THE UNIVERSITY OF MELBOURNE

MELBOURNE MATERIALS INSTITUTE

Melbourne Materials Institute

Annual Report

2010

Melbourne Materials Institute
The University of Melbourne
Victoria 3010
t +61 3 8344 6415
f +61 3 9347 4783
Editor: Annabelle Pontvianne
Design: Jeanette Dargaville

For further information visit:
http://www.materials.unimelb.edu.au

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Introduction

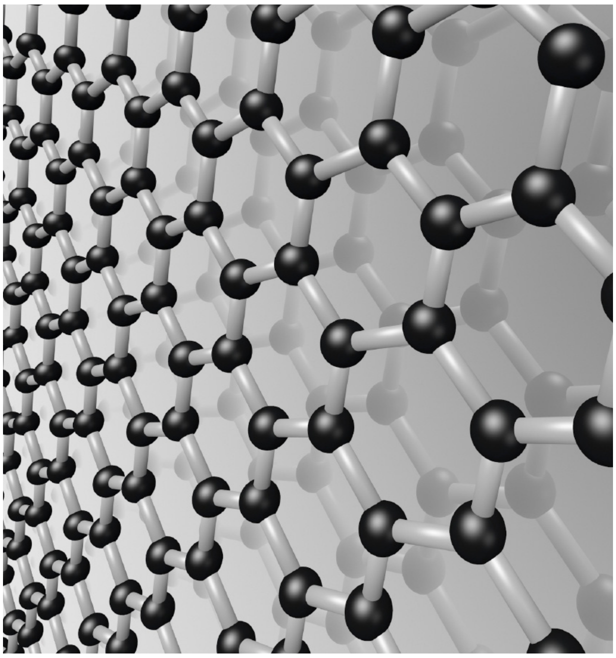
Advances and innovations in materials science and materials processing are essential if we are to meet the grand challenges of our age in sustainability, medicine and energy. These challenges are on a global scale, they are complex and multi-faceted. Today, we recognise the need for a multidisciplinary approach to address them.

The Melbourne Materials Institute (MMI) was established in 2009 as one of five initial Melbourne Research Institutes. The Research Institutes were created to harness the University of Melbourne's research capacity and develop interdisciplinary collaborations to respond to these critical challenges. The MMI is committed to providing solutions by bringing together researchers from a range of disciplines across the University.

The MMI is the entry-point for researchers and industry seeking to work with leading researchers at the University of Melbourne on innovative solutions in the materials science domain. The Institute seeks to establish partnerships with industry and to use its expertise to turn problems into solutions and deliver sustainable and practical applications.

This, our first annual report, showcases the depth and breadth of materials research at the University of Melbourne. The research has been funded by various sources, including the Australian Research Council, the National Health and Medical Research Council, and by internal MMI funds.

The MMI's vision is to establish the University of Melbourne as a major player in materials research on the international, national and regional stage. The Institute aims to be recognised by governments, the research community and industry for its excellence in fundamental and applied research and ability to deliver enabling technologies to benefit humanity.



Grapene carbon monolayer. The discovery of graphene results in a Nobel prize for Andre Geim and Konstantin Novoselov in 2010.

Mission

In pursuit of this vision, the MMI aims:

- to promote world-class research around its core research themes;
- to increase the level of materials research collaboration across the University of Melbourne;
- to create opportunities for scientists to collaborate with and assist industry in developing new products and processes requiring innovative materials;
- to develop the research critical mass, the infrastructure and the resources to solve large-scale problems of global importance;
- to train the next generation of materials research scientists and technologists; and
- to provide seed-funding for high-risk, high-return materials research.

Director's welcome

Materials are the unsung heroes of our modern way of living. In previous centuries, the development of steel and reinforced concrete enabled us to build sky scrapers. Last century, the development of pure and doped silicon enabled us to build computers and usher in the information age. Further developments in semiconductor materials have given us inexpensive and reliable lasers, which are used in everything from medical diagnostics to DVD players. Advances in materials have underpinned each technological revolution and directly impact on the way we live our lives. Today, however, many technologies are nearing the point of diminishing returns in terms of efficiency and efficacy. Furthermore, the distribution of advanced technologies to more of the world's population without new innovation will break our global energy and resources budget.

The MMI aims to create the environment, both intellectual and physical, where materials innovation and discoveries are nurtured, whilst ensuring that we capture the results of our work in the medium term for the benefit of the broader community. We achieve this by supporting core theme areas to pursue visionary and risky research projects that address the big challenges we face in energy, health and sustainability.

As one of the University of Melbourne's Research Institutes, we believe that the best chance for emergence of new paradigms is to develop a truly multidisciplinary environment. The Institute fosters interdisciplinary research through seminars, visitor programs and importantly seed-funding for new initiatives across disciplines. In the pages of this report you will find some of our early successes, including for example, ground breaking research of quantum measurements in a living cell constituting the first studies of quantum signatures of life and death.

Another key plank in our strategy is the formation of strategic partnerships with companies and other research organisations who share our vision of innovation-driven solutions to seemingly intractable problems. The Institute has forged strong linkages with Better Place Australia, Bionic Vision Australia, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Defence Science and Technology Organisation (DSTO). Through these key partnerships, the Institute has brought in over $7M in project funding; more importantly, these partnerships have been transformational as more academics have been convinced by the idea that their formidable talents in basic research can be applied to address some of the most pressing problems that we face today.

Steven Prawer

MMI, Director

2010 in review

The MMI has completed a successful year by bringing together members of the University's materials research community, establishing collaborations, driving partnerships, building new sources of funding and strengthening the materials science and engineering research links.

Bridging disciplines

The MMI has brought together over sixty associated researchers, spread across nine different disciplines. The MMI Management Committee comprises senior academics from Business and Economics, Chemistry, Engineering, Medicine, Dentistry and Health Sciences and Physics. MMI's four major themes are lead by academics from Physics, Chemical and Biomolecular Engineering and Chemistry.

Bionic Vision Australia (BVA)

BVA is a national consortium of world-leading Australian research institutions collaborating to develop an advanced retinal prosthesis, or bionic eye, to restore the sense of vision to people with degenerative or inherited retinal disease. As a member in the BVA consortium, the MMI's role is to produce a fully biocompatible diamond electrode array that will be used to stimulate the optic nerve. The MMI has brought together physicists and chemical engineers in the design and development stage as well as appointed three post-doctoral fellows to help solve the problems of fabrication, encapsulation, integration and testing.

Better Place Australia

The MMI has led the University's engagement with Better Place Australia a company dedicated to the mass adoption of electric vehicles. Better Place Australia and the University of Melbourne have signed a Memorandum of Understanding (MoU). The new partnership will explore the social, political and environmental impacts of the mass adoption of electric vehicles in Australia. This relationship has generated a successful ARC Linkage grant, partnering with key Faculty of Engineering staff, to explore the problem of grid-optimisation for the mass-adoption of electric vehicles.

CSIRO

The MMI has driven a partnership with Dr Calum Drummond, Chief of CSIRO Materials Science and Engineering (now Group Executive). CSIRO has agreed to co-fund and co-supervise at least six PhD students in the materials science and engineering field. This will significantly strengthen research in this area and bring researchers in both organisations into closer collaboration. These high-profile scholarships will be used to recruit the best and brightest national and international students.

DSTO

The MMI has worked closely with the Knowledge Partnership Office, Melbourne Consulting and Custom Programs, the Melbourne Research Office and the Legal Services, to drive a partnership with the DSTO. This has resulted in the establishment of the Defence Science Institute (DSI), with Professor Prawer as the Interim Director. Funded by the State Government for three years in the first instance, the role of the DSI is designed to promote collaboration across six key research themes to 'future-proof' Australia's defence capability.

Professor Steven Prawer at the DSI launch on 29 October 2010.

Nano-neuro

The Directors of the the MMI and the Melbourne Neuroscience Institute have brought together a broad collaboration of researchers in the nanotechnology and neuroscience areas. The ambition is to encourage new thinking by combining the talents of researchers from disparate disciplines. Goals include sponsoring a proposal for the next round of interdisciplinary seed funding and partnering with the Vanderbilt Institute of Nanoscience and Engineering on the topic of nanoparticle based drug delivery.

Interdisciplinary Seed-Funding scheme

The MMI received thirteen applications out of 109 for the Interdisciplinary Seed-Funding scheme. The six selected projects forged new linkages between researchers in Chemical and Biomolecular Engineering, Dentistry, Medicine and Physics. These exciting new projects are profiled in this report.

ARC success

MMI affiliated researchers have been very successful in winning ARC grants. Notable successes include:

- The award of an ARC Laureate Fellowship to Professor Paul Mulvaney, School of Chemistry, in the field of plasmonics and metamaterials.
- ARC linkage grant to MMI/Hewlett Packard researchers to study Technologies for the Diamond Quantum Co-Processor.
- ARC linkage grant to Professor Iven M Mareels, Professor Doreen A Thomas (Engineering) and Better Place researchers to study the impact of the mass-adoption of electric cars on the Australian electricity grid.

Discovery grants include:

- Professor F Caruso; Associate Professor GG Qiao: "Engineered nanostructured materials via continuous polymer assembly for advanced bioapplication".
- Professor AB Holmes; Professor AW Burgess; Dr BL Catime: "Synthesis of phosphatidylinositol and inositol polyphosphate derivatives to probe key signalling proteins associated with cell growth and cancer".
- Associate Professor SE Kentish; Dr AJ Hill: "Tuning membrane chemistry for desalination and water re-use applications".
- Professor P Mulvaney; Professor JE Sader: "Repulsive van der Waals forces and Brownian ratchet motors: manipulating thermal and quantum fluctuations".
- Professor S Prawer; Dr AD Greentree; Dr S Tomljenovic-Hanic; Professor A Hoffman; Dr JM Smith: "Fabrication strategies for diamond-based quantum devices: concepts to applications".

