powered mobile sensing fish.

Dr Minett spent 10 days in Dublin visiting collaborators at Trinity College Dublin (TCD) and Dublin City University (DCU). At TCD, discussions on existing collaborations with Professors Jonathan Coleman and Werner Blau continued, and new collaborations with Assoc Prof Georg Duesberg and Dr Vojislav Krstic were launched in the area of carbon nanotube nanoparticle composites. At DCU, Dr Minett discussed functionalising carbon nanotubes with Dr Carol Lynam.

ACES links with DCU led to six refereed publications during the year.

JAPAN - ACES researchers maintain a number of links with Japanese research groups in the electrochemistry and device areas, including with Yokohama University, Sophia University and Tokyo University of Technology. Exchange of personnel and materials took place regularly through 2008.

A collaborative research agreement signed between Shinshu University, Japan, and the University of Wollongong to carry out fundamental spectroscopic studies of organic solar cell materials resulted in a high impact journal communication during the year.

Associate Prof Shogo Mori's group at Shinshu University has expertise in electron injection, recombination and charge transport measurements in dye-sensitised photo-electrochemical solar cells. Such measurements performed using a range of porphyrin dyes developed within ACES continue to provide valuable insights into ACES research programs on dye synthesis (P1) and solar energy conversion (P2).

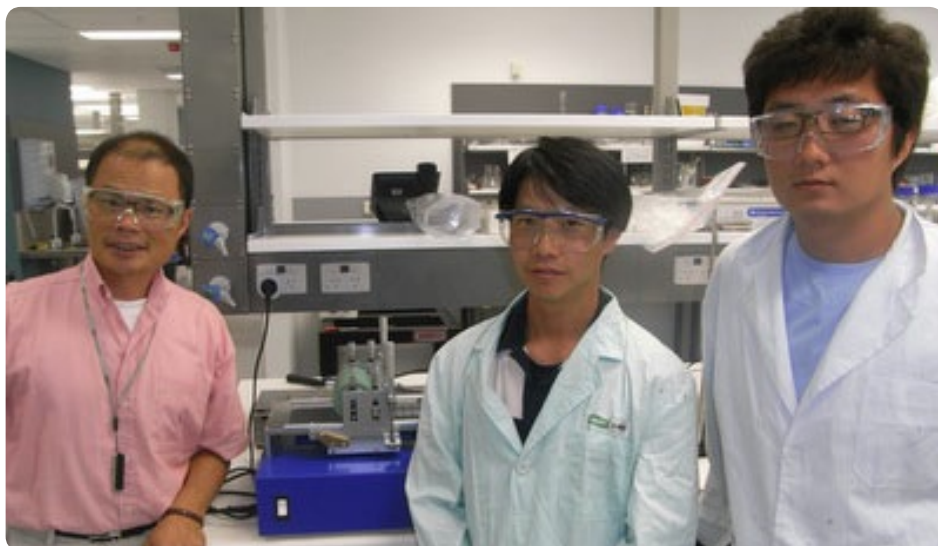
ACES researchers have established a state-of-the-art charge mobility and lifetime setup at the AIIIM building in Wollongong and have expertise to measure charge mobility and lifetime in polymer / fullerene bulk heterojunction solar cells. A second part of the agreement with Shinshu University focused on further developing these

measurement techniques into a unified organic solar cell characterisation setup and to advise our Japanese collaborators on these measurement techniques.

A number of research staff and students have been exchanged between the labs, including a visit by Shogo Mori and Dr Katoh of AIST, Japan in June and a two-month occupational trainee program by Kenji Sunahara to ACES.

KOREA - Important strategic research linkages continue to grow in Korea. Links with both Hanbat National University (Prof Jang Myoun Ko) and Hanyang University (Prof Seon Jeong Kim) produced significant outputs in 2008 in the area of polymer-based capacitors and new artificial muscle technologies, respectively.

With strong interest in solar cell research developing in Korea, Hanbat University held an International Symposium on Solar Cells in June, organised by Prof Ko for the opening of a new renewable energy centre at Hanbat. Prof David Officer was one of six invited speakers and he was



Dr Byung Chul Kim (left) of ACES, Mr Hwi Won Kang (centre) and Mr Gwang Yong Lee (right).

interviewed by the local Daejeon television network about the benefits of solar energy for Korea.

The strong links with Hanbat University also led to an invitation to Prof Officer to attend and chair a session of the 5th World Technopolis 2008 University Presidents Forum in Daejeon in October.

Prior to this, Prof Officer visited the Information Display Research Institute at Daejin University, Seoul and signed a Memorandum of Agreement on collaboration. After presenting an overview of ACES research and touring the impressive IDRI clean room facilities, Prof Jae-woong Yang and Prof Officer discussed future areas of collaboration.

Links with Sunchon National University (Prof Gyou-Jin Cho) were also further developed during the year. Prof Officer visited Suncheon in June and presented a lecture on ACES solar cell research. This was followed by a collaborative research visit to Wollongong by two Korean students, Hwi Won Kang and Gwang

Yong Lee, from December 2008 to February 2009 to work on ink jet printing and reel-to-reel printing technologies.

In April 2008 Prof David Officer and Dr Bynug Chul Kim, from ACES attended a meeting between members of a Korean delegation from Gangwon Province and NSW Government officials and science and technology company members and representatives.

The main aim of the meeting was the signing of a technology collaboration agreement between Gangwon Province and NSW by Science Minister Verity Firth and Seung-Ho Han, Director of the Gangwon Technopark/Regional Innovation Agency, in order to create a technology cooperation framework within which there will be a collaborative grant program to support joint proof-of-concept projects between researchers and/or companies from both regions. Priority areas in this agreement will be medical devices, information and communication technologies, advanced materials and biotechnology.

Following the signing ceremony, Prof David Officer presented relevant aspects of ACES research work to members of the delegation and discussed areas of future collaboration. Dr Sang-Yeop Park, the Director of the Gangwon Technopark Ceramic Cluster Agency, expressed an interest in hosting a visit by members of ACES to Gangwon.

An exciting development already from the above interactions has been a successful application for an ARC Linkage International collaborative grant. The NSW and Gangwon government will together contribute a total of AUD \$100,000 to assist a joint research team from ACES and Kangnung University's Department of Ceramics Engineering to develop a new high performance energy storage device for use in mobile phones, personal digital assistants and digital cameras.

Dr Zaiping Guo (ACES AI) received a Visiting Prof award and visited the Battery research lab at Gyeongsang National University from April to June.

Pictured left: NSW Science Minister Verity Firth (centre) and Seung-Ho Han (right)

Pictured right: Prof David Officer (left) and Dr Jae Cheon Sohn (right) who is Team leader, Gangneung Science Industry Foundation



Prof Hyo-Jun Ahn, Prof Ki-Won Kim and three students from Gyeongsang National University visited ACES in Wollongong and supported the 'Battery workshop' in July, as well as Prof J-H Ahn from Andong National University.

NEW ZEALAND - Interactions with Associate Prof Keith Gordon (University of Otago) continue to be highly productive, with material synthesis/characterisation and device construction at the University of Wollongong linking with quantum mechanical calculations and Raman spectroscopy at the University of Otago. Projects include research on solar cells jointly with Imperial College London researchers (ICOS) and Japanese collaborators, as well as the development of novel functionalised polythiophenes and new materials for electroluminescence. Mr Michael Fraser visited ACES for two months following the IPS-17 conference in July and both Prof Officer and Dr Attila Mozer visited Otago in November, all part of the ICOS interaction.

Prof Officer continues to interact with researchers at both Otago University and Massey University on both a New Zealand Royal Society Marsden grant and a Foundation for Research Science and Technology International Investment Opportunities Fund (IIOF) grant. Prof Officer visited Massey University twice in 2008 as part of these interactions.

Eight researchers from ACES presented their work in the areas of bionics, fibre spinning, drug delivery, graphene and polythiophene chemistry at the 2nd Alan MacDiarmid Symposium, hosted by The Alan MacDiarmid Institute, Victoria University, Wellington, New Zealand in April. To honour the memory of Alan, the nature of the Symposium was relaxed with an emphasis on fostering collaborative discussion.

SINGAPORE - Prof Gordon Wallace visited the Institute of Materials Research and Engineering (IMRE) in Singapore in March. The visit was hosted by Dr Alan Sellinger - a collaborator on the DEST funded linkage project - ICOS - on development of new solar cells.

Prof. Wallace delivered a seminar on "Nanostructured Electromaterials from Solar Cells to Living Cells". The development of collaborative research links with IMRE continued to be explored in a number of areas.

THAILAND - Prof David Officer, Dr Attila Mozer and Dr Andrew Minett were invited to present their research at a two-day Symposium on Conducting Polymers, Carbon Nanotube Composites and Applications at Chiang Mai University in June. The symposium was organised by Associate Prof Sukon Phanichphant on behalf of the Center of Nanoscience and Nanotechnology Program at the Faculty of Science, Chiang Mai University. Prof Phanichphant is a collaborator of ACES and mentor to many past and present ACES post-graduate students.

In addition to the three Wollongong participants, the symposium involved seminars by internationally recognised researchers Prof David Carroll (Wake Forrest University, USA), Prof Thomas Randall-Lee (University of Houston, USA), and Dr Akira Baba (Niigata



ACES researchers at the 2nd Alan MacDiarmid Symposium in Wellington NZ

University, Japan). Two panel discussions about the latest research on conducting polymers and carbon nanotubes were organised with participants from Chiang Mai University as well as other Thai universities and industries.

