Submission
No 10

INQUIRY INTO NANOTECHNOLOGY IN NEW SOUTH WALES

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UNSW

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28 March 2008

The Director,
Standing Committee on State Development
Legislative Council
Parliament House
Macquarie Street
SYDNEY NSW 2000

RE: UNSW SUBMISSION TO THE INQUIRY INTO NANOTECHNOLOGY IN NEW SOUTH WALES

The University of New South Wales welcomes the opportunity to make a submission to the Inquiry into Nanotechnology in New South Wales.

1. SUMMARY OF RECOMMENDATIONS

RECOMMENDATION 1	Any discussions and recommendations regarding nanotechnology must be focussed on the different risks and benefits of specific applications.
RECOMMENDATION 2	A Ministry which has responsibility for research, science, innovation & development needs to be established in New South Wales.
RECOMMENDATION 3	The Ministry should be supported and informed by the creation of a NSW Science Advisor/Chief Scientist.
RECOMMENDATION 4	New South Wales needs to develop a long-term strategic plan to address critical research infrastructure.

2. "NANOTECHNOLOGY" IS A VERY BROAD TERM - ONE SIZE DOES NOT FIT ALL

Nanotechnology is the science of understanding the structure and behaviour of materials at the atomic or molecular level. Technically it is the science that deals with very small structures – less than one millionth of a millimetre. Through an understanding of how to manipulate very small structures (on the scale of atoms, individual molecules and clusters of molecules) it is possible to create new devices, materials and even machines with unique properties and applications. The power to design, manufacture, control and exploit structures on the nano-scale has led effectively to a new manufacturing sectors based on our ability to observe, characterise and manipulate the atomic and molecular structure of materials which form the basis of the bio-communications, information and environmental technologies.

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The terms "Nanotechnology" or "Nanoscience" refer to emerging disciplines very much based at the interface of physics, chemistry, biochemistry and biotechnology, materials science and information and computer science technologies.

While "Nanotechnology" might seem like a new, cutting-edge discipline, examples of nanotechnology have been around forever. Consider how bodies convert the food we eat into finger-nails, bones, cells and hair – these materials are all built up molecule-by-molecule in a predetermined fashion - this is nanotechnology at work. There are also many examples of manufactured nanotechnology in archaeological remains, for example the Lycurgus Cup, one of the most important exhibits in the British Museum. This is a goblet that contains nano-particles of gold so the cup appears to change colour in different lights.

Amongst the more modern examples of nanotechnology, we would include sunscreen where the components are engineered to absorb the harmful parts of radiation, computer devices with atom-sized switches allowing faster calculations and incredible memory capacity, ceramic particles that can be used as capsules for targeted drug delivery, and modern carbon-fibre composites which are light-weight strong materials used in the manufacture of aircraft hulls. Nanodevices can also be used in medical diagnostics to sense the presence of specific cancer pathogens. There are also projects under way, for example, to develop atomic-size computer devices on silicon chips, to build molecules that can selectively detect particular bacteria or viruses, and surface coatings that can use sunlight to control pollutants.

Nanotechnology is an incredibly broad discipline/subject area dealing with everything from air borne particles and coatings to components of new materials to agents for delivering drugs into the body to advanced engineering devices manufactured to the highest precision and solar cells as alternative sources of energy. It covers an incredible number of fields of application and it is all around us.

In making this submission UNSW wants to ensure that Nanotechnology is put in the correct perspective. While there are Occupational Health and Safety aspects that must be managed (as there are with any new product or device), nanomaterials, nanodevices *etc* need to be considered as with any "new" technology and the benefits and risks need to be carefully evaluated. ***These controls however do not need to be outside the normal regulatory and testing framework.***

While it is important that regulatory frameworks keep up to speed with the developments in nanotechnology, UNSW does not want the outcome of this Review to increase the regulatory burden on researchers in this important area or duplicate the efforts of the Australian Office of Nanotechnology. This framework needs to have a balanced approach and must be science/evidence based - not driven by subjective perceptions of uninformed factions.

RECOMMENDATION 1

Any discussions and recommendations regarding nanotechnology must be focussed on the different risks and benefits of specific applications.

3. UNSW IS A WORLD LEADER IN NANOTECHNOLOGY

The University of New South Wales is a leading Group of Eight research-intensive university which leads the nation in many areas of research **(See Attachment 1)** including nanotechnology **(See Attachment 2).**

UNSW has over 125 researchers and 38 current Australian Research Council Discovery Projects across all aspects of nanotechnology **(See Attachment 3)**.