International visitors and public lectures

The MMI has hosted a number of distinguished visitors who have given well-received public lectures on a variety of topics: "The Future of nanotechnology" by Professor Gabriel Aeppli, from the London Centre for Nanotechnology; "The materials revolution" by Professsor Len Feldman, from Rutgers University and Vanderbilt University; "The energy challenge: What is the problem and what is the role of basic science?" by Professor David Cahen, from the Weizmann Institute of Science.

The MMI also hosted the Gifkin Lecture with Materials Australia, presented by Professor David Jamieson: "Materials for the quantum industrial revolution."

Research workshop - Exploring the materials challenges

In preparation for the 2010 Interdisciplinary Seed-Funding round, Melbourne Materials Institute has hosted a half-day workshop across its key research themes to discuss the challenges in these research areas and to encourage novel approaches to problems that will become funded projects.

Honours

- Associate Professor Rachel Caruso was included in the top 100 most cited researchers in materials science (2000-2010).
- Professsor Frank Caruso was awarded the Woodward medal and was included in the top 100 cited researchers in materials science (2000-2010).
- Professor Steven Prawer was elected to the Australian Academy of Science.

Media

The work of MMI's researchers has been featured in print and online press:

- "Diamond to become the blind's best friend", Australian Academy of Science Media releases.
- "The coming age of diamond", Cosmos Online.
- "Rock stars", Sydney Morning Herald.

Program map

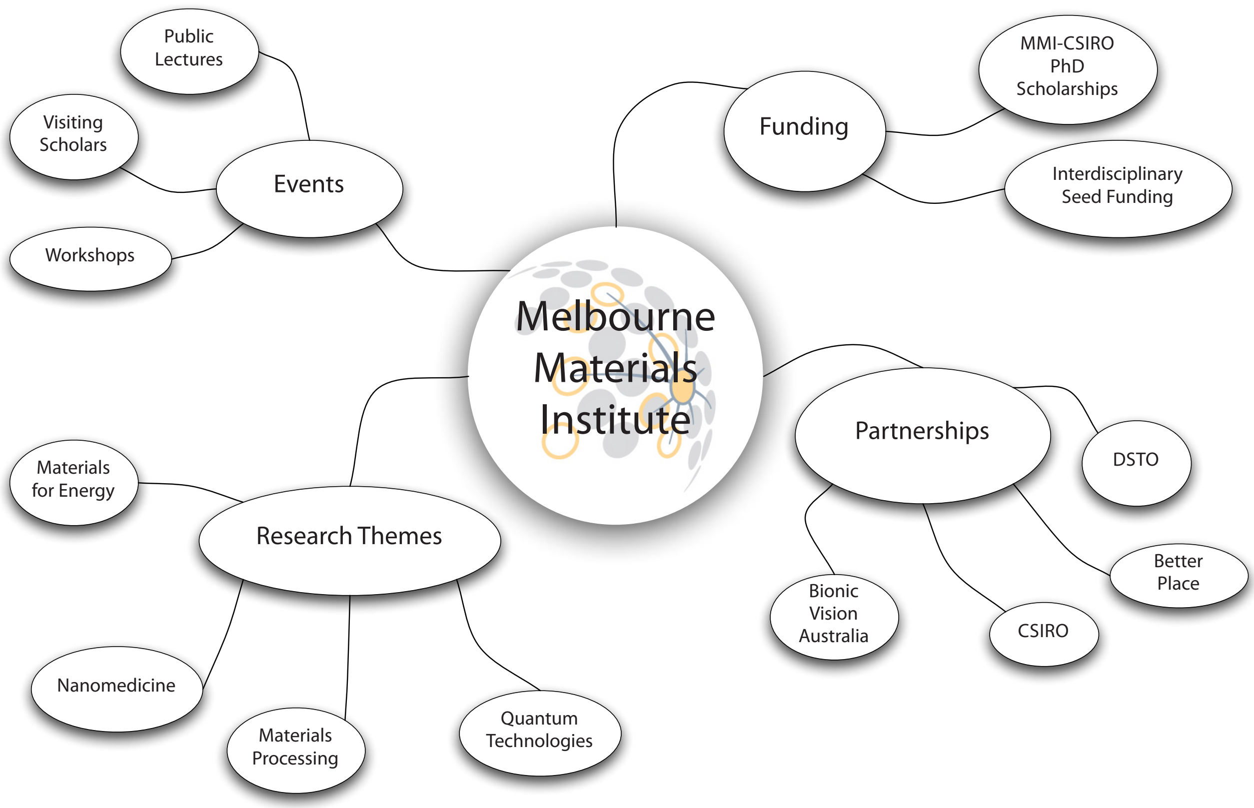
The MMI brings together the University of Melbourne's materials research expertise under the broad umbrella of the research themes: Nanomedicine, Materials for energy, Materials processing and Quantum technologies. The MMI captures much of the materials research strenghts of the Univesrity.

The MMI supports the full breadth of materials research by:

- providing interdisciplinary seed funding;
- holding research workshops;
- hosting visting scholars; and
- managing the joint CSIRO-MMI PhD scholarship program.

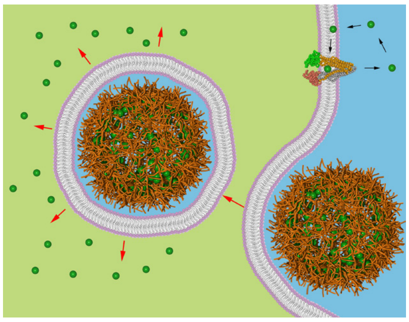
The Institute raises public awareness on materials advances and their implications on society by holding public lectures.

The MMI contributes to the University's external engagement through partnerships with organisations such as Bionic Vision Australia, the Defence Science Technology Organisation (DSTO) and Better Place Australia.



MMI research themes: overview

MMI's research is focused around four major themes, covering the breadth and depth of materials research: Nanomedicine, Materials for energy, Materials processing and Quantum technologies. Themes are led by academics from Physics, Chemical and Biomolecular Engineering and Chemistry.



Nanomedicine

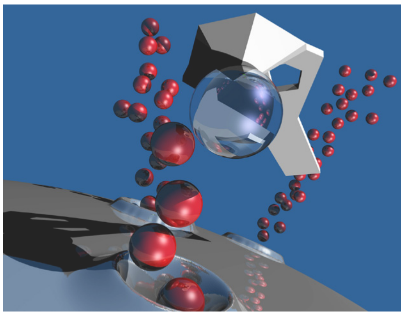
This theme explores the interface between biological and inorganic materials by synthesising nanotechnological drug delivery systems. It also aims to develop biomedical platforms for advanced tissue engineering.
Theme leader:
Prof. Frank Caruso, Department of Chemical & Biomolecular Engineering.

Materials for energy

This theme explores new materials that enhance energy efficiency or provide more sustainable alternatives to existing technologies .
Theme leader:
Assoc. Prof. Rachel Caruso, School of Chemistry.

Materials processing

This theme covers colloid and surface science, bioengineering, biomechanics and particle processing. It focuses on on solving major biomedical, health and water challenges.
Theme leader:
Prof. Peter Scales, Department of Chemical & Biomolecular Engineering.



Quantum technologies

This theme exploit powerful and previously untapped principles of the quantum world to create novel materials and devices, such as quantum sensors capable of monitoring sub-cellular processes.
Theme leader:
Prof. Lloyd Hollenberg, School of Physics.

Please note that the lists of names of researchers, students and associated research centres appearing under each theme in the following pages are not exhaustive and only aim to be 'a snapshot' of the research done in the corresponding field at the University of Melbourne.

Nanomedicine 2010 highlights

Theme leader:
Prof. Frank Caruso

Researchers
Prof. Stephen Kent, Prof. Robert Lamb, Prof. James McCluskey, Prof. Paul Mulvaney, Prof. Greg Qiao, Prof. Robert Shepherd, Prof. Geoff Stevens, Assoc. Prof. Muthupandian Ashokkumar, Assoc. Prof. Andrea O'Connor, Dr Anton Blencowe, Dr Jiwei Cui, Dr Kumar Ganesan, Dr Sally Gras, Dr Angus Johnston, Dr Carrie Newbold, Dr Clem Powell, Dr John Provis, Dr Rob de Rose, Dr Gabriel da Silva, Dr Georgina Such, Dr Yajun Wang, Dr Yan Yan.

Students
Ms Sarah Dodds, Ms Dewi Go, Ms Marleos Kamphius, Mr Kang Liang, Mr Berkay Ozcelik, Mr Nicolin Tirtaatmadja.

Associated Research Centres
Bio21 Institute, Particulate Fluids Processing Centre (PFPC).

Nano-engineered polymer capsules for cancer therapy

Advanced polymeric drug delivery systems hold significant promise for improving cancer therapy outcomes. The favourable impact of these systems on the treatment of various cancers has already been realised by several nanotechnology-based anticancer products.

This project aims to develop intelligent polymer capsules based on layer-by-layer technique to improve specificity, bioavailability, and therapeutic index of a range of therapeutics. Towards this goal, several major achievements have been fulfilled by the Nanostructured Interfaces and Materials Group (NIMs) in 2010:
1) Targeting human colorectal cancer cells has been demonstrated by functionalisation of capsules with monoclonal antibodies.
2) Several chemotherapeutic compounds have been successfully encapsulated in capsules and released in response to physiological stimuli, such as enzymes and redox potential. These systems have exhibited enhanced cytotoxicity compared with free drugs. Further, these capsules have been shown the ability to partially overcome P-glycoprotein-mediated multidrug resistance.
3) Polymer capsules with subcompartments have been developed as microreactors and drug carriers. These capsules can be readily equipped with multifunctionalities for synergistic delivery.