UNITED KINGDOM - Prof Maria Forsyth spent several months on sabbatical leave at Warwick University collaborating with Dr Mark Smith and colleagues. As part of an EPSRC Fellowship, Prof Forsyth spent a significant period working in collaboration with Professor Smith as well as Dr. Alison Davenport and Dr Melanie Britton (Birmingham University) on developing NMR characterisation techniques for electromaterials.

She also gave invited seminars at Cambridge, Oxford, Leicester, St. Andrews and Bath Universities.

As part of the ICOS programme, Prof Officer visited Profs James Durrant and Ian McCulloch at Imperial College as well as Dr Martin Heeney at Queen Mary College, University of London in October. These visits followed his presentation of an invited lecture at the 2008 Plastic Electronics Conference in Berlin. During the Imperial College visit, a draft of the first joint ICOS publication between Imperial College and ACES researchers was developed.

USA - Dr Philip Whitten continued research in collaboration with members of Prof Richard Kaner's group at UCLA on polyaniline nanofibres (resulting in a publication in *Advanced Materials*). During a visit to UCLA in March, he spent three days working in Prof Kaner's laboratory. Findings and discussions from this visit will produce further significant publications in the future on the

production and application of polyaniline nanofibres. A novel method for producing coatings of polyaniline nanofibres was also studied.

ACES was well represented at the American Chemical Society meeting in Philadelphia, where Prof MacFarlane, Drs Jenny Pringle, Patrick Howlett and Steve Pas presented five invited talks. Dr Howlett also gave two invited talks at the Electrochemical Society meeting in Hawaii in October.

Links with the University of Texas at Dallas (UTD) were expanded during 2008. An extended visit by ACES PhD student Javad Foughi led to the development of a novel carbon nanotube – conducting polymer hybrid. Visits from Prof Anvar Zhakidov and Josef Velton (from UTD) to Wollongong enabled collaborative studies in novel solar cells to be initiated.

Further collaborative links were developed with Prof Paul Calvert at the University of Massachusetts at Dartmouth, following a visit by an ACES PhD student Charles Mire from October to November. He was able to see first hand how the Massachusetts group uses printer systems to deposit conducting and functional materials or stem cells onto fabric or other flexible substrates to produce sensors, actuators, hydrogels, biomaterials, and other novel structures. Charles is assessing the capabilities of their printer systems with respect to his research at ACES.

An ARC Linkage International Award for Prof Calvert to undertake research here in ACES/IPRI in 2009 on inkjet printing bio-functional materials was successful. (LX0989950: Prof GG Wallace; Dr MP in het Panhuis; Prof P Calvert).

Prof Gordon Wallace travelled to Boston Scientific in Minneapolis in late September to further collaborative research links in areas such as advanced heart stents.

Mr John Dymon from Prof. Anna Larsens' group at Ithaca College, New York, USA, visited ACES to investigate the electrochemical properties of some novel carborane ionic liquids being synthesised at Ithaca.

In January, Prof Officer visited both Cornell University and Georgia Institute of Technology and, following invited presentations on ACES solar cell research work, discussed future collaboration under the ICOS programme. This resulted in functionalised polythiophene materials being sent to Cornell for photoconduction measurements.

Invited International Presentations

ACES personnel delivered 39 invited presentations at international conferences in 2008 (Appendix III). Several of the invited presentations are highlighted below.

- ▶ Dr Patrick Howlett gave an invited presentation on lithium batteries at the 2008 Pacific Rim Meeting on Electrochemical and Solid-State Science held in Honolulu, Hawaii in October.
- ▶ Dr Andrew Minett presented an invited talk titled 'Modification of carbon nanotube architectures for alternative energy applications' at the 22nd International Winterschool on Electronic Properties of Novel Materials (IWEPMN), in Austria, 1-8 March 2008. IWEPMN is held annually and is an important meeting of pre-eminent nanomaterial scientists. The Winterschool provides a platform for reviewing and discussing new developments in the field of electronic properties of molecular nanostructures and their applications.
- ▶ Dr. Joselito Razal presented his work on wet-spinning of carbon nanotube biofibres (published in *Advanced Functional Materials* 2008, 18, 61-66) at the ChemOnTubes Conference held in Zaragoza, Spain on April 6 - 9. After the conference, Dr. Razal worked with Dr. Edgar Muñoz and Dr. German de la Fuente Leis at the Instituto de Carboquímica on producing new metal-carbon nanocomposites by laser ablation of organometallic compounds. International collaboration on utilising these new carbon nanostructures for catalysis applications is now underway.
- ▶ Dr Philip Whitten (invited talk), Dr Scott McGovern and PhD candidate Stephen John represented ACES at the 15th Annual SPIE Smart Structures and NDE Conference. These key researchers in the field of polymer actuators went to San Diego, CA to wow the audience with the novel technologies that they are producing based on the controlled expansion and contraction of conducting polymers, carbon nanotubes and polymer gels. A video was produced by Associate Press (AP) during the EAP-in-Action Session of the SPIE's 2008 EAPAD Conference held in March featuring Dr Scott McGovern and can be viewed at <http://cosmos.bcst.yahoo.com/up/player/popup/?cl=7064054>
- ▶ Prof Gordon Wallace delivered an invited lecture to the MRS Spring Meeting in San Francisco on 25 March. His talk, "Organic Conducting Polymers and Living Cells – New Platforms for Medical Bionic Devices", was part of the Symposium AA: 'Conjugated Organic Materials – Synthesis, Structure, Device, and Applications' which was one of the biggest ever symposium hosted by the MRS.
- ▶ In January, Dr. Joselito Razal presented an invited plenary talk on the importance and applications of interfacing organic conductors with living systems at the 10th Eurasia Conference on Chemical Sciences (EuAsC2S) in Manila, Philippines. The conference was organized to emphasize scientific activities in the Eurasia continent and the developing Asian countries, achieving support from other continents such as America, Canada and Australia.
- ▶ Dr Patrick Howlett was an invited speaker at the 236th American Chemical Society National Meeting, held in Philadelphia, Pennsylvania (August) and spoke on "Interphase Formation on Reactive Metal Surfaces in Ionic Liquids". Dr Jun Chen also gave an invited talk titled "Conducting Polymer and Carbon Nanotube Architectures for Electrocatalysis".
- ▶ PhD student Javad Foroughi gave his talk "How artificial muscles can be improved using polypyrrole" at NanoTxUSA08, Dallas, Texas, October.
- ▶ Prof HK Liu gave an invited talk at the Eastern Forum at Shanghai University on 9 June about "Nano-materials for energy storage applications".
- ▶ Prof HK Liu visited Hubei University on June and gave an invited talk about "Advanced materials for energy storage applications" in the Li-ion battery and for hydrogen storage.
- ▶ Prof Hua Liu was a member of the Scientific Advisory Committee and Awarding Committee of the 8th China International Battery Fair (IMLB2008) which also incorporated the 14th International Meeting on Lithium Battery. She was also co-chair of the poster session 2 held on 24 June at this event.
- ▶ Prof Maria Forsyth and Prof Doug Macfarlane presented invited talks at the Ionic Liquids in Electrochemical Devices Symposium held in Rome in June.
- ▶ Prof Forsyth presented an invited talk at the International Symposium on Polymer Electrolytes in Portugal in August.
- ▶ Prof Doug MacFarlane presented a Plenary lecture at the EUCHEM meeting on molten salts and ionic liquids in Copenhagen in August.
- ▶ Prof David Officer, Dr Attila Mozer and Dr Andrew Minett were invited to present their research at a two-day Symposium on Conducting Polymers, Carbon Nanotube Composites and Applications at Chiang Mai University in June.

- ▶ Prof David Officer visited Cornell University in January and presented an invited lecture entitled "Artificial Photosynthesis: New Structures for Light Harvesting".
- ▶ Prof David Officer visited the Georgia Institute of Technology in January and presented an invited lecture entitled "Designing Light Harvesting Dyes for Organic Solar Cells".
- ▶ Prof David Officer presented an invited lecture at the International Symposium on Solar Cells in June at Hanbat National University entitled "Developing New Materials for Organic Solar Cells".
- ▶ Prof David Officer presented an invited lecture in June at Sunchon National University entitled "Developing New Materials for Organic Solar Cells".
- ▶ Prof David Officer presented an invited lecture at the IPS-17 conference in Sydney in July entitled "Towards Artificial Photosynthesis: Light Harvesting Using Porphyrins".
- ▶ Prof David Officer presented an invited lecture at the 2008 Plastic Electronics Conference in Berlin in October entitled "Artificial Photosynthesis: New Structures for Light Harvesting".
- ▶ Prof David Officer visited Imperial College London in November and presented an invited lecture entitled "Porphyrin Dye-sensitised Solar Cells".
- ▶ Prof David Officer visited Queen Mary College, University of London, in November and presented an invited lecture entitled "Developing New Materials for Organic Solar Cells".

07 Outreach Activities

In 2008, ACES received substantial media attention totaling 30 print, 807 websites, 28 radio and 12 television reports (Appendix IV). Several outreach activities are highlighted below.

ABC Radio National: Boyer Lecture Series

November – December 2007

Taken from : www.abc.net.au/rn/boyerlectures/

This year marks the 48th anniversary of the Boyer Lectures. Professor Graeme Clark creator of the bionic ear, is ABC Radio National's Boyer lecturer for 2007. In this series of six lectures beginning 11 November and last one on 15 December, Professor Clark draws on decades of experience as a clinician, surgeon and researcher to celebrate our senses. He also tells the compelling story of how the bionic ear was created, and provides an insight into the extraordinary future of bionics.