UNSW is home to a range of major research centres and initiatives aimed at advancing research in the areas of nanotechnology including:

- ***ARC Centre of Excellence for Quantum Computer Technology*** - The development of a quantum computer has been listed as one of the ten major challenges in science and engineering this century. The ability of a quantum computer to carry out calculations via superposition and entanglement of quantum states offers the potential for massively parallel computing and has led to significant activity internationally in the past few years due to its economic and strategic importance. Key targets on a 5-year timescale include: realisation of few-qubit spin- and charge-based silicon quantum computer devices, single-charge and single-spin readout, demonstration of few-qubit linear optics quantum gate operations, and a firm understanding of decoherence mechanisms in these systems. The Centre's longer term goal is to develop key technologies underpinning a large scale quantum computer aligned with the world's existing computer industry dominated by silicon, as well as opening a pathway for quantum photonics.
- ***The ARC Photovoltaics Centre of Excellence*** which is internationally recognised for its research in the field of photovoltaics. It covers areas including silicon wafer-based ('first generation') photovoltaic approaches, silicon thin-film ('second generation') approaches, 'third generation' photovoltaic approaches, thin film gallium arsenide solar cells, research on photovoltaic systems and applications, and industry issues. The associated ***School of Photovoltaic and Renewable Energy Engineering*** has growing research programs in complementary fields of renewable energy including bioenergy and biofuels, energy efficiency, and energy policy
- ***UNSW's Semiconductor Nanofabrication Facility*** - UNSW's Semiconductor Nanofabrication Facility (SNF) is a joint facility shared by the Faculties of Science and Engineering and houses a microelectronics laboratory and a nanofabrication laboratory for e beam lithography. The SNF provides an Australian capability for the fabrication of advanced nanoscale semiconductor devices and their integration with microelectronics. SNF research projects form an integrated effort to fabricate innovative semiconductor nanostructures using the latest techniques of electron beam patterning and scanning probe manipulation. A major applied objective of the facility is the development of a prototype silicon nuclear spin quantum computer. This facility has received funding under the National Collaborative Research Infrastructure Scheme (NCRIS) to extend and re-tool its laboratories. These funds will see the SNF accommodate the NSW node of the Australian National Fabrication Facility (ANNF) and deliver a new high-resolution electron beam lithography system capable of producing nano-scale semiconductor devices as small as 10nm.

- ***UNSW Atomic Fabrication Facility*** - The Atomic Fabrication Facility within the Faculty of Science is a unique facility world-wide dedicated to the development of atomic-scale devices in silicon with atomic resolution in all three spatial dimensions. With five inter-linked laboratories it contains three customised high resolution scanning tunnelling microscopes (STM) for single atom manipulation combined wit ultra high vacuum Molecular Beam Epitaxy (MBE) systems. In addition to supporting the development of a solid state quantum computer this laboratory investigates the ultimate limit of miniaturisation of conventional silicon transistor technology, the integration of different materials on the silicon platform, the development of novel 3D transistor architectures and the development of scanning probes for atomically precise manufacturing.
- ***ARC Centre of Excellence for Functional Nanomaterials*** - The ARC Centre of Excellence for Functional Nanomaterials is an internationally renowned research centre in the field of Functional Nanomaterials, and UNSW is one of four nodes across the country, researching both the fundamental and applied levels of synthesis, characterisation and application of various nanomaterials. The main focus of the Centre is the application of clean energy production and utilisation, environmental technologies and biomaterials and biotoxicity.
- ***ARC Centre of Excellence for Design in Light Metals*** - The ARC Centre of Excellence for Design in Light Metals is Australia's highest funded new Centre of Excellence in recent times. Its aim is to vary the nanostructure of key materials in NSW industry, in particular aluminium, to produce better lightweight structural materials for transport and infrastructure for improved industry and societal sustainability. UNSW is one of six nodes across the country, in recognition of its international leadership in the field of metallurgy.
- ***ARC Nanotechnology Network*** - UNSW's researchers are active members of the Australian Research Council Nanotechnology Network (ARCNN) which is dedicated to substantially enhancing Australia's research outcomes in this area through collaboration.
- ***UNSW Analytical Centre*** - The UNSW Analytical Centre houses major instrumentation used by researchers in the Faculties of Science, Medicine and Engineering for the study of the structure and composition of biological, chemical and physical materials. This critical infrastructure underpins much of the nanotechnology research conducted at UNSW and in the greater Sydney region. The Centre contains 4 major Research Facilities accessible to all staff and students of UNSW, as well as to external researchers including:
    - Electron Microscope Unit
    - Bioanalytical Mass Spectrometry Facilities
    - Nuclear Magnetic Resonance Facility
    - Solid State & Elemental Analysis Unit

In addition, and in response to the rapid developments in this field, as well as from the presence of innovative research programs undertaken at UNSW, the university ***introduced a new undergraduate degree in Nanotechnology in 2002***. This is a four year cross-disciplinary research-led program based in the Faculty of Science and provides training in this rapidly evolving discipline to train the next generation of researchers and innovators.