Biomolecule delivery systems for tissue engineering and skeletal muscle regeneration

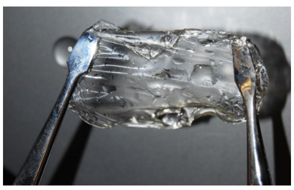
Current drug treatments for the muscle wasting and weakness common in many diseases, such as muscular dystrophy, tend to have short half-lives *in vivo* and may promote side-effects, such as cardiac hypertrophy. This project aims to develop safer and more effective methods of treating muscle wasting and weakness, by means of controlled release of the β2-adrenoceptor agonist, formoterol, from tailored microsphere delivery vehicles. The ability of the loaded microspheres to improve muscle function and treat muscle wasting is currently being tested *in vivo*.

Controlled delivery of biomolecules for tissue engineering applications

Delivery of growth factors has the potential to regenerate adipose tissues in patients suffering from trauma. However, many biomaterials that are used as delivery platforms cause foreign body responses *in vivo*. Excessive inflammation can severely reduce the effectiveness of such delivery systems and so limit tissue regeneration. The aim of this research project is to modulate the inflammatory response to biomaterials using an anti-inflammatory hormone normally produced in humans.

Ultrathin, biocompatible and biodegradable hydrogel films for corneal endothelium regeneration

Corneal endothelial cells are responsible for maintaining the optical clarity of the cornea. When the number of endothelial cells decrease greatly due to trauma or disease, optical clarity in the cornea is impaired leading to loss of vision. This research project aims to develop a substrate where autologous endothelial cells grown *in vitro* are transplanted into the damaged cornea allowing restoration of vision. To achieve this aim, synergistic materials incorporating natural and synthetic polymers have been exploited to produce optically clear ultrathin films with excellent mechanical, biological and permeability properties.



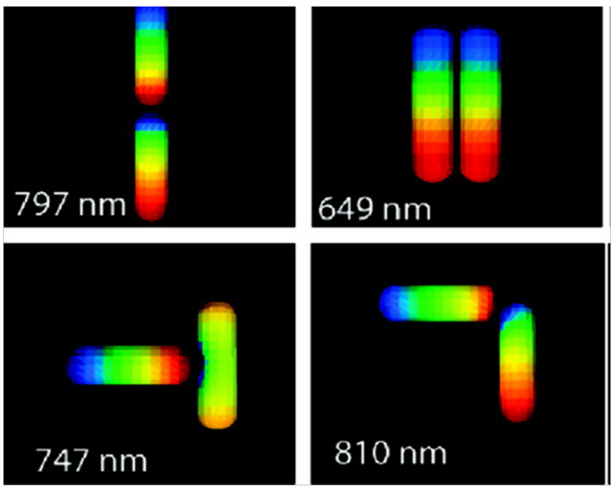
Ultrathin hydrogel film. The film has approximately 50 μm thickness and maintains very robust mechanical properties, which makes it ideal for implantation purposes.
Credit: Berkay Ozcelik

Materials for energy 2010 highlights

Theme leader
Assoc. Prof. Rachel Caruso

Researchers
Prof. Ken Ghiggino, Prof. Lloyd Hollenberg, Prof. Andy Holmes, Prof. Paul Mulvaney, Prof. John Sader, Assoc. Prof. Ray Dagastine, Assoc. Prof. George Franks, Assoc. Prof. Kenong Xia, Dr Dehong Chen, Dr. Liza Forbes, Dr David Jones, Dr Daniel McDonald, Dr Anthony Morfa, Dr Tich Lam Nguyen, Dr. John-Paul O'Shea, Dr. Carolina Tallon, Dr Xingzhan Wei, Dr Xiaolin Wu, Dr Wei Xu.

Associated Research Centres
Bio21 Institute, PFPC.



This image shows the near-field distribution associated with the coupling of small gold nanorods. The numbers refer to the wavelength of the coupled modes; the isolated rods exhibit a longitudinal LSPR mode at 707nm. Rods are 1.5nm apart. Credit: Alison M. Funston, Carolina Novo, Tim J. Davis, and Paul Mulvaney.

Plasmon coupling on the nanoscale
Prof.essor Paul Mulvaney's team has made dramatic progress in understanding plasmon coupling in nanoscale metal systems. This work should ultimately lead to the creation of plasmonic transistors, enhanced solar cells and even fast optical switches with a lower energy consumption than current electrical devices.

Understanding particle suspension behaviour
Associate Professor George Franks' research has provided further understanding of how to control suspension behaviour. His work relates inter-particle forces with suspension behaviour such as the flow properties of a suspension solution and how the particles pack. The use of novel additives such as smart polymers (polymers which can respond to stimuli) enables control of particle network microstructure and strength which can be used to improve titania nanoparticle networks for dye-sensitised solar cells (thin film, semiconductor based devices).

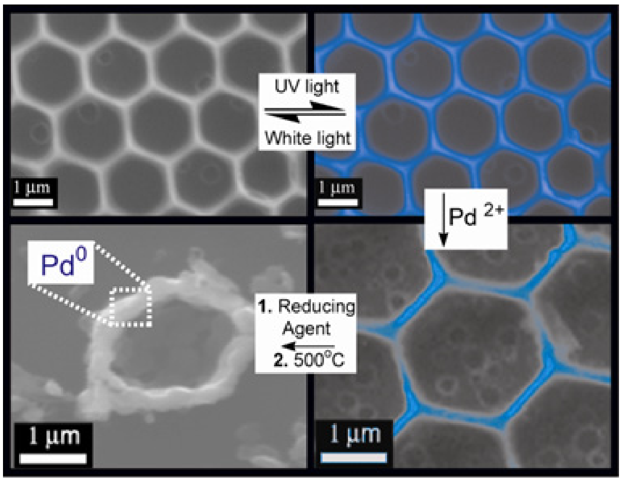
High efficiency dye-sensitised solar cells
Power conversion efficiencies greater than 10% in dye-sensitised solar cells have been achieved by using monodisperse mesoporous titanium dioxide beads, with high surface area and high scattering ability, prepared by Dehong Chen in Assoc. Professor Rachel Caruso's group.

Materials processing 2010 highlights

Theme leader
Prof. Peter Scales

Researchers
Prof. Muthupandian Ashokkumar, Prof. Frank Caruso, Prof. David Dunstan, Prof. Robert Lamb, Prof. Greg Qiao, Prof. Richard Strugnell, Assoc. Prof. Rachel Caruso, Assoc. Prof. Ray Dagastine, Assoc. Prof. Malcolm Davidson,Assoc. Prof. George Franks, Assoc. Prof. Michelle Gee, Assoc. Prof. Barry Hug hes, Assoc. Prof. Sandra Kentish, Prof. Kerry Landman, Assoc. Prof. Andrea O'Connor, Assoc. Prof. Kenong Xia, Dr Gabriel DeSilva, Dr Sally Gras, Dr Dalton Harvie, Dr Greg Martin, Dr John Provis, Dr Anthony Stickland.

Associated Research Centres
ARC Centre of Excellence in Design of Light Metals, Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), PFPC.



This image presents a generalised method for the preparation of photoresponsive, metal absorbing, and ordered porous materials. Credit: L. A. Connal, G. V. Franks and G. G. Qiao.

Engineered products
A number of products emerged as the outcome of ongoing research in this theme. These include patents for the production of metal nanoparticles in water at high concentrations, new membrane products for gas and ionic separations, changes to dairy products through ultrasonic processing, new methods for the processing of high grade ceramic materials and significant developments in the production of biofuels from algae. Research outcomes in nano-structured and light metals include the successful recycling of titanium machining chips, production of nanocrystalline beta titanium, refining of nickel-aluminium-bronze copper alloys, and forging of titanium powder on several pre-sintered alloys.

Material separations
Key research areas in materials separations include the separation of CO_2 from other gases, including N_2 and H_2, the separation of ions from water streams and the separation of particulates from slurries. The gas separation research includes pilot and semi-scale work including tonnes per day facilities in the Latrobe Valley in Victoria. Both pre and post combustion capture research is ongoing. Membrane flux and fouling research is critical to the improved performance of desalination processes and a key partnership with CSIRO in this area is ongoing. A range of new polymers that show temperature responsive behaviour have been formulated in the area of solid-liquid separation and a new theoretical approach to particulate suspension desaturation is now being tested.

Interfacial phenomena
This area is integral to a large proportion of the research in the materials processing theme. A significant new development included an enhanced fundamental understanding of the interaction of two deformable interfaces, including encouraging overlap between theory, simulation and experiment. The experiments involved atomic force microscopy and move our knowledge base forward from work on hard (non-deformable) interfaces.

Quantum technologies 2010 highlights

Theme leader
Prof. Lloyd Hollenberg

Researchers
Prof. Frank Caruso, Prof. David Jamieson, Prof. Fedor Jelezko (University of Ulm, Germany),Prof. Paul Mulvaney, Prof. Steven Prawer, Prof. Jorg Wrachtrup (University of Stuttgart, Germany), Assoc. Prof. Ann Roberts , Assoc. Prof. Robert Scholten, Dr Andrew Alves, Dr Alberto Cimmino, Dr Andy Greentree, Dr Charles Hill, Dr Angus Johnson, Dr Stefan Kaufman, Dr Jeffrey McCallum, Dr David Simpson, Dr Paul Gregory Spizzirri, Dr Yan Yan, Dr Changyi Yang.