In the introduction to his first lecture Professor Clark provides his own overview of what he will discuss in this lecture series.

In *Restoring the Senses* I want to highlight the importance of our senses, and how they can be restored with bionics. In the course of the first lecture, I hope you will appreciate the amazing way our senses function. Then in the second lecture, discover how we are affected by the loss of any one of these senses, as they are the only way we experience the world around us. In the third lecture I will explain how I set out to restore the

sense of hearing. In lecture four we will learn how the bionic ear became a reality for those severely and profoundly deaf people who had hearing before going deaf. In the fifth lecture we will discover that children born deaf can use a bionic ear to develop normal spoken language. Finally, in the sixth lecture we will learn how bionic ear research has created a new field of Medical Bionics, which I hope will eventually lead to a bionic eye for blindness, a bionic spinal cord, and bionic nerve repair to help restore the senses of touch and movement.

- ▶ Lecture 1: Exploring the World Around Us
- ▶ Lecture 2: Loss of Contact
- ▶ Lecture 3: Pushing Back a Frontier in Medicine
- ▶ Lecture 4: Imagination Becomes a Reality
- ▶ Lecture 5: Brain Plasticity Gives Hope to Children
- ▶ Lecture 6: Shaping the Future

Focus on 'intelligent materials' launches the Research Strength Showcase Series

March 2008

The inaugural lecture for the Research Strength Showcase Series was today (12 March) presented by Professor Leon Kane-Maguire from the Intelligent Polymer Research Institute (IPRI) at the University of Wollongong.

The Research Strength Showcase Series is a new lunchtime lecture series aimed to provide an opportunity to showcase the

research conducted within each of UOW's 'research strengths' areas, and introduce the researchers involved to the general campus and the community.

Researchers at IPRI have been actively exploring new nanomaterials for two decades, learning many of the secrets of their properties/capabilities and developing effective methods for their processing and integration into 'intelligent' devices.

More recently, the multidisciplinary IPRI team (encompassing chemists, materials engineers, biologists and collaborators in medicine and physics) has successfully coupled these electromaterials with natural and synthetic biopolymers to produce new hybrid materials that can bridge the bionic interface – providing a more effective conduit between electronics and biology.

In his talk, Professor Kane-Maguire described the exploitation of the unique chemical, electronic and mechanical properties of nanomaterials by IPRI researchers in a range of exciting areas such as chemical and biochemical sensors, artificial muscles, solar cells, plastic batteries and smart fabrics.

A particular focus of his talk was on recent groundbreaking developments in the nanobionics area, where these advanced electromaterials are being exploited in applications such as nerve cell regeneration in the bionic ear and in damaged spinal cord.

NSW Government Inquiry into Nanotechnology in NSW

March 2008

On March 17th, members of the Standing Committee on State Development, undertaking the "Inquiry into Nanotechnology in New South Wales", visited ACES (IPRI). Professor Gordon Wallace and Professor Susan Dodds addressed the committee at Wollongong highlighting the technical opportunities as well as the important ethical issues arising from nanotechnology research. Research staff were available for discussion with the committee members. The visiting committee members were:

- ▶ The Hon Tony Catanzariti MLC (*Chair*) (Australian Labor Party)
- ▶ The Hon Matthew Mason-Cox MLC (Liberal Party)
- ▶ Revd The Hon Fred Nile MLC (Christian Democratic Party)
- ▶ The Hon Christine Robertson MLC (Australian Labor Party)

- ▶ The Hon Mick Veitch MLC (Australian Labor Party)

UOW celebrates GerMANY connections

May 2008

Dr Andrew Minett presented a talk at GerMANY Innovations. The talk was titled '*Alternative energy applications of nanostructured carbon-based materials*' and highlighted research carried out by Dr Minett that began with his post-doctoral research at the Max-Planck-Institut fuer Festkoerperforschung in Stuttgart, culminating with his current research in conjunction with colleagues at the Intelligent Polymer Research Institute and ARC Centre of Excellence for Electromaterials Science. GerMANY Innovations 2008 was a joint initiative of the German Consulate, German industry and cultural organisations and the University of Wollongong. The mix of serious and social events on the program was designed to allow students, staff and the general Illawarra community to get involved.

Inaugural Australian Research Council (ARC) Graeme Clark Research Outcomes Forum

June 2008

The keynote address at the inaugural Australian Research Council (ARC) Graeme Clark Research Outcomes Forum was given by Professor Graeme Clark AC "*The Cochlear implant: A model for bio-medical innovation and industrial development*"

The inaugural Australian Research Council (ARC) Graeme Clark Research Outcomes Forum, was held in Canberra. The forum brought together 20 top ARC-supported researchers to demonstrate – in plain English – how their work is 'making a difference' to the world in which we live.

"Research is generally a slow business, there's no doubt about it," ARC Chief Executive Professor Margaret Sheil says. "How many times have you heard about a 'breakthrough' that is expected to lead to a

Professor Graeme Clark (centre) who presented the Public Plenary Lecture at the inaugural Asia-Pacific Symposium on Nanobionics on Sunday June 22 flanked by symposium co-chairs Professor Robert Kapsa (left) from St Vincent's Hospital Melbourne and Professor Gordon Wallace (UOW).



result in five to 10 years? The news is full of these items – now we have an opportunity to find out what happened next.

“The results of a lot of innovative and exciting Australian research do have a positive and significant impact on our lives today. Even if we don’t always realise it, Australia definitely *is* a clever country.”

Professor Sheil says that it is important to recognise Australia’s research talent, and seek to foster and strengthen opportunities for researchers in the public and private sectors, industry, academia and the wider community.

“Our researchers are a valuable resource. Their work has a profound impact on our wellbeing as individuals and as a nation,” she says. “The Graeme Clark Research Outcomes Forum is a way of showcasing some extraordinary Australian research projects that have achieved real world outcomes and making research accessible to a general audience, with the help of Master of Ceremonies Adam Spencer.”

It was in the 1960s that Professor Graeme Clark AC started the research that led to the Cochlear implant, which has brought hearing to tens of thousands of people around the world. Now in his 70s, Professor Clark is continuing his research in the field of medical bionics, with a focus on infection control using implanted devices, the correction of nerve and spinal cord injuries, and the treatment of drug resistant epilepsy.

Public Plenary Lecture - “Interfacing the World to Human Consciousness” given by Professor Graeme Clark

June 2008

A Public Plenary Lecture on the topic “Interfacing the World to Human Consciousness” was given by the inventor of the bionic ear, Professor Graeme Clark at the inaugural Asia-Pacific Symposium on Nanobionics, hosted by the ARC Centre of Excellence for Electromaterials Science, at UOW’s Innovation Campus.

The bionic ear is a prime example of one successful application of nanobionics research. The device uses an electrode array inside the cochlea to electrically stimulate nerve endings to transmit the appropriate signals to the brain.

Conducting, intelligent polymers have contributed greatly to the field of nanobionics. These conductors are often biocompatible, and are therefore ideal for bridging interfaces between biology and electronics. Spinal cord prostheses, in development under the ARC Centre of Excellence for Electromaterials Science program, aims to use intelligent polymers to promote nerve growth in spinal cord repair.

Innovation Campus Open!

June 2008

During the opening, Premier Lemma said that the Innovation Campus itself represented a success story of government, business and academia forming strong partnerships and working towards “a better future for the children and grandchildren of today.”

The Innovation Campus is a research and development precinct that represents an eventual investment of \$500 million. The \$32 million iC Central building that opened today is the first of an anticipated 25 buildings on the site. Three others are currently under construction with one, the Institute for Innovative Materials, almost complete.

“The Innovation Campus represents a brighter, stronger future for Wollongong, the Illawarra and all of NSW. It places Wollongong at the centre of our knowledge economy, our future depends on what is in our minds,” Premier Lemma said.

Police Minister and Minister for the Illawarra, David Campbell, thanked the government and university for their commitment to making the Innovation Campus come together.

In his introduction to the official opening, UOW Chancellor Michael Codd AC said the Innovation Campus was “a venture that enhanced the image and growth of the Illawarra region, as well as the reputation of the University.”

Professor Sutton said the Innovation Campus would become “the engine that drives the Illawarra economy”.

On this “red letter day” scientists from ACES gave the community a feel for the science being undertaken within the group. Professor Leon Kane-Maguire and Professor Gordon Wallace gave interviews on ABC Illawarra, with presenter Nick Reinberger, and Dr Simon Moulton demonstrated his research into drug release from heart stents.

Technology network conference

July 2008

Professor Gordon Wallace was an invited speaker at the Australian TCF Technology Network Conference in Melbourne on “*Future Fibre Materials: Renaissance through Innovation*”. Gordon spoke about the research in IPRI on Putting Function into Fashion: Organic Conducting Polymer Fibres & Textiles. The TCF network is managed by the peak representative body for the Australian textile and clothing sectors, the Council of Textile and Fashion Industries of Australia Limited, and has

the backing of the Victorian Government and Victorian research and educational institutions.