Some of UNSW's research into nanotechnology has been picked up by the research@UNSW magazine and in the popular media in recent years. ***See Attachment 4.***

4. LONG-TERM STRATEGIC LEADERSHIP IN NEW SOUTH WALES

With the establishment of the Commonwealth's Australian Office of Nanotechnology within the Department of Industry, Innovation, Science and Research, and the commencement of the Australian National Nanotechnology Strategy in July 2007, public awareness of all things "Nano" has increased.

There still exists, however, a public perception that we should be worried about that which we cannot see. Most "nanophobia" stems from the fact that small particles, like dust and smog, have a detrimental effect on health. There is no question that the increased surface area that you get with nanoparticles gives rise to many of the properties that make nanotechnology important, but may also potentially makes them harmful in some instances. This very point provides good reason to invest in the science and technology around nanomaterials so that we can know and understand how they behave.

Nanotechnology is but one area of science/technology where there is a great opportunity for the State Government to take a strong leadership role in addressing public perceptions.

Research, science, industry and technology do not fit well within the current structure of the State Government, and when an important issue like nanotechnology surfaces in this arena, the State Government is not positioned well to respond strategically.

A few key points:

A. Research, Science, Technology portfolio for New South Wales

If New South Wales is to compete on the national and international stage of cutting edge research and the development of new technologies, then the State Government needs to be committed to this important area in much the same way that the Victorian and Queensland State Government's have positioned themselves to be the "preferred location" for research, industry, science, technology and innovation.

The University of New South Wales is firmly of the view that ***NSW needs a Minister which has responsibility for research, science, innovation and development.*** This approach would:

- Provide the technical expertise to digest and assess the nanotechnology capabilities and requirements in NSW;
- Develop a long-term strategic plan (5-10 years) for nanotechnology and other areas of research which are a priority for New South Wales;
- Facilitate proactive engagements with industry and research organisations in New South Wales;
- Leverage support from the Commonwealth and international agencies – with long term benefit to New South Wales; and
- Compete with other States who already have a well-developed agenda in the area of nanotechnology, to make NSW a desirable location to conduct nanotechnology.

RECOMMENDATION 2

A Ministry which has responsibility for research, science, innovation & development should be established in New South Wales.

B. Chief Scientist for New South Wales

This ministry suggested in the previous section should be supported and informed by a NSW Science Advisor/Chief Scientist. The establishment of a Science Advisor/Chief Scientist is a critical role in increasing public awareness and communication, and public confidence in nanotechnology and other areas of research.

RECOMMENDATION 3
The Ministry should be supported and informed by the creation of a NSW Science Advisor/Chief Scientist.

C. Critical Research Infrastructure & Planning

Cutting–edge research areas such as nanotechnology rely on complex infrastructure. Such programs are not short-term – they take many years to establish and the benefits will flow over the space of decades rather than months. The infrastructure is typically expensive to purchase and install, and requires an on-going and long term commitment to properly maintain. ***The management of critical research infrastructure requires long-term strategic planning at all levels of Government, industry, and research organisations.***

The necessity for long-term planning permits the government to position the State for many national initiatives which require strong support from State Governments. It is absolutely clear that major research initiative must align strongly with state priorities before they will be considered seriously by Commonwealth and external agencies. Such programs as the CRC Program, the National Collaborative Research Infrastructure Program (NCRIS), Higher Education Endowment Fund (HEEF), ARC and National Centres of Excellence Programs (including NICTA), all bring research capacity, employment, follow-on industry development to our State. All of these schemes require the state government to have an effective mechanism to engage proactively. Not all of these schemes are appropriate for NSW, and we do need to be selective in our investments that are made. The decision making needs to be well thought out and articulated through a strategic plan for New South Wales research.

At this time, other State Governments (most notably QLD, Vic, and SA) have been engaging much more aggressively with these programs. They do so with the full knowledge that if they are successful in their application, the long-term benefits for the State, will far out-weigh any initial investment for the State.

RECOMMENDATION 4
New South Wales needs to develop a long-term strategic plan to address critical research infrastructure.

5. CONCLUSION

The term "Nanotechnology" covers a broad range of activities across a broad range of sectors. Research and development in the area of nanotechnology is growing rapidly. Any discussions regarding nanotechnology must be focussed on the different risks and benefits of specific applications.

If New South Wales wants to attract researchers and grow industry investment in this important area, then this Inquiry provides a good opportunity for the NSW Government to realise long-term benefits of nanotechnology for the State. There needs to be a Ministry which has specific responsibility for research, science, innovation & development and this should be supported by a NSW Science Advisor/Chief Scientist. This will permit the development of a long-term strategic plan to address critical research infrastructure across and beyond nanotechnology.

The University of New South Wales is open to further discussions in this important area of research and industry development in New South Wales.

Yours sincerely,

L D Field.

Professor Les Field
Deputy Vice-Chancellor (Research)
The University of New South Wales


UNSW
Areas of Research Strength
The University of New South Wales
Sydney Australia

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AREAS OF RESEARCH STRENGTH

1. Biomedical Sciences
2. Water