Students
Ms Jessica van Donkelaar, Mr Liam Hall, Mr Liam McGuinness, Mr Jonathon Newnham, Mr Philipp Senn, Mr Alastair Stacey, Mr Sam Thompson.

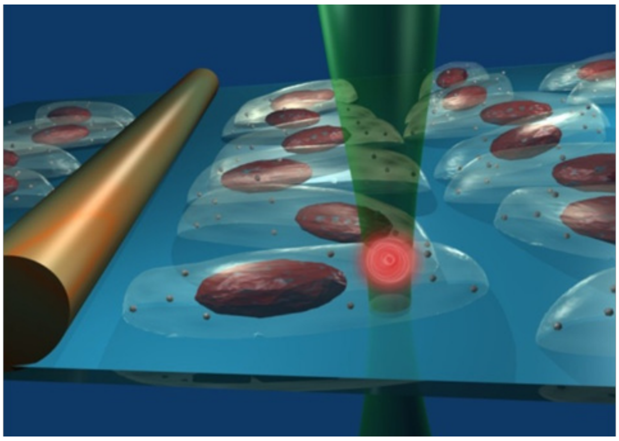
Associated Research Centres
Bio21 Institute, Centre for Coherent X-ray Science, Centre for Nanoscience and Nanotechnology, Centre for Quantum Computer Technology (CQCT), Micro-Analytical Research Centre (MARC).

Plasmonic lens
The research team led by Associate Professor Ann Roberts in the School of Physics demonstrated the first two-dimensional 'plasmonic lens'. This compact device, consisting of an array of nanometric cross-shaped apertures in a thin film of silver, can produce a three-dimensional focus. This research may lay the foundations for novel devices for imaging and data storage.

Placement of single atoms into nano-scaled electronic devices
Today's semiconductor industry is facing a serious challenge in the fabrication control of doping atoms in silicon with a shrinking feature size down to sub-100 nm; it has been a formidable quest for a new technology capable of placing single, to a few donor, atoms in a precise location in a nano-scaled structure. The new technology developed at the UoM in the CQCT is capable of deterministicly doping single atoms in silicon. This is essential for achieving a new functionality and a high reliability in the next generation of silicon electronic applications, especially silicon quantum computer applications.

Quantum computing
University of Melbourne researchers in collaboration with colleagues in the ARC Centre of Excellence for Quantum Computer Technology at UNSW and Aalto University in Finland have developed a 'single electron reader', one of the key building blocks needed to make a quantum computer. The CQCT team have fabricated the nanoscale silicon device that reads the spin state of a single electron in a single phosphorus atom implanted in a block of silicon. The discovery opens the way to constructing a large-scale quantum computer amenable to mass-production.

Quantum sensing
By studying the quantum properties of a single atomic defect within a diamond nanocrystal, an interdisciplinary team at UoM and University of Stuttgart has investigated a new quantum fluorescent marker. The nitrogen-vacancy (NV) defect centre in diamond acts as stable fluorescent beacon and critically also allows its quantum properties to be explored and manipulated, yielding new ways to explore complex intracellular mechanisms. In a world-first, the team has demonstrated quantum measurement in living cells, monitoring of the orientation of a nanoparticle to an accuracy of less than one degree. Quantum coherence measurements were also demonstrated in a living cell for the first time. This opens up new possibilities in nanoscale bio-magnetometry, enabling a unique probe of changes in the cells electromagnetic environment.



Quantum measurement of nanodiamonds in living cells (artist's impression). Credit: David Simpson.

Interdisciplinary seed funding: overview

This scheme provides funding to address complex problems facing society with solutions that demand an interdisciplinary approach. The scheme seeks to support research activities that:

- will benefit from short-term seed-funding;
- will lead to new interdisciplinary collaborations;
- can identify strong opportunities for external funding; and
- are consistent with the broad research objectives of one or more of the Melbourne Research Institutes or designated emerging areas of focus.

The MMI supported six projects commencing in 2010 in a range of areas:

- Rapid environmental detection of Legionella
- Quantum decoherence imaging for biological systems
- Nanoparticle mucosal vaccines
- Electroactive polymer foams for medical bionics
- Magnetic resonance and optical imaging to study the dynamics of neural stem cells in situ using nanodiamonds
- Towards a design framework for functionalised wettability.

Quantum dots based on Cadmium Selenide. The luminescence varies from blue to deep red for nanocrystals varying in size from 2 to 6 nm. Credit: TL NGuyen.

Rapid environmental detection of *Legionella*

Prof. Elizabeth Hartland, Department of Microbiology and Immunology.
Prof. Frank Caruso, Centre for Nanoscience and Nanotechnology.
Prof. Greg Qiao, Department of Chemical & Biomolecular Engineering.

Purpose

Legionnaire's disease is a life threatening form of acute pneumonia caused by inhaling the environmental bacterium, *Legionella.* The species, *L. pneumophila,* is the most serious and most common cause of Legionnaire's disease. Identification of *Legionella* in contaminated water relies on bacteriological culture which is not only slow but lacks sensitivity.

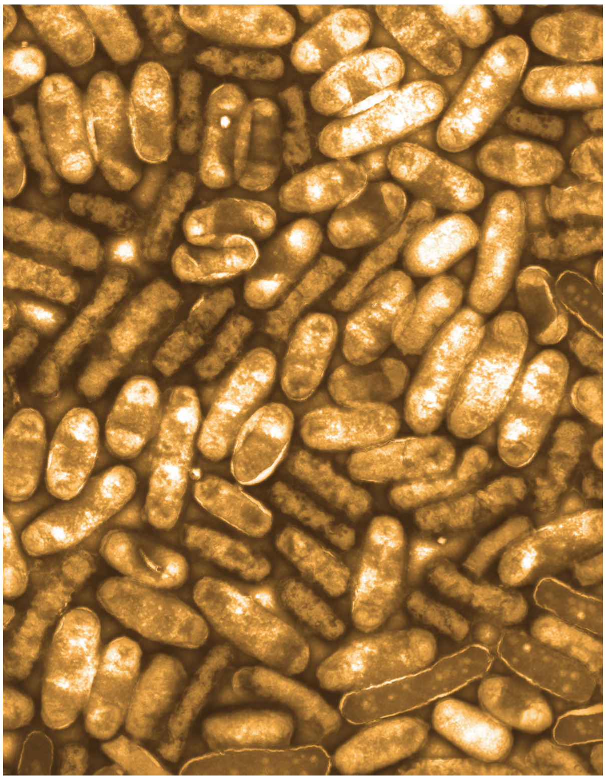
The broad aim of this interdisciplinary project is to develop an in situ test for the rapid detection of live L. pneumophila in water based on detecting the activity of the major *Legionella* secreted protease. The ultimate goal is to build a detection polymer into a filter based system for on-site detection of live *Legionella* in water samples.

Progress

Tests provided validation that the *Legionella* protease may be used as a marker for the most serious cause of Legionnaire's disease.

The team is currently identifying peptides that the major protease from *L. pneumophila* cleaves with maximum sensitivity and specificity.

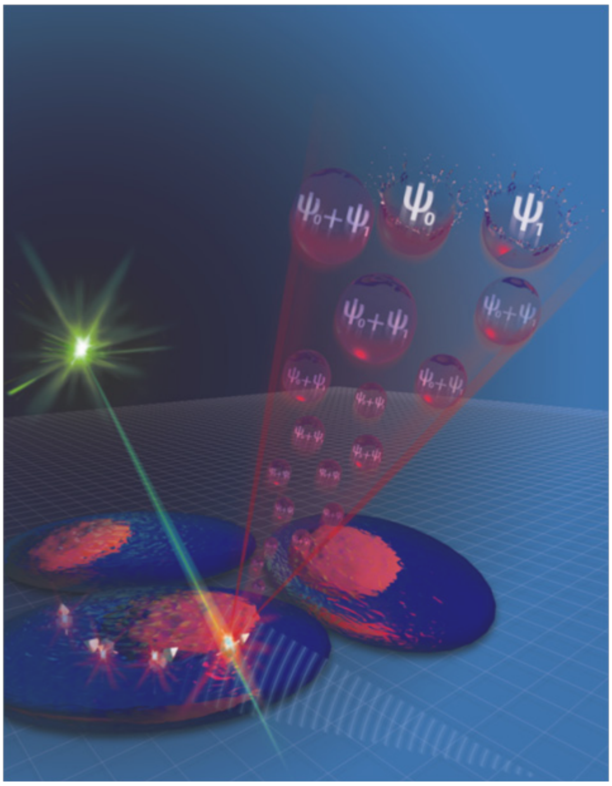
Once the preferred peptide is identified it will be incorporated into a polymer matrix to develop a sensitive and specific protease test.



False-colour transmission electron micrograph of a colony of the Gram-negative bacteria Legionella pneumophila, cause of Legionnaire's disease. Original image magnification: x7000. Credit: Hartland laboratory.

Quantum decoherence imaging for biological systems

Prof. Lloyd Hollenberg, School of Physics.
Prof. Paul Mulvaney, Chemistry, Bio21.
Prof. Frank Caruso, Department of Chemical and Biomolecular Engineering.



Quantum measurements performed on single-spin nanodiamond probes within living HeLa cells (artist's impression). Credit: David Haworth

Purpose

This project aims to build on the early development of a fundamentally new imaging and sensing mode for application in biology and the life-sciences. Preliminary work shows that this imaging mode has the sensitivity required to detect the minute magnetic field fluctuations corresponding to important processes in the biological environment.