The event had renowned speakers from many companies in Australia and around the world presenting their work:

- ▶ Future Materials Magazine
- ▶ Fiber Innovation Technologies Inc
- ▶ EMPA Materials Science & Technology
- ▶ The German Institute for Textile & Fibre Research
- ▶ Micronisers Pty Ltd
- ▶ Bruck Textiles Pty Ltd
- ▶ Intelligent Polymer Research Institute
- ▶ SmartLife Technologies
- ▶ CSIRO Textile & Fibre Technology Division
- ▶ Department of Innovation, Industry, Science & Research - Biotechnology Division
- ▶ The Council of Textile and Fashion Industries of Australia.

RACI Chemistry keynote address

July 2008

Prof. Gordon Wallace presented the RACI Chemistry keynote address at CONASTA 57 which is the annual Conference of the Australian Science Teachers Association, Gold Coast, Queensland on 6-9 July. This conference is considered to be an essential professional development forum for all science educators, enabling them to explore the latest science teaching innovations and trends with leading educators from Australia and the World.

Australian cricketer Adam Gilchrist an ambassador for UOW

August 2008

Australian cricketer Adam Gilchrist will be an ambassador for UOW on an upcoming trip to India. He will be involved in

Pictured left: Dr Joselito Razal (left) of ACES and Adam Gilchrist (right).

Pictured right: A tour group in the spectacular foyer of the Australian Institute for Innovative Materials at the Innovation Campus, Wollongong.

promoting the Innovation Campus to key business leaders as well as promoting the University to prospective student agents and students.

In August 2008, Adam visited Wollongong and the university and then visited IPRI to learn more about the ACES bionics programme. IPRI staff and students were delighted to explain their research to one of their favourite cricket heroes (and line up to get their photos taken with Adam!).

UOW showcases Innovation Campus to business community

Sep 2008

The University of Wollongong showed off the Innovation Campus to the Illawarra business community at the Illawarra Business Chamber's September Business After Hours function, attended by 400 people, on Wednesday (24 September).

Innovation Campus staff took guests on guided tours of the facilities, including the almost complete Australian Institute for Innovative Materials which will house two of UOW's flagship research Institutes, the Intelligent Polymer Research Institute and the Institute for Superconducting and Electronic Materials.

Innovation Campus Director David Fuller welcomed guests to the function, saying he hoped they would become ambassadors for the facility. "This is your science and technology precinct and the community must own it for it to be a success," Mr Fuller said. "Please tell people you've been there, seen it and know what it is about. We would like you to be advocates for the Innovation Campus (because) it is imperative that it continues to grow imperative not so much for the university but for the city."

UOW plays host to senior delegation from China's Ministry of Science and Technology

Nov 2008

Among members of the delegation were Mr Huang Jing, who is the Deputy Director-General of the Department of Personnel in China's Ministry of Science and Technology. His role is to develop human resource capacity within the Ministry; selecting and supervising diplomats assigned to Chinese embassies and consulates abroad; and also responsible for developing policy and advising the State (National) Steering Committee of Science and Technology and Education. One of the current priorities is steering funds towards sustainable environment initiatives.

Another member was Mr Guo TieCheng, Vice President of the Chinese Academy of Science and Technology for Development,



whose focus is on expanding industrialisation and infrastructure projects. Mr Guo has the authority to select and invite research centres/ organisations from abroad to collaborate and network with key centres in China.

UOW Vice-Chancellor, Professor Gerard Sutton, officially welcomed the delegates to the University, highlighting the close and growing relationship that UOW has with China.

Professor Gordon Wallace presented to this senior delegation describing ACES activities and collaborations. ACES continues to have a growing number of collaborations in China.

Print coverage

February 2008

ABC News in Science reported on a presentation by researchers at ACES at the **International Conference On Nanoscience and Nanotechnology** in Melbourne on research into repairing damaged tissue by extending bionic ear technology. The article reported that the bionics program at ACES is developing flexible conducting polymers that can be implanted in the body and interact directly with living cells.

Dr Michael Higgins, IPRI, was interviewed. Dr Renee Kyle and Professor Susan Dodds, UOW ethics, were also interviewed in the same article on the social and ethical implications of bionic research.

You can read the interview by Anna Salleh at www.abc.net.au/science/articles/2008/02/29/2176665.htm

April 2008

Nikkei Electronics Asia Magazine reports scientists at UOW have developed a cost effective method of graphene fabrication. Professor Gordon Wallace and Dr Dan Li were quoted in the story.

June 2008

The Illawarra Mercury did a question and answer segment in the IQ Higher Education section with Professor Graeme Clark talking about "*building better bionics*" and his public lecture at the Asia-Pacific Symposium. Read the article.

www.electromaterials.edu.au/news/media16june08bionic.pdf

June 2008

Grant Mc Arthur of the Herald Sun, Melbourne, reports on how "*Implant could buzz sufferers to beat epileptic seizures*". Bionic Ear Scientists in collaboration with St Vincents Hospital and the University of Wollongong recently conducted tests on 3 epilepsy patients to see if electrical pulses could stop their seizures.

www.news.com.au/heraldsun/story/0,21985,23875557-661,00.html

June 2008

Illawarra Mercury talks to Professor Gordon Wallace and Dr Simon Moulton about hosting the Asia-Pacific Nanobionics symposia starting 22 June 2008.

August 2008

Cheaper Fuel Cells are on the Way.

"A much cheaper fuel cell could be on its way thanks to a new cathode built by Australian researchers. A team at the ARC Centre of Excellence for Electromaterials Science at Monash University in

Melbourne reports their findings in today's issue of the journal Science. Fuel cells convert hydrogen and oxygen to electricity and water and are thus a key area of research for powering greener cars....." Read more about this story as covered by ABC's Science reporter Anna Salleh. www.abc.net.au/science/articles/2008/08/01/2320386.htm?site=science&topic=latest

Monash fuels the next generation of Hybrid cars. "Monash University scientists have revolutionised the design of fuel cells The breakthrough revolves around the design of a fuel cell in which a specially-coated form of popular high tech outdoor and sporting clothing material Goretex is the key component.have designed and tested an air-electrode, where a fine layer -- just 0.4 of a micron thick, or about 100 times thinner than a human hair -- of highly conductive plastic is deposited on the breathable fabric. The conductive plastic acts as both the fuel cell electrode and catalyst....." Read more of this story on the Monash news line. www.monash.edu.au/news/newsline/story/1310

TAKE some high-tech fabric used in outdoor clothing and add a very thin layer of plastic. "TAKE some high-tech fabric used in outdoor clothing and add a very thin layer of plastic. This unusual combination, created by Australian scientists, is likely to accelerate the shift towards a cleaner, hydrogen economy".

Read more of this story by the Sydney Morning Herald Science Editor Deborah Smith www.smh.com.au/news/science/anorak-fabric-a-boost-for-fuel-cells/2008/08/01/1217097479505.html

The story by Deborah Smith also appeared on drive.com.au. www.drive.com.au/Editorial/ArticleDetail.aspx?ArticleID=55632&vf=1

Research could cut cost of energy
- as reported by AAP on yahoo news
<http://au.news.yahoo.com/a/-/world/4843342/research-cut-cost-energy>

August 2008

Chemical & Engineering News, Volume 86, Number 31, page 7. "*Sunny Forecast For Fuel Cells*" writes Steve Ritter. Novel electrode materials bring large-scale use of solar power closer to reality. "**Douglas R. MacFarlane**, Bjorn Winther-Jensen, and coworkers at Australia's Monash University prepared a new type of electrode that drives the water-splitting reaction in the opposite direction to reduce oxygen (*Science* **2008**, *321*, 671). Such electrodes are used in fuel cells running on H₂ to produce electricity. The Monash team's three-phase electrode consists of an electrolyte layer, a thin layer of the inexpensive conducting polymer poly(3,4-ethylenedioxythiophene) deposited on a Gore-Tex membrane (a porous form of polytetrafluoroethylene), and air".

<http://pubs.acs.org/cen/news/86/i31/8631notw.html>

August 2008

New Scientist magazine reported that flexible and sensitive 'skin' is being developed for robots so that they can be used in everyday life. Gordon Wallace was quoted saying "that the material, formed using carbon nanotubes and a polymer base, will be quite a breakthrough

because the material will allow electronics to stretch and bend without breaking".
Story by Rachel Nowak.

September 2008

Illawarra Mercury reports on the recently acquired *Atomic Force Microscope (AFM)* that can see forces of single living cells with nanometric resolution. Professor Gordon Wallace was quoted and Dr Michael Higgins pictured.

September 2008

"Bionic advancement within researchers' grasp". Illawarra Mercury story by Michele Tydd. "After 15 years of intensive research, Wollongong scientists have a bionic man in their sights. Professor Gordon Wallace, who pioneered the "intelligent" polymers program at the University of Wollongong, said his dream of developing artificial limbs could be as little as five years away.

September 2008

Wollongong Advertiser reports the story where Professor Gordon Wallace was awarded the Chemistry category of the NSW Scientist of Year Award.

November 2008

'Seeking a material difference' by The Age newspaper. High-tech fabric has been used to make a greener type of fuel cell, writes Geoff Maslen, as he interviews Professor Douglas MacFarlane about the research at Monash on electrodes.

December 2008

New Scientist magazine (web) reported on breakthrough technology for *biobatteries* that can be implanted into the human body, developed by the team at

the Intelligent Polymer Research Institute. Professor Gordon Wallace was quoted in the article.

December 2008

'Smart Stent Breakthrough'. News story in the Sydney Morning Herald written by the health reporter, Louise Hall. "A "SMART" implant that delivers drugs to targeted parts of the body and controls how quickly they are released into the bloodstream has been developed by Australian scientists. Experts in nanomedicine at the University of Wollongong say the implants could remove the need for the electronics used in artificial pacemakers and cochlear implants and could revolutionise the way drugs are circulated around the body. Dubbed "biobatteries", the smart implants build on technology already developed by the university's Intelligent Polymer Research Institute to create a bioabsorbable stent for use in cardiac patients"

Read the entire article: www.smh.com.au/news/specials/science/smart-stent-breakthrough/2008/12/13/1228585181538.html

TV coverage

February 2008

ABC1: Catalyst Bytes features the Graeme Clark Profile

www.abc.net.au/tv/guide/netw/200802/programs/SC0602H064D27022008T115300.htm

June 2008

WIN Wollongong interviews Professor Gordon Wallace about the nanobionics research meeting at UOW Innovation campus which is hosting several world leaders in nanobionics.

June 2008

IC opening on WIN TV

August 2008

Professor Douglas MacFarlane interviewed for Channel 7 News, Melbourne, about Monash research on fuel cells.

August 2008

ABC Catalyst TV show features Australia's Top Scientific Contributions. Professor Graeme Clark is featured as number 6.

"Professor Graeme Clarke's bionic ear gifted the powers of hearing and speech to the otherwise severely or profoundly deaf. His cochlear implant has changed the lives of more than 100,000 deaf people in over 55 countries."

September 2008

Graeme Clark featured on ABC TV on Talking Heads with Peter Thompson.

www.abc.net.au/tv/talkingheads/txt/s2377055.htm

Radio

January 2008

ABC Illawarra interview with Professor Gordon Wallace about Nano research facing big cuts.

January 2008

ABC Illawarra interviewed Professor Gordon Wallace about the research done in his group concerning "using fine sheets of carbon and nanotechnology for solar technology."

January 2008

ABC Coast FM, Gold Coast, ran an interview with Professor Gordon Wallace about the discovery that could impact solar technology.

January 2008

ABC 612, Brisbane, interviewed Professor Gordon Wallace about the discovery that could impact solar technology.

January 2008

Report from ABC News in Science: Researchers leap nanohurdle.

"Australian researchers have discovered a cheap and simple way to make sheets of carbon just one atom thick. Their finding has implications for a range of developments from solar cells to bionic ears. The sheets, known as graphene, normally stack together to make the kind of graphite used in pencils.

But when separated, graphene sheets have extraordinary electronic, thermal and mechanical characteristics, says Professor Gordon Wallace from University of Wollongong."

www.abc.net.au/science/articles/2008/01/29/2148939.htm

January 2008

ABC radio PM - Aust researchers strike graphene breakthrough

Professor Gordon Wallace interviewed and featured on the ABC radio PM programme. This interview was also run on ABC 612 Brisbane, same day.

"It was a simple solution to a complex problem and now the range of possible developments is mind-boggling. Graphene sheets are layers of carbon one atom thick and when separated they have extraordinary electronic, thermal and mechanical properties.

They usually stick together to form the type of graphite found in pencils. The problem was how to separate the sheets. Australian researchers have solved it and there are big potential spin-offs in fields from solar cells and batteries, to medical bionics".

www.abc.net.au/pm/content/2008/s2150426.htm

March 2008

'Bionic implants raise ethical questions' story by Anna Salleh ABC. www.abc.net.au/science/articles/2008/02/29/2176665.htm

April 2008

ABC Radio National Science show podcast talked to ACES International Advisory Board member and collaborator, Professor Ric Kaner. Amongst other interesting aspects of his research, Ric discusses his collaboration with Wollongong in the area of smart materials.

www.abc.net.au/rn/scienceshow/stories/2008/2208438.htm

June 2008

ABC Illawarra talks to Professor Gordon Wallace about the upcoming Asia-Pacific Nanobionics Symposium.

July 2008

Craig Widowson, from ABC Queensland, interviews Professor David Officer about the IPS-17 conference in solar energy.

August 2008

ABC radio Gippsland asked Professor David Officer to comment on the Victorian solar cell tariff system.

August 2008

"Scientists unveil cheaper fuel cell alternative" - ABC Local Radio on 'The World Today programme'. Reporter Jesse Leary interviews Dr Bjorn Winther-Jensen, Monash University, about his research into cheaper alternative electrodes compared to platinum electrodes.

www.abc.net.au/worldtoday/content/2008/s2321481.htm

September 2008

ABC Illawarra news reports that Professor Gordon Wallace was awarded the Chemistry category of the NSW Scientist of Year Award.

October 2008

Professor Graeme Clark is a guest on the ABC conversation hour. You can hear his 50 min interview at: www.abc.net.au/local/stories/2008/10/13/2389527.htm?site=brisbane

November 2008

ABC radio Illawarra presenter Nick Reinberger asked Prof David Officer to comment about "the introduction of feed-in tariff on solar cells by the NSW government".

December 2008

ABC local radio programme **The World Today - Pioneer of bionic ear concerned about problems here**

"Professor Graeme Clark has just taken up the inaugural post of Distinguished Professor at La Trobe University where he'll continue his research on the next generation bionic ear".

www.abc.net.au/worldtoday/content/2008/s2449228.htm

08 Prizes and Awards

Students

Sau Yen Chew (Sophie), a PhD candidate working on the lithium-ion battery project with ACES, was awarded a prestigious F. M. Becket Summer Fellowship to enable a visit to the Paul Scherrer Institute (PSI), Switzerland. The award consisted of US\$5000. The applicant pool was very strong and highly competitive. She was one of the five award winners from all over the world to be selected by the ECS Selection Committee.

Yong Liu, a PhD student within ACES was awarded one of the Chinese Government's Awards for Outstanding Self-Financed Students. There were 21 awards made in Australia overall, with successful candidates receiving \$US 5,000 each.

The scholarship is approved by the Ministry of Education in China and administrated by the Chinese Scholarship Council. The award is for Chinese self-financed students under 40 who are studying PhD degree programs abroad and have completed one or more years. The Office of the Education of

Consulate-General of China in Australia is responsible for the assessment of applicants, and the Chinese Scholarship Council finalises the awards list.

Timothy Khoo, a Masters student in ACES, won the award for the "Best Energy Systems and Efficiency Project", at the Australian Institute of Energy Post-Graduate Student Awards.

The postgraduate awards were organised by the Australian Institute of Energy and held at the Royal Society of Victoria. They were open to postgraduate students in Victoria working in the energy field. The Victorian Minister for Energy and Resources, Peter Batchelor MP, attended and presented the award to Tim.

Tim followed up on his success at the annual ARNAM (ARC Network for Advanced Materials) student and early career researcher conference held at Deakin University in December. Students and researchers from around Australia presented their work on materials and Tim Khoo was a poster award winner. The standard of work was very high and the

students not only prepared a poster but also gave a 2 min presentation summarising the work in front of around 200 people.

Javad Foroughi, a PhD candidate in ACES, was awarded \$5,000 from the ARC Australian Research Network for Advanced Materials (ARNAM), to support him in collaborative research at the University of Texas at Dallas, USA for 3 months. This enabled Javad to develop new approaches to spinning and utilizing carbon nanotube yarns.

Dennis Antiohos, David Marshall, Shane Ellis and Tom Higgins, four undergraduate students at the University of Wollongong, were selected via a competition amongst all senior undergraduate students in the Bachelor of Nanotechnology degree to receive scholarships from ACES. These scholarships were for the undergraduates to attend the International Conference of Nanotechnology and Nanoscience (ICONN2008) held in Melbourne in late February. Coordinator of the Nanotechnology Degree, Prof Will Price, said that it was a fantastic opportunity for the students to see and hear the latest



research and developments in this emerging area. The students also had the opportunity to attend specialist workshops and talk to industrial companies who want to employ graduates in Nanotechnology. Prof Gordon Wallace, Executive Director of ACES, was glad to be able to provide this opportunity to those students as it is a great investment to inspire high quality students to enter careers in the forefront of technology.

Wayne Neil, a PhD student won the Best Poster Paper Award for his poster on "Microstructure and Corrosion of Mg Alloy ZE41" at the Australasian Corrosion Association (ACA) Corrosion and Prevention Conference 2008.

Research Fellows

Dr Steven Pas, an ARC APD Fellow working with ACES and CSIRO Materials Science and Engineering, was awarded a prestigious Victoria Fellowship at Government House. The Victorian Government annually awards up to six Victoria Fellowships to emerging leaders in engineering, science or technology. Each Fellow receives a travel grant of

up to \$18,000 to undertake a short-term overseas study mission to assist in developing a commercial idea, undertaking specialist training or career development.

The Fellowship provides Steve with funds to further his research in areas relating to biomedical imaging using positrons. It recognises both the high quality of his research to date and the innovative and strategic nature of his proposal.

Dr David Nayagam, a Research Fellow in ACES, was awarded a Victorian Neurotrauma Initiative (VNI) Skill Development scholarship of \$2,200. This award provides opportunities for new and early career researchers to attend short courses designed to develop research skills. David used his funds to attend the Royal Australasian College of Surgeons (RACS) Australian and New Zealand Surgical Skills Education and Training (ASSET) course.