This sensing technology is based on the control and measurement of a single nitrogen-vacancy atomic defect in a nanoparticle of diamond which is sensitive to small magnetic fluctuations at the nanoscale. The immediate challenge is to be able to conduct the required quantum measurements on this atomic system in a moving nanodiamond in a biological environment.

The program supports a multi-disciplinary team formed in 2008 across the Physics, Chemistry/Bio21 and Chemical and Biomolecular Engineering Departments to address biological applications of the new nanodiamond quantum sensing technology. The research in this seed program focuses on converting the existing nanodiamond quantum sensing apparatus to a system appropriate for biological samples and to perform the first proof of principle experiments.

Progress

Adapting the existing vertical configuration set-up has allowed the team to carry out the first quantum measurements of a single atom sensor in a living cell. Human HeLa cells were cultured in a suspension of nanodiamonds containing single nitrogen-vacancy (NV) centres. A cell containing nanodiamonds with fluorescent NV centres was identified and quantum control and measurement of the atomic NV systems carried out over many hours.

The results showed a new perspective of the nanoscale biological environment through monitoring the quantum coherence of the NV centres, and their orientation.

As a world first measurement breaking new ground in biological sensing, the work was published in Nature Nanotechnology.

Nanoparticle mucosal vaccines

Assoc. Prof. Neil O'Brien Simpson, Bio 21, Melbourne Dental School.
Prof. Frank Caruso, Department of Chemical and Biomolecular Engineering.
Prof. Eric Reynolds, Melbourne Dental School.

Purpose

This project aims to construct and formulate novel protein/peptide nanoparticle vaccines that (1) induce an antigen-specific immune response after mucosal administration and (2) provide protection against the bacterial-induced oral disease chronic periodontitis.

Periodontitis is a pathogen-associated inflammatory mucosal disease leading to the destruction of the tooth's supporting tissues and ultimately tooth loss. The disease is a major public health problem in all societies and has been linked with cardiovascular diseases and certain cancers. It is estimated to affect at least 30% of the adult dentate population ,with severe forms affecting up to 15%.

Most of the current vaccines are parenterally administered (i.e. through a channel other than the digestive tract, as by intravenous or intramuscular injection). Yet the majority of infections are initiated at mucosal surfaces. Although parenteral vaccination induces a good systemic immunity, it induces poor mucosal immunity. Mucosal vaccination, however, can induce both systemic and mucosal immunity.

Future immunisation may be as easy as sucking a lozenge loaded with nanoparticle vaccines.

Progress

The major focus of the team's research has been to evaluate the immunopotentiation (i.e. the ability to enhance the immune response) of polymeric nanoparticles. The aims were 1) to produce (bacterial) antigen loaded nanoparticles and 2) to compare the immune response induced by the nanoparticles to that induced by a bacterial protein antigen in an oil based adjuvant (IFA), and the phosphate buffered saline (PBS).

Nanoparticles with an average diameter of 400nm were produced whereby the protein antigen was encapsulated within a biodegradable poly-lysine shell and this was used in the immunological studies.

The antibody response induced by the antigen encapsulated within the polymeric nanoparticles was five times that induced by the antigen in PBS and similar in magnitude to the antigen administered in IFA.

This research has shown that the nanoparticles have a very strong immunopotentiation ability and an effect equivalent to that of IFA. This property of polymeric nanoparticles is of great significance, since they are biodegradable and non-toxic, while IFA, although well known as a strong immunopotentiator, cannot be used for human vaccination.

These results have led the researchers to apply for NHMRC funding to continue this work and further develop the nanoparticles as a mucosal delivery vehicle for vaccination.

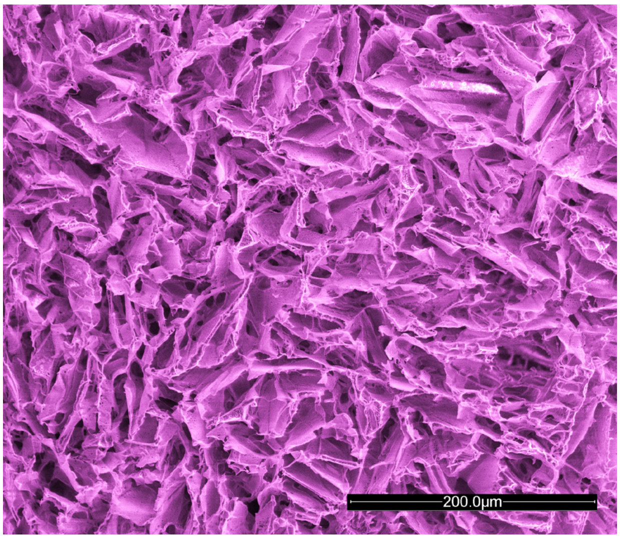
Electroactive polymer foams for medical bionics

Assoc. Prof. Andrea O'Connor, Department of Chemical & Biomolecular Engineering.
Dr Silvana Mergen, Otolaryngology Eye and Ear Hospital.
Dr Carrie Newbold, Otolaryngology Eye and Ear Hospital .
Ms Silvia Leo, Department of Chemical & Biomolecular Engineering.
Ms Dimitra Stathopoulos, Otolaryngology Eye and Ear Hospital.

Purpose

Metal electrodes used for electrical stimulation of neural tissue can corrode in body fluids and generate by-products which are potentially damaging to the surrounding tissues. The aim of this project is to develop enhanced electrodes for medical bionics, using electroactive polymers to provide safe electrical stimulation. The challenge is that electroactive polymers have a charge capacity much lower than that of metals, resulting in insufficient charge delivery to the neural tissue.

This project aims to bridge this gap by preparing polymer foams that would be able to attach to the neural tissue, e.g. in the cochlea. Such a configuration would require much lower charge generation, making the electroactive polymers promising materials for electrical stimulation.



False-colour electroactive polymer foam on a latinum substrate.
Credit: S. Leo, C.M. Wong, S. Mergen, A.J. O'Connor, unpublished data.

Progress

Two types of electro-active polymer coatings were produced and their electrical properties characterised: (1) dense thin film polymer coatings and (2) foam polymer coatings with significantly higher surface area than the films, in order to increase the charge capacity.

Two types of electrodes containing the above polymer coatings on platinum substrates were produced and tested: one with the film polymer coatings; the other one with a composite of film and foam coatings. The composite coatings exhibited higher charge transfer capacity than that of the polymer film alone, hence showing promise for development of capacitive electrodes.

Porous inorganic materials have also been assessed as an alternative high-capacitance material for inclusion in electrodes. Investigation of the potential of these materials in medical bionics is continuing.

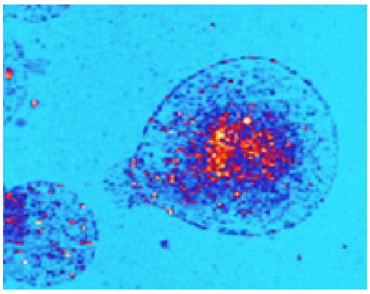
Magnetic resonance and optical imaging to study the dynamics of neural stem cells *in situ* using nanodiamonds

Assoc. Prof. Ann Turnley, Centre for Neuroscience.
Dr Stefania Castelletto, School of Physics.
Dr Tobias Merson, Howard Florey Institute.

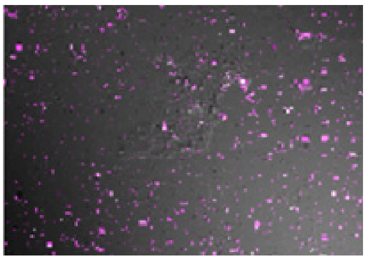
Purpose

Current techniques to investigate the mechanisms of stem cell-mediated repair of neural tissue are limited to analysis of post-mortem tissue. This project aims to develop a method of real time, non-invasive whole animal imaging to assess the migration of endogenous neural stem cells.

This research is focused on investigating the use of nanodiamonds to label endogenous neural stem cells for magnetic resonance and optical imaging. The primary aim is to exploit nanodiamond particles to study the dynamics of cellular behaviour. The eventual aim is to determine how endogenous neural stem cells migrate, differentiate and integrate into the brain in the course of a regenerative response to neural damage.



Confocal image of SiV centres in nanodiamonds inside a neural stem cell. Credit: Merson et al. 2010 (Unpublished)



Wide field image of 80nm diameter nanodiamonds (purple) in neural stem cells (grey). Credit: Merson et al. 2010 (Unpublished)

Progress

The biocompatibility of the labelling technique has been established *in vitro*. A concentration of nanodiamonds up to 100µg/ml had no effect on neural stem cell characteristics (such as their ability to proliferate) and was not toxic.

The team has investigated the suitability of various colour centres in nanodiamonds for optimal fluorescent imaging of nanodiamond-labelled neural stem cell.s Colour centres are defects in the crystal lattice that produce optical absorption bands in an otherwise transparent crystal. In colour centres studied here, defects are created by replacing a carbon atom with another atom (e.g. silicon or chromium atoms).

Results show that nanodiamonds containing colour centres based on nitrogen are less efficient for cellular labelling. Indeed, their quite narrow absorption spectra and broad emission spectra overlaps with intrinsic cellular auto-fluorescence.

By contrast, in-house synthesis of nanodiamonds containing colour centres based on chromium and silicon impurities were much better candidates for cell labelling, since they exhibit very bright and photo-stable fluorescence, broad absorption spectra and narrow emission spectra following red laser excitation.

Finally, nanodiamonds containing colour centres based on chromium and silicon-vanadium were found to be amenable to dipole imaging microscopy due to their optical polarisation properties and very narrow spectral emission. Dipole imaging microscopy is a type of microscopy based on the electric charges inherent to the colour centre. This method could allow tracking of dynamic changes in the orientation of individual nanodiamonds at the cell surface or within the cell.