Dr Jun Chen, IPRI, visited the Technology University of Denmark (DTU) for 4 weeks in September. The visit was funded under the 'Scientific Visits to Europe'

program, 2008/09 by the Australian Government Department of Innovation, Industry, Science and Research's International Science Linkages – Science Academies Programme. During his visit, he established collaborative research in the Danish Polymer Centre on the linkage project "Electroactive Nanoporous Polymers for Aanalytic Application". Jun also gave oral presentations at DTU, Risø National Laboratory (Denmark) and the University of Copenhagen.

Dr Simon Moulton was one of over a hundred leading Australian scientists awarded scientific grants to undertake important international collaborative research under the *International Science Linkages – Science Academies Program*. The program supports Australian scientists, from both the public and private sectors, to collaborate with international partners on leading edge science and technology in order to contribute to Australia's economic, social and environmental wellbeing.

Simon will be undertaking research in France with Dr Philippe Poulin at CNRS Bordeaux and Prof Eric Anglaret at University Montpellier II in 2009 to develop Aligned Carbon Nanotube Biomaterial Structures.

Dr Simon Moulton was “highly commended” for his presentation on: “*In vivo* site specific drug delivery: New technology to replace mulesing in sheep farming” in the University of Wollongong’s annual Trailblazer competition. The University of Wollongong’s annual Trailblazer innovation competition (run in conjunction with UniQuest Pty Ltd), now in its 4th year, rewards innovative ideas and early-stage research, which have the potential to benefit the community, industry or business as well as generate a financial return.

Chief Investigators

Prof Gordon Wallace, Director of IPRI and the Executive Research Director of ACES, was this year’s winner of the H.G. Smith Memorial Award. The H.G. Smith award is one of the RACI’s most

prestigious awards and acknowledges outstanding contribution to a branch of chemical science, and the volume and quality of work published in the last ten years.

Submissions nominating Prof Wallace for the award spoke highly of his contributions to chemical science. One submission said: “Professor Wallace has made the most outstanding research contributions to the Chemistry profession in Australia over the past ten years, particularly in the areas of organic conductors, nanomaterials and electrochemical probe analysis. The national and international significance of his contributions in these areas between 1997 and 2007 can be highlighted by his diverse collaborations with several Australian companies and research organisations in Australia and overseas.”

Prof Gordon Wallace was the winner of the ‘Chemistry Category’, at the inaugural NSW Scientist of the Year Awards held in Sydney. Solar cell expert Prof Martin Green from the University of New South Wales was named overall winner of the NSW Scientist of the Year Award.

The ceremony held at Government House in Sydney was a celebration and recognition of outstanding individuals carrying out cutting-edge work that generates economic, health, environmental or technological benefits to NSW.

Prof Graeme Clark’s awards were:-

The inaugural oration for the annual Graeme Clark Oration for the National Information, Communications and Technology Association for Life Sciences (NICTA).

The new science building at Scots College Sydney named the Graeme Clark Centre for Innovation in the Sciences.

Honorary Doctor of Science, Zaragoza University, Spain (one of the oldest universities and home to the father of neuroscience Ramon y Cajal).

The first appointment as distinguished professor at La Trobe University.

The Graeme Clark Unit in Hearing and Neuroscience created at La Trobe University.

09

Industry/End-User Liaison

ACES has cultivated an open and vibrant research environment that ensures close interaction with other Australian and international scientists. These collaborative activities are undertaken under agreements that cover:

- ▶ Appointments as Visiting Research Fellows, or
- ▶ Specific collaborative research agreements, or
- ▶ Commercial research agreements.

The ACES approach ensures high visibility for our research activities and the opportunity to establish partner engagement at the early stage of research. This approach ensures strategic input from a commercial as well as a technology perspective. The high profile, open engagement approach encompasses end-user driven intentions and has proven highly effective in developing externally funded programs with a range of organisations, both private and public sector – a critical measure of success (see Table 9.1).

Two vital steps in the enhancement of the Centre's interaction with the private sector and government instrumentalities have been the appointment in 2006 of a part-time *Business Development Officer* funded by the NSW Department of State and Regional Development and the establishment in early 2007 of an *End-Users Committee* (EUC) comprising senior representatives from BlueScope Steel, Cochlear, CAP-XX, DSTO, Rio Tinto, Visiocrp and Ian Wark Research Institute/CAMR. The End-Users Committee has provided valuable feedback on a range of issues including industry input into the training of PhD students (6 PhD students attended a UniQuest Research Commercialisation Workshop), industrial outlets for ACES research, new opportunities, and mechanisms for commercialisation of Centre technologies.

To date, ACES has not engaged in a strategy to develop technologies to a more mature stage before involving selected third parties. However, the opportunity to do this in selected areas

will be made possible by the appointment of a full-time Director of Commercial Development. Funding for this position involves a partnership between the University of Wollongong and the NSW Department of State and Regional Development.

There was an End-Users Committee meeting on the 17th July 2008 at which the EUC was asked for advice on how ACES could maximise benefits to end-users in the future. In addition, the EUC also gave advice on the selection criteria that would be appropriate for the recruitment of a Director of Commercial Development to spearhead the business development activities of the Centre. During 2008 the EUC consisted of: Evan Evans (BlueScope Steel), Jim Patrick (Cochlear), Phil Aitchison (Cap-XX), Tan Truong (DSTO), Ray Shaw (Rio Tinto) James Nicholson (Visiocrp) and Peter Murphy (Ian Wark Research Institute/ CAMR). Since then, Dr Anita Hill (CSIRO) has joined the Committee.

	Electro-materials Synthesis	Energy Storage	Energy Conversion	Bionics
Private Sector				
Bionic Technologies Australia	✓			✓
BlueScope Steel	✓			
Boston Scientific	✓			✓
Cap-XX	✓	✓		
DLG Battery Co. Ltd China	✓	✓		
Lexel Battery Ltd China	✓	✓		
Dyesol	✓		✓	
Rio Tinto	✓			
Schefenacker Vision Systems (Visiocrp)	✓		✓	
Public Sector				
CRC for Polymers	✓		✓	
CRC Hear	✓			✓
CSIRO	✓	✓	✓	
DSTO	✓		✓	

Table 9.1. Current research and development collaborations with industry.

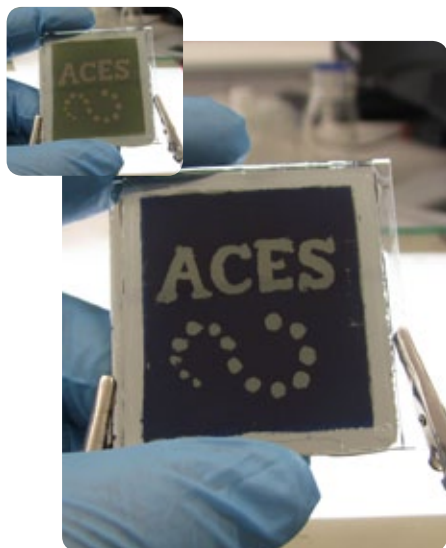
End-User Highlights

Smart Mirror Project – VisioCorp

This project involves the development of a rapidly switching electrochromic device in collaboration with VisioCorp and our research partners at the University of South Australia. Advances to date involve the development of novel electrolytes and electrochromic polymers as well as innovative processing/fabrication methods.

During 2008, VisioCorp received South Australian Government support to establish a manufacturing facility for these devices.

In parallel, the project has produced exciting developments in our fundamental understanding of these materials (**Electrochimica Acta 2008**). The project is supported by an ARC Linkage Grant.



Biodegradable Stents – Boston Scientific

The development of biodegradable stents based on the corrosion of active metals (Mg or Fe) is the focus of our current collaborative activities with Boston Scientific. Coupling the active material with conducting polymers has been shown to be an effective means of controlling the rate of degradation. The project has also enabled further development of the self-powered device concept (**Patent pending**) in the form of an autonomously powered stent structure for controlled drug release (**J. Mat. Chem. 2008, New Scientist 2008**).

An ARC Linkage proposal to further develop this work is currently pending.

A Novel Electrowinning Process – Rio Tinto

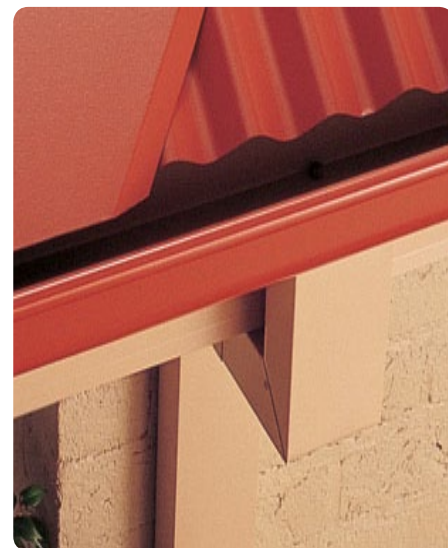
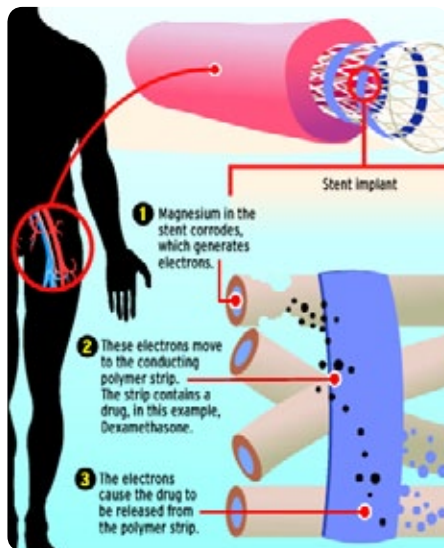
ACES researchers from UOW and Monash joined forces to investigate the use of ionic liquid electrolytes to enable electrodeposition of titanium metal. The work has revealed the challenges yet to be overcome if the inherent

properties of ionic liquid electrolytes are to be used in this way. A number of significant publications emerged in 2008 (**Electrochim. Comm. 2008, Phys. Chem. Chem. Phys. 2008**) and the commercial collaborators benefited from the valuable knowledge acquired through this project. The project was supported by an ARC Linkage Grant.