Towards a design framework for functionalised wettability

Dr Dalton Harvie, Department of Chemical and Biomolecular Engineering.
Prof. Paul Mulvaney, School of Chemistry, Bio21.

Purpose

In nature organisms use specific surface structures to control wetting, to the advantage of the organism. Current international advanced materials research is focused on reproducing this functionalised wettability by 'biomimicking' these surface structures.

While this research has been largely successful under controlled laboratory conditions, the technology uptake in real world applications has been limited. Limitations include:

- the inability to create a surface robust enough to withstand environmental conditions and wear;
- the inability to predict (and hence control) the conditions under which a designed surface will act as intended.

This project aims to gain a fundamental understanding of the relationship between surface morphology and wettability. In particular, it will examine whether for chemically inert, incompressible and immiscible fluids, wettability depends only on the form rather than the size of the surface structure.

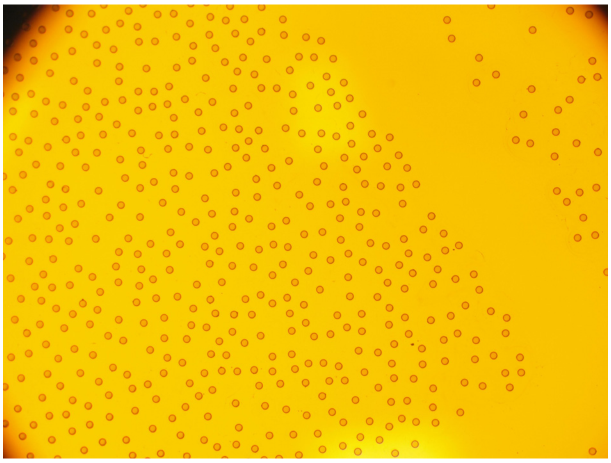
The project will involve experimentation and modelling of controlled morphology surfaces having randomly distributed, uniformly sized and controlled density 'hole' and 'pole' structures created via photolithography.

Progress

Structured surfaces consisting of randomly spaced micro-poles having diameters of 10, 20, 40 and 80 microns have been constructed.

Surfaces have been chemically modified to ensure consistent wetting behaviour and low flat-surface contact angle hysteresis, consistent with the proposed modeling approach.

Initial analysis confirms the hypothesis that wetting behaviour is independent of structure size at the micron scale, however data collection and analysis is still underway.



Surface structured with random arrays of poles. Credit: Dr Dalton Harvie, Prof. Paul Mulvaney.

Contact angle measurements. Credit: Dr Dalton Harvie, Prof. Paul Mulvaney.

MMI partnerships: "Brings us your problems."

Developing and nurturing strategic partnerships is a high priority for the Institute. We seek to develop deep, long lasting relationships with organisations who share our passion for addressing BHAGs – Big, Hairy Audacious Goals. By combining the creativity and innovation of researchers at the University with those of our partners, we can have the confidence to embark on projects that have the capacity to bring about transformational change, from alleviating blindness to radically changing the way we view the future of transportation.

The MMI is at the forefront of a new partnership between the University and Better Place Australia. Through an ARC Linkage Project with the School of Engineering the partnerships is investigating the effect of mass adoption of electric cars on electricity distribution grids.

The MMI-CSIRO PhD Scholarship Program not only provides students with broader career options but also nurtures a new generation of materials researchers and contributes to increased collaboration through joint supervision.

As a member of the Bionic Vision Australia consortium, the MMI is developing biocompatible, high-density electrode arrays that are key components of advanced high resolution bionic eye prosthesis.

With the launch of the Defence Science Institute in 2010 the MMI has formalised the research collaboration with the DSTO. This multidisciplinary engagement include researchers from the faculties of Science, Engineering, and Medicine, Dentistry and Health Sciences.

Better Place Australia

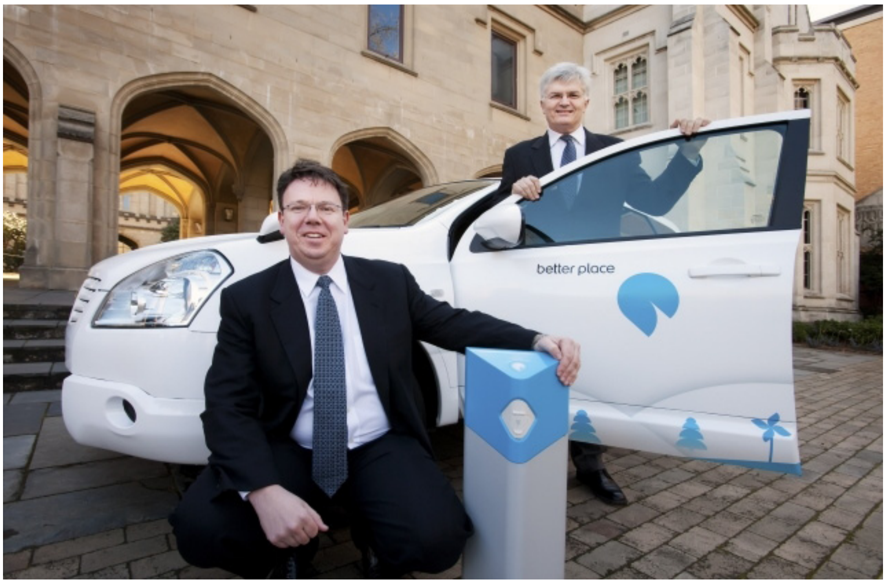
The MMI is at the forefront of the partnership between the University and Better Place Australia, investigating the mass adoption of electric cars. MMI's Director Professor Steven Prawer has led the University's engagement with Better Place Australia, resulting in the signature of a Memorandum of Understanding (MoU) between the two organisations. The partnership marks an important step in the collaboration between public and private sectors and will explore the social, political and environmental impacts of the mass adoption of electric vehicles in Australia.

Better Place Australia's vision is that of an electric car network that provides a complete solution to enable the mass-market adoption of electric cars. Better Place provide the infrastructure and services that makes driving an electric car convenient, reliable and affordable. Using an innovative battery-switch model that provides instant range extension, combined with renewable energy wherever possible, Better Place are accelerating the global transition to sustainable transport. Better Place was founded in Palo Alto, California, and has operations in North America, Europe and the Asia Pacific. The company will deploy its first electric car networks in Israel, Denmark and Australia.

The partnership with the UoM has led to an ARC supported joint-research project with Better Place Australia as a partner, involving key Faculty of Engineering staff - including the Dean, Professor Iven Mareels, and the Head of the department of Mechanical Engineering, Professor Doreen Thomas - to examine the implications of mass adoption of electric vehicles on the electricity grid. Issues such as optimisation of the location of battery swap stations will also be considered.

The company's first demonstration electric vehicle (pictured), housed at the University of Melbourne, was used to evaluate the new technology. As part of the Memorandum of Understanding, Better Place Australia and the University of Melbourne will begin to install charge points on the campus in preparation for the arrival of the first commercial electric vehicles. It is hoped that one day the entire University fleet could be converted to electric operation. Further initiatives for 2011 will be determined in ongoing discussions between the partner organisations, which have been broadened to include organisations such as CSIRO.

For more information, visit:
http://australia.betterplace.com
http://visions.unimelb.edu.au/episode/72



The Memorandum of Understanding was fittingly signed on the bonnet of the demonstration electric car by Vice-Chancellor Professor Glyn Davis (right) and CEO of Better Place Australia, Evan Thornley.

Bionic Vision Australia

The MMI is a member of the $42 million Bionic Vision Australia (BVA) consortium. BVA is developing a bionic eye to restore some sense of vision to people with degenerative forms of vision impairment, such as retinitis pigmentosa or age-related macular degeneration. MMI's involvement in the project consists in solving the materials-related problems for the design and encapsulation of high-density stimulation electrodes.

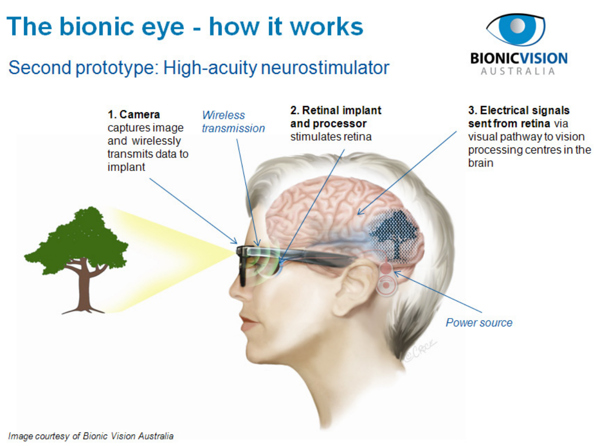
In December 2009, the Australian bionic eye project was awarded a $42 million Australian Research Council grant by the Australian Federal Government to develop bionic vision technology. Formally launched in March 2010, BVA brings together researchers from the Bionic Ear Institute (now known as the Bionics Institute), the Centre for Eye Research Australia, NICTA, the University of Melbourne and the University of New South Wales.

Two prototypes are currently being developed: a wide-view neurostimulor device; and a high-acuity neurostimulator device. The wide-view neurostimulator device will utilise an implanted chip with 98 electrodes to stimulate the retina. The device aims to enable patients to manoeuvre around large objects such as buildings, cars and park benches.

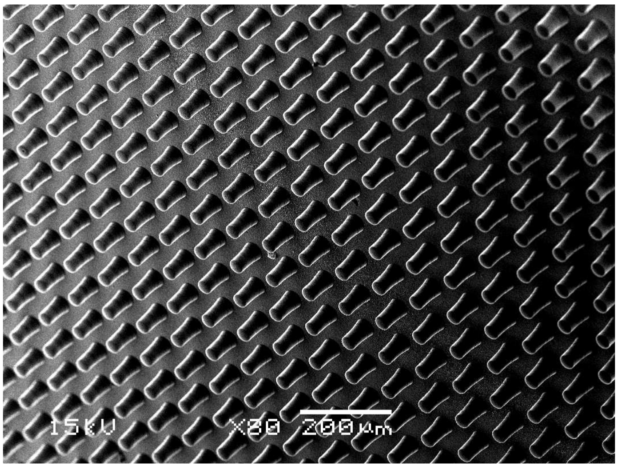
The high-acuity device will include an implanted chip with over one thousand stimulation electrodes, allowing a more detailed visual perception. This device aims to enable patients to recognise faces and read large print.

The MMI team, led by Professor Steven Prawer, is working in collaboration with researchers from NICTA on the development of biocompatible, high-density electrode arrays for the high-acuity device. The electrode array is based on nitrogen-doped ultrananocrystalline diamond and will be encapsulated in a biocompatible and thermally-insulating diamond case.

For more information, visit:
http://www.bionicvision.org.au/



How the second prototype bionic eye works .
Credit: Beth Croce CMI, Copyrights apply.



High density diamond array for the high-acuity device.
Credit: Kate Fox.

CSIRO

The MMI has forged strong links with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), particularly the CSIRO Materials Science and Engineering (CMSE) Division, to collaboratively build research capacity in the area of materials science and engineering through postgraduate training and supervision.

The CMSE Division has over 800 researchers who utilise a diverse range of research capabilities, with an emphasis on working at the interface between biology, chemistry and physics within an engineering framework. CMSE researchers seek to improve devices, processes and materials to transform manufacturing and to solve major national and global challenges in areas such as health, energy, water and transport.

The MMI-CSIRO Materials Science PhD Scholarship Program has been established to support outstanding local and international students as they embark on a career in materials research. Under this innovative scheme, the successful applicants are invited to contribute to research by partaking in sophisticated scientific dialogue with leading established researchers, industries and the government through the MMI and the CSIRO Division of Materials Science and Engineering.

The program will offer competitive tax-free PhD scholarships of AUD $30,000 p.a. and fee remission for the duration of three and a half years to outstanding local and international students pursuing doctorate research in materials science.

This unique opportunity allows prospective students to not only join research teams conducting cutting-edge materials science research, but also access the rich networks and state-of-the-art research facilities of the University of Melbourne and CSRIO across the nation. These sites include the Bio21 Institute, Centre for Quantum Computing Technology, the Melbourne Centre for Nanofabrication, the Australian Synchrotron, and the CSIRO extensive network of materials science infrastructure across Australia in the Parkville, Clayton, Highett, North Ryde and Lindfield laboratories.

For more information, visit:
http://www.csiro.au
http://www.materials.unimelb.edu.au

DSTO

Witnesses and signatories to the DSTO/UoM Memorandum of Understanding (clockwise from top left) Dr Ian Sare, Prof. Glyn Davis, Mr Alan Gray, and Prof. Liz Sonenberg.

The MMI has lead the University's multidisciplinary engagement with the Defence Science and technology Organisation (DSTO), resulting in a formal partnership and the creation of the Defence Science Institute (DSI).

Experts across the University have worked informally with the DSTO for several years. On 18th March 2010, a Memorandum of Understanding (MoU) was signed by the University of Melbourne and the DSTO, formalising the relationship. The MoU commits both organisations to a long-term strategic partnership. This alliance will benefit both organisations by expanding their respective research capabilities and lead to the joint development of technologies and programs to enhance Australia's national security.

On 29th October 2010, the DSI was officially launched, with Professor Steven Prawer as the Interim Director. Supported by the Victorian State Government, the DSI is the first research institute founded jointly by the University of Melbourne with an external organisation. Combining research strengths from Bio21, the DSTO, National ICT Australia (NICTA) and other Victorian universities and industry partners, the DSI aims to find innovative responses to future-proof the nation's defence sciences.

Headed by co-theme leaders from the University and the DSTO, the research fields currently include:

- innovation in biological and chemical systems
- human protection and performance
- active materials
- energy and propulsion systems
- micro-radar
- intelligent information systems.

For more information, visit:
http://www.defence.unimelb.edu.au
http://www.dsto.defence.gov.au

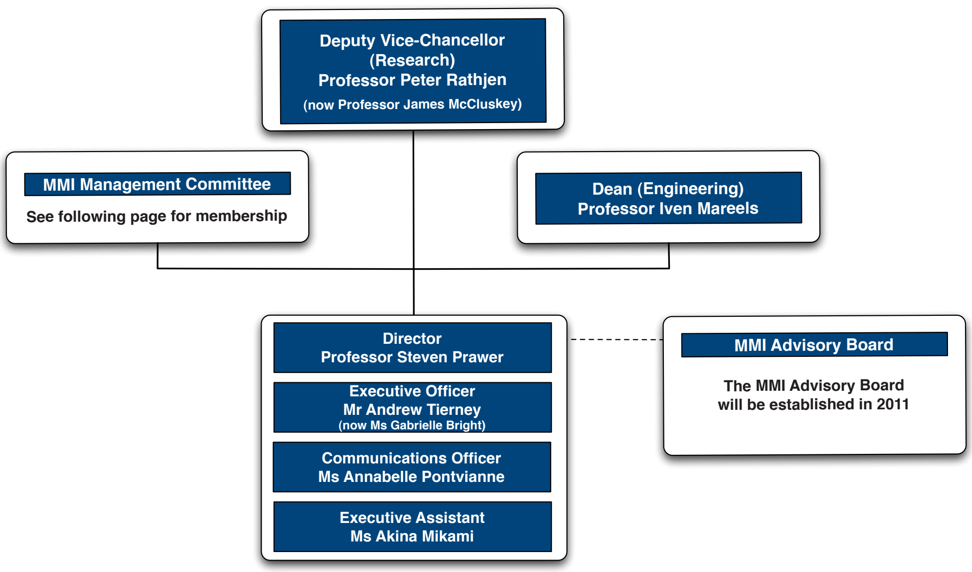
Governance

The MMI is one of five interdisciplinary research institutes established by the University of Melbourne in 2009. The Institutes have been established to promote research linkages and collaboration across the University and to play a lead role in articulating University research to external audiences.

The Director of the MMI is responsible for the strategic and overall management of the Institute. The Director works with the MMI Management Committee to develop and organise new research programs, to oversee the communications and outreach work of the Institute, and to provide a public voice for the University's overall research activity in materials.

The Director reports to the Deputy Vice-Chancellor (Research) on strategic and financial matters, and the MMI custodial Dean (Engineering) on operational matters. Reports on the operations of the Institute are provided annually to the University Council through the Deputy Vice-Chancellor (Research).

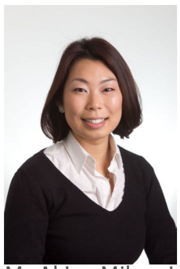
The Executive Officer (EO) develops and delivers strategic programs and has responsibility for the day-to-day operations of the Institute. The EO undertakes liaison with internal and external stakeholders, to identify new external opportunities and build relationships with external organisations.




Prof. Steven Prawer


Ms Gabrielle Bright (2011)


Ms Annabelle Pontvianne


Ms Akina Mikami

Management Committee

The Management Committee is composed of senior academics from Bio21, Chemistry, Chemical and Biomolecular Engineering, the Faculty of Business and Economics, Mechanical and Manufacturing Engineering, Microbiology and Immunology, and Physics, providing an interdisciplinary perspective to address materials challenges of today's society.

Prof. Frank Caruso
Chemical and Biomolecular Engineering

Assoc. Prof. Rachel Caruso
Chemistry

Assoc. Prof. George Franks
Chemical and Biomolecular Engineering

Dr Andrew Greentree
Physics

Prof. Lloyd Hollenberg
Physics

Prof. David Jamieson
Physics

Prof. Iven Mareels
Engineering

Prof. Ampalavanapillai Nirmalathas
Engineering

Prof. Richard O'Hair
Chemistry

Dr Joseph Palamara
Dental Science

Assoc. Prof. Ann Roberts
Physics

Prof. Peter Scales
Chemical and Biomolecular Engineering

Prof. Arthur Shulkes
Medicine

Prof. Gregory Whitwell
Business & Economics

Selected publications 2010

Journal articles

Burdukova, E; Li, H; Ishida, N; O'Shea, JP; Franks, GV. "Temperature Controlled Surface Hydrophobicity and Interaction Forces Induced by Poly (N-Isopropylacrylamide)." *Journal of Colloid and Interface Science,* 2010, 342, 586-592.

Chan, NY; Dunstan, DE. "The thermodynamics of polymer mixing and compression in the semidilute refime." *Journal of Physical Chemistry*, 2010, 114 (32), 10520-10523.

Chandrawati, R; Hosta-Rigau, L; Vanderstraaten, D; Lokuliyana, SA; Stadler, B; Albericio, F; Caruso, F. "Engineering Advanced Capsosomes: Maximising the Number of Subcompartments, Cargo Retention and Temperature-Triggered Reaction." *ACS NANO*, 2010, 4, 1351-1361.

Davidson, MR; Bharti, RP; Harvie, DJ. "Electroviscous effects in a Carreau liquid flowing through a cylindrical microfluidic contraction." *Chemical Engineering Science*, 2010, 65 (23), 6259-6269.

Gladman, BR; Rudman, M; Scales, PJ. "The effect of shear on gravity thickening: Pilot Scale Modelling." *Chemical Engineering Science*, 2010, 65 (14), 4293-4301.