Peripheral Nerve Conduit - Bionic Technologies Australia

ACES researchers combined forces with colleagues from the Bionic Ear Institute and CSIRO to develop an effective conduit for peripheral nerve repair. The conduit incorporates materials that have been tested and selected by ACES researchers for their specific capacity to grow the individual components of nerve tissue: the neurons and supportive neuroglial cells.

This collaborative work continues with a major focus on the refinement of the material tissue compliance and evaluation of hybrid materials and fibre formats to



improve the conduit's effectiveness. An NHMRC grant application was submitted in January 2009.

Improving Corrosion Resistant Products – BlueScope Steel:

ACES researchers are undertaking a collaborative project with BlueScope Steel that utilises state-of-the-art techniques to probe what occurs at the micro-nano level in the very early stages of corrosion (**J. Solid State Chem 2008**). This valuable information will be useful in designing even more highly resistant coatings to protect against corrosion.

A Mobile Sensing Platform – DSTO

ACES researchers are utilising a robotic fish platform developed with Dublin City University to integrate sensing technologies of interest to DSTO. Improving the efficiency of propulsion also involves input from DSTO scientists working in collaboration with ACES.

Solar Cells – CRC Polymers

ACES researchers, along with researchers at UNSW, ANSTO and CSIRO, are collaborating to develop dye-sensitised solar cells. Funding from the CRC Polymers has contributed to the establishment of a state-of-the-art solar cell characterisation facility at UOW. This has enabled fundamental insights to be attained into the factors determining the performance of the materials in devices. Advances in both our understanding of solar cell materials (**Electrochimica Acta 2008**) and the realisation of device configurations with commercially viable efficiencies have emerged during 2008.

10 Management Arrangements

The Governance/Organisation Chart for ACES is shown below (Chart 10.1).

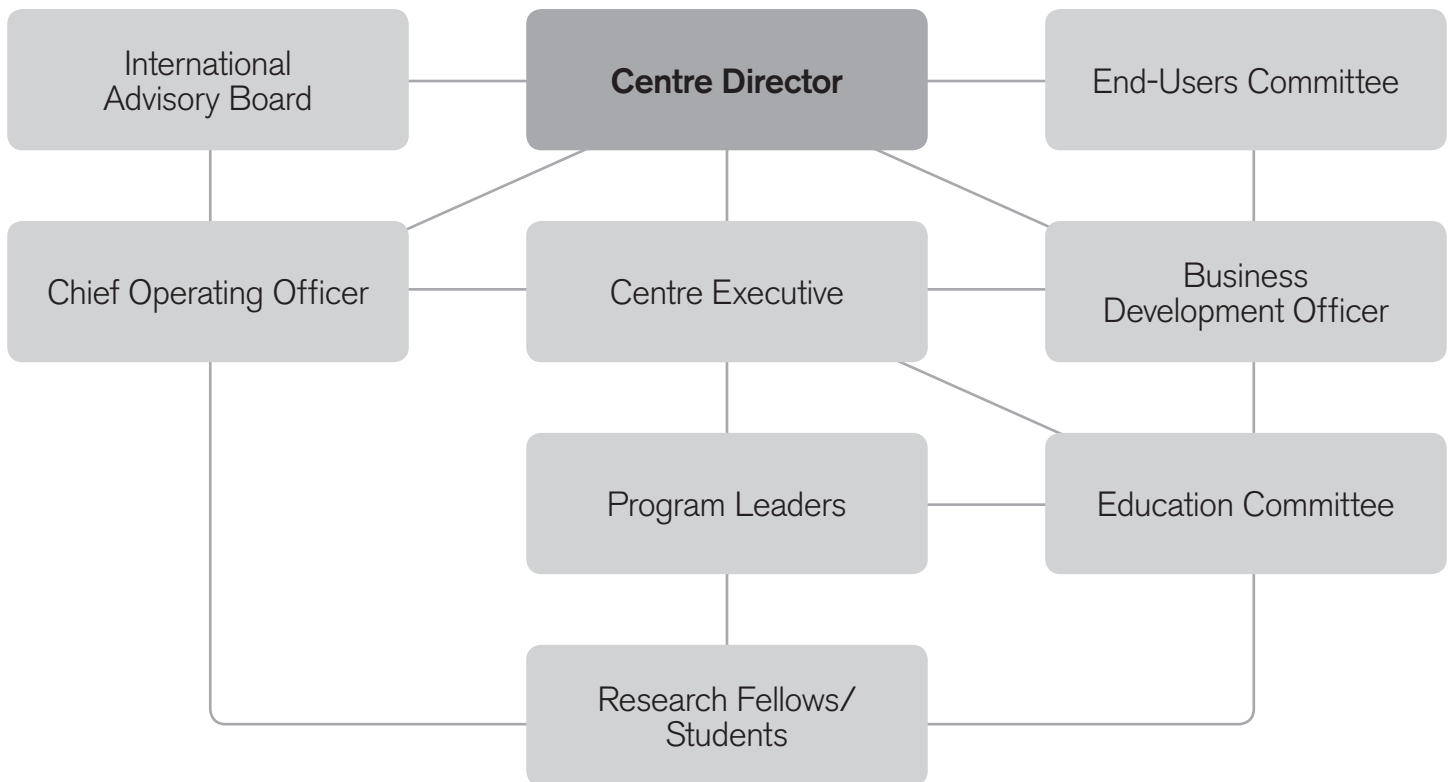


CHART 10.1. ACES GOVERNANCE/ORGANISATION CHART

The Centre Executive (Table 10.1) met 7 times in 2008 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.

TABLE 10.1. MEMBERS OF ACES MANAGEMENT

Centre Executive	End-Users Committee
<p>Executive Director: Prof. G. Wallace</p> <p>Associate Director: Prof. M. Forsyth</p> <p>Selected Senior Researchers: Prof. L. Kane-Maguire, Prof. D. MacFarlane, Prof. G. Clark, Prof. D. Officer A/Prof. R. Kapsa, Prof. G. Spinks</p> <p>Chief Operating Officer: A/Prof. C. Too</p> <p>Business Development Officer: Director Commercial Development (TBA 2008-2010+)</p> <p>Education Director: Prof. W. Price</p> <p>Early Career Researchers Representative: A/Prof. P. Innis</p>	<p>E. Evans (BlueScope Steel)</p> <p>J. Patrick (Cochlear)</p> <p>P. Aitchison (Cap-XX)</p> <p>T. Truong (DSTO)</p> <p>R. Shaw (Rio Tinto)</p> <p>J. Nicholson (Visiocrp)</p> <p>P. Murphy (IWRI, UNISA)</p>
International Advisory Board	Education Committee
<p>Dr Bridget Ogilvie AC, DBE, FAA, FRS, FMedSci (Chair)</p> <p>Prof. R. Baughman (University of Texas at Dallas)</p> <p>Prof. S. Roth (Max Planck Institute, Stuttgart)</p> <p>Dr. A. Mau (CSIRO)</p> <p>Dr. G. Smith (SciVentures)</p> <p>Prof. J. Raper (DVC Research, UOW)</p> <p>Dr. A. Khan (Monash University)</p> <p>Prof. R. Kaner (UCLA)</p> <p>Prof. M. Cook (St Vincent's Hospital, Melbourne)</p> <p>Dr. I. Sare (DSTO)</p> <p>Prof. N. Ogata (Chitose Institute of Science and Technology)</p> <p>Prof. A. Holmes (University of Melbourne)</p>	<p>Prof. W. Price (Chair)</p> <p>Prof. G. Spinks (UOW)</p> <p>Prof. Y.-B. Cheng (Monash)</p> <p>A/Prof. P. Innis (UOW)</p> <p>A/Prof. R. Kapsa (St Vincent's)</p>

The International Advisory Board (IAB) (Table 10.1) met on 20th February 2008 and 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 10.1) provided advice on strategies used to engage End-Users and identified new collaborative opportunities. The EUC met once in 2008. Dr Anita Hill (CSIRO) will join the EUC in 2009.

The Education Committee (Table 10.1) initiates and implements strategies to attract and engage high calibre research students. Chaired by Professor Will Price, it met regularly during 2008.

The Business Development Officer part-time position has been vacant for 2008. With UOW and DSRD support, a **Director of Commercial Development** has now been appointed. A major focus of this new role will be the development of a strategic plan for industry commercial engagement for the next two or five years as appropriate. This appointment

will considerably bolster our interaction with industry through active identification and development of new commercial opportunities.

Staff of ACES includes 2 QEII Fellows, 25 research fellows, 2 ARC Fellows, 1 APD and 2 research assistants (Appendix V).

Intellectual Property (IP) Management. The IP Register is given at Appendix VI. Four new patents were lodged in 2008.

11 Publications

The target for 2008 was 40 refereed publications of which at least 50% would have an impact factor greater than 2. We have greatly exceeded these targets with a total of 93 refereed publications of which 74 (79%) have an impact factor greater than 2. In fact, 34 refereed publications have an impact factor greater than 4. The publications list is given below.

ARC Centre 2008 Publications List

(IF = Impact factor)

Refereed journal papers

1. J. Adebahr, M. Grirnsley, N. M. Rocher, D. R. MacFarlane and M. Forsyth, *Rotational and translational mobility of a highly plastic salt: Dimethylpyrrolidinium thiocyanate*, Solid State Ionics 2008, 178(35-36), 1798-1803. IF: 2.012
2. P. M. Bayley, B. Winther-Jensen, D. R. MacFarlane, N. M. Rocher and M. Forsyth, *Enhanced properties in chemically polymerized poly(terthiophene) using vapour phase techniques*, Reactive & Functional Polymers 2008, 68(7), 1119-1126. IF: 1.720
3. S. Y. Chew, J. Z. Sun, J. Z. Wang, H. K. Liu, M. Forsyth and D. R. MacFarlane, *Lithium-polymer battery based on an ionic liquid-polymer electrolyte composite for room temperature applications*, Electrochimica Acta 2008, 53(22), 6460-6463. IF: 2.848
4. J. A. Choi, S. M. Eo, D. R. MacFarlane, M. Forsyth, E. Cha and D. W. Kim, *Effect of organic additives on the cycling performances of lithium metal polymer cells*, Journal of Power Source 2008, 832-836. IF: 2.809
5. B. R. Clare, P. M. Bayley, A. S. Best, M. Forsyth and D. R. MacFarlane, *Purification or contamination? The effect of sorbents on ionic liquids*, Chemical Communications 2008, (23), 2689-2691. IF: 5.141
6. M. Forsyth, T. F. Kemp, P. C. Howlett, J. Sun and M. E. Smith, *A potential novel rapid screening nmr approach to boundary film formation at solid interfaces in contact with ionic liquids*, Journal of Physical Chemistry C 2008, 112 (36), 13801-13804. IF: N/A
7. M. Forsyth, T. Markley, D. Ho, G. B. Deacon, P. Junk, B. Hinton and A. Hughes, *Inhibition of corrosion on aa2024-t3 by new environmentally friendly rare earth organophosphate compounds*, The Journal of Science and Engineering Corrosion 2008, 191-197. IF: N/A
8. K. M. Johansson, E. I. Izgorodina, M. Forsyth, D. R. MacFarlane and K. R. Seddon, *Protic ionic liquids based on the dimeric and oligomeric anions: [(aco)(x)hx-1](-)*, Physical Chemistry Chemical Physics 2008, 10(20), 2972-2978. IF: 3.343
9. D. W. Kim, S. R. Sivakkumar, D. R. MacFarlane, M. Forsyth and Y. K. Sun, *Cycling performance of lithium metal polymer cells assembled with ionic liquid and poly(3-methyl thiophene)/carbon nanotube composite cathode*, Journal of Power Sources 2008, 180(1), 591-596. IF: 2.809
10. J. M. Pringle, O. Winther-Jensen, C. Lynam, G. G. Wallace, M. Forsyth and D. R. MacFarlane, *One-step synthesis of conducting polymer-noble metal nanoparticle composites using an ionic liquid*, Advanced Functional Materials 2008, 18(14), 2031-2040. IF: 7.496
11. B. Winther-Jensen, M. Forsyth, K. West, J. W. Andreasen, P. Bayley, S. Pas and D. R. MacFarlane, *Order-disorder transitions in poly(3,4-ethylenedioxythiophene)*, Polymer 2008, 49(2), 481-487. IF: 3.065
12. B. Winther-Jensen, M. Gaadingwe, D. R. Macfarlane and M. Forsyth, *Control of magnesium interfacial reactions in aqueous electrolytes towards a biocompatible battery*, Electrochimica Acta 2008, 53(20), 5881-5884. IF: 2.848
13. B. Winther-Jensen, O. Winther-Jensen, M. Forsyth and D. R. MacFarlane, *High rates of oxygen reduction over a vapor phase-polymerized pedot electrode*, Science 2008, 321(5889), 671-674. IF: 26.372
14. Jiazeng Sun, Patrick C. Howlett, Douglas R. MacFarlane, Ji Lin, Maria Forsyth, *Synthesis and physical property characterization of phosphonium ionic liquids based on P(O)₂(OR)₂- and P(O)₂(R)₂-anions with potential application for corrosion mitigation of magnesium alloys*, Electrochimica Acta 2008 54, 254-260. IF: 2.848

15. R. Byrne, K.J. Fraser, E. Izgorodina, D.R. MacFarlane, M. Forsyth, D. Diamond, *Photo- and solvatochromic properties of nitrobenzospiropyran in ionic liquids containing the [NTf₂]⁻ anion*, Physical Chemistry Chemical Physics 2008, 10(38), 5919-5924. IF: 3.343
16. Shu-Lei Chou, Jia-Zhao Wang, Jia-Zeng Sun, David Wexler, Maria Forsyth, Hua-Kun Liu, Douglas R. MacFarlane and Shi-Xue Dou, *High Capacity, Safety, and Enhanced Cyclability of Lithium Metal Battery Using a V₂O₅ Nanomaterial Cathode and Room Temperature Ionic Liquid Electrolyte*, Chemistry of Materials 2008, 20(22), 7044-7051. IF: 4.883
17. N. Byrne, P. C. Howlett, D. R. MacFarlane, M. E. Smith, A. Howes, A. F. Hollenkamp, T. Bastowe, P. Hale and M. Forsyth, *Effect of zwitterion on the lithium solid electrolyte interphase in ionic liquid electrolytes*, Journal of Power Sources 2008, 184(1), 288-296. IF: 2.809
18. F. Endres, S.Z. El Abedin, A.Y. Saad, E.M. Moustafa, N. Borissenko, W.E. Price, G.G. Wallace, D.R. MacFarlane, P.J. Newman, A. Bund, *On the electrodeposition of titanium in ionic liquids*, Physical Chemistry Chemical Physics 2008, 10(16), 2189-2199. IF: 3.343
19. E.H. Cha, S.A. Lim, J.H. Park, D.W. Kim, D.R. Macfarlane, *Ionic conductivity studies of gel polyelectrolyte based on ionic liquid*, J. Power Sources 2008, 178(2), 779-782. IF: 2.809
20. Vijay Ranganathan, Jennifer M. Pringle, Douglas R. MacFarlane, *Anionic Polymerisation of Styrene in Ionic Liquids*, European Polymer Journal 2008, 44(6), 1758-1762. IF: 2.248
21. R. Auxilio, P. C. Andrews, P. C. Junk, L. Spiccia, D. Neumann, W. Raverty, N. Vanderhoek, J. M. Pringle, *Functionalised Pseudo-Boehmite Nanoparticles as an Excellent Adsorbent Material for Anionic Dyes*, Journal of Materials Chemistry 2008, 18(21), 2466-2474. IF: 4.339
22. P. Pearson, A. M. Bond, G. B. Deacon, C. Forsyth and L. Spiccia, *Synthesis and characterisation of bis(2,2'-bipyridine)(4-carboxylic acid-4'-(pyrid-2-ylmethylamido)-2,2'-bipyridine)ruthenium(II) di(hexafluorophosphate): Comparison of spectroelectrochemical properties with related complexes*. Invited contribution to Special Volume "Protagonists in Chemistry: Michael Grätzel", Inorg. Chim. Acta 2008, 361, 601-612. IF: 1.713
23. G. Gasser, L. Tjioe, B. Graham, M. J. Belousoff, S. Juran, M. Walther, J.-U. Küntler, R. Bergmann, H. Stephan and L. Spiccia, *Synthesis, copper(II) complexation, ⁶⁴Cu-Labeling, and bioconjugation of a new bis(2-pyridylmethyl) derivative of 1,4,7-triazacyclononane*, Bioconjugate Chem. 2008, 19, 719-730. IF: 4.384
24. S. A. Cerneaux, S. M. Zakeeruddin, M. Grätzel, Y.-B. Cheng and L. Spiccia, *New functional triethoxysilanes as iodide sources for Dye-Sensitized Solar Cells*, J. Photochem. Photobiol. A: Chemistry 2008, 198, 186-191. IF: 4.384
25. N. A. Lewcenko, M. J. Byrnes, Y.-B. Cheng, S. M. Zakeeruddin, M. Grätzel and L. Spiccia, *Alkylpyrrolidiniumtrialkoxysilyl iodides as organic iodide sources for Dye-Sensitized Solar Cell*, Chem. Commun. 2008, 3852 – 3854. IF: 5.141
26. G. Gasser and L. Spiccia, *Synthesis of a ferrocenyl uracil PNA monomer for insertion into PNA sequences*, J Organomet. Chem. 2008, 693, 2478-2482. IF: 2.168
27. M. J. Belousoff, G. Gasser, B. Graham, Y. Tor and L. Spiccia, *Binding of the HIV-1 TAR mRNA to peptide nucleic acid conjugates bearing metal ion binding multidentate ligands*, J. Biol. Inorg. Chem., published online: 18 November 2008. 10.1007/s00775-008-0448-6. IF: 3.325
28. S.A.Cerneaux, S.M.Zakeeruddin, M.Gratzel, Y.B.Cheng, L.Spiccia, *New functional triethoxysilanes as iodide sources for dye-sensitized solar cells*, Journal of Photochemistry And Photobiology A-Chemistry 2008, 198(2-3), 186-191. IF: 5.9
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