Go, DP; Palmer, J; Gras, SL; O'Connor, AJ. "Delivery of an anti-inflammatory hormone via layer-by-layer assembly of biomolecules." *European Cells and Materials,* 2010, 20 (3), 93.

Hajimohammadi, A; Provis, JL; van Deventer, JSJ. "Effect of alumina release rate on the mechanism of geopolymer gel formation." *Chemistry of Materials,* 2010, 22 (18), 5199-5208.

Hamid, ZAA; Blencowe, A; Ozcelik, B; Palmer, JA; Stevens, GW; Abberton, KM; Morrison, WA; Penington, AJ; Qiao, GG. "Epoxy-amine synthesised hydrogel scaffolds for soft-tissue engineering." *Biomaterials*, 2010, 31(25), 6454-6467.

Hosta-Rigau, L; Stadler, B; Yan, Y; Nice, EC; Heath, JK; Albericio, F; Caruso, F. "Capsosomes with Multilayered Subcompartments: Assembly and Loading with Hydrophobic cargo." *Advanced Functional Materials*, 2010, 20, 59-66.

Huang, F; Chen, D; Zhang, XL; Caruso, RA; Cheng, YB. "Dual-function scattering layer of submicrometer-sized mesoporous TiO2 beads for high-efficiency dye-sensitized solar cells." *Advanced Functional Materials,* 2010, 20, 1301-1305.

Huebl, H; Nugroho, CD; Morello, A; Escott, CC; Eriksson, MA; Yang, C; Jamieson, DN; Clark, RG; Dzurak, AS. "Electron tunnel rates in a donor-silicon single electron transistor hybrid." *Physical Review B - Condensed Matter and Materials Physics*, 2010, 81 (23).

Jagannathan, M; Grieser, F; Ashokkumar, M. "Combined advanced oxidation processes for the synergistic degradation of ibuprofen in aqueous environments." *Journal of Hazardous Materials*, 2010, 178, 202-208.

Johnson, BC; Tettamanzi, GC; Alves, ADC; Thompson, S; Yang, C; Verduijn, J; Mol, JA; Wacquez, R; Vinet, M; Sanquer, M; Rogge, S; Jamieson, DN. "Drain current modulation in a nanoscale field-effect-transistor channel by single dopant implantation." *Applied Physics Letters*, 2010, 96 (26).

Johnston, APR; Such, GK; Caruso, F. "Triggering Release of Encapsulated Cargo." Angewandte Chemie International Edition, 2010, 49, 2664-2666.

Kamphuis, MMJ; Johnston, APR; Such, GK; Dam, HH; Evans, RA; Scott, AM; Nice, EC; Heath, JK; Caruso, F. "Targeting of Cancer Cells Using Click-Functionalized Polymer Capsules." *Journal of the American Chemical Society*, 2010, 132, 15881-15883.

Lin, L; Goh, XM; McGuinness, LP; Roberts, A. "Plasmonic lenses formed by two-dimensional nanometric cross-shaped aperture arrays for fresnel-region focusing." *Nano Letters,* 2010, 10 (5), 1936-1940.

Morello, A; Pla, JJ; Zwanenburg, FA; Chan, KW; Tan, KY; Huebl, H; Möttönen, M; Nugroho, CD; Yang, C; Van Donkelaar, JA; Alves, ADC; Jamieson, DN; Escott, CC; Hollenberg, LCL; Clark, RG; Dzurak, AS. "Single-shot readout of an electron spin in silicon." *Nature*, 2010, 467 (7316), 687-691.

Möttönen, M; Tan, KY; Chan, KW; Zwanenburg, FA; Lim, WH; Escott, CC; Pirkkalainen, JM; Morello, A; Yang, C; Van Donkelaar, JA; Alves, ADC; Jamieson, DN; Hollenberg, LCL; Dzurak, AS."Probe and control of the reservoir density of states in single-electron devices." *Physical Review B - Condensed Matter and Materials Physics*, 2010, 81 (16).

Ochs, CJ; Such, GK; Yan, Y; Caruso, F. "Biodegradable Click Capsules with Engineered Drug-Loaded Multilayers." *ACS NANO* 2010, 4, 1653-1663.

Ong, LO; Dagastine, RR; Kentish, SEK; Gras, SG. "Transmission electron microscopy imaging of the microstructure of milk in cheddar cheese production under different processing conditions." *Australian Journal of Dairy Technology*, 2010, 65 (3), 222-225.

Scholes, CA; Chen, GQ; Stevens, GW; Kentish, SE. "Plasticization of ultra-thin polysulfone membranes by carbon dioxide." *Journal of Membrane Science*, 2010, 346 (1), 208-214.

Scholes, C; Smith, K; Kentish, S; Stevens, G. "CO2 capture from pre-combustion processes - Strategies for membrane gas separation." *International Journal of Greenhouse Gas Control*, 2010, 4 (6), 739-755.

Stickland, AD; de Kretser, RG; Scales, PJ. "One dimensional model of vacuum filtration of compressible flocculated suspensions." *AIChE Journal*, 2010, 56 (10), 2622-2631.

Tallon, C; Limacher, M; Franks, GV."Effect of particle size on the shaping of ceramics by slip casting." *Journal of the European Ceramic Society*, 2010, 30, 2819-2826.

Tan, KY; Chan, KW; Möttönen, M; Morello, A; Yang, C; Van Donkelaar, J; Alves, A; Pirkkalainen, JM; Jamieson, DN; Clark, RG; Dzurak, AS. "Transport Spectroscopy of single phosphorus donors in a silicon nanoscale transistor." *Nano Letters,* 2010, 10(1), 11-15.

VVakarelski, IU; Manica, R; Tang, XS; O'Shea, SJ; Stevens, GW; Grieser, F; Dagastine, RR; Chan, DYC. "Dynamic interactions between microbubbles in water." *Proceedings of the National Academy of Sciences of the United States of America*, 2010, 107 (25), 11177-11182.

Van Donkelaar, JA; Greentree, AD; Alves, ADC; Jong, LM; Hollenberg, LCL; Jamieson, DN. "Top-down pathways to devices with few and single atoms placed to high precision." *New Journal of Physics,* 2010, 12.

Wang, YJ; Yan, Y; Cui, JW; Hosta-Rigau, L; Heath, JK; Nice, EC; Caruso, F. "Encapsulation of Water-Insoluble Drugs in Polymer Capsules Prepared using Mesoporous Silica Templates for Intracellular Drug Delivery.' *Advanced Materials,* 2010, 22, 4293-4297.

Weerasinghe, HC; Franks, GV; Plessis, JD; Simon, GP; Cheng, YB. "Anomalous rheological behavior in chemically-modified TiO2 colloidal pastes prepared for flexible dye sensitized solar cells." *Journal of Materials Chemistry*, 2010, 20, 9954-9961.

White, CE; Provis, JL. Proffen, T; Riley, DP; van Deventer, JSJ. "Combining density functional theory (DFT) and pair distribution function (PDF) analysis to solve the structure of metastable materials "the case of metakaolin"." *Physical Chemistry Chemical Physics,* 2010, 12 (13), 3239-3245.

Xia, K. "Consolidation of Particles by Severe Plastic Deformation: Mechanism and Applications in Processing Bulk Ultrafine and Nanostructured Alloys and Composites." *Advanced Engineering Materials*, 2010, 12, 724-729.

Yan, Y; Ochs, CJ; Such, GK; Heath, JK; Nice, EC; Caruso, F. "Bypassing Multidrug Resistance in Cancer Cells with Biodegradable Polymer Capsules." *Advanced Materials* 2010, 22, 5398-5403.

Book

Scholes, C; Kentish, S; Stevens, G. "The Effects of Minor Components on the Gas Separation Performance of Polymeric Membranes for Carbon Capture". In Y Yampolskii & B Freeman, (Eds.). Membrane Gas Separation. (John Wiley & Sons: West Sussex, 2010): 201-226.

Finance

INCOME		
Core Funding		$900,000.00
Internal Recoveries		$84,329.00
	TOTAL	$984,329.00
EXPENDITURE		
Director		$225,136.80
Executive Officer		$68,671.31
Other salaries		$27,817.29
Administration		$6,343.32
Marketing and web development		$6,229.55
Travel and entertainment		$40,870.18
Operations		$23,103.63
Equipment		$3,382.82
Capital works		$35,100.25
Interdisciplinary seed funding		$125,000.00
Less reimbursement for 2009 expenditure		-$6,806.36
Carry forward from 2009		$69,206.74
	TOTAL	$624,055.53
Balance (carried forward)		$360,273.47

Contact details

Melbourne Materials Institute

General enquiries:
Tel: +61 3 8344 6415
Fax: +61 3 9347 4783
Email: materials-info@unimelb.edu.au

Address:
Room 159, Ground Floor
David Caro builidng
Corner Tin Alley and Swanston Street
The University of Melbourne
3010, Victoria, Australia

Director: Prof. Steven Prawer
Tel: +61 3 8344 5460
Email: s.prawer@unimelb.edu.au

Executive Officer: Ms Gabrielle Bright
Tel: +61 3 8344 6415
Email: gbright@unimelb.edu.au

Communications Officer: Ms Annabelle Pontvianne
Tel: +61 3 8344 6415
Email: pa@unimelb.edu.au

Project Officer: Ms Akina Mikami
Tel: +61 3 8344 6415
Email: amikami@unimelb.edu.au

Melbourne Materials Institute

For more information visit our website at www.materials.unimelb.edu.au

Melbourne Materials Institute

General enquiries:
Email: materials-info@unimelb.edu.au
Telephone: +61 3 8344 6415
Facsimile: + 61 3 9347 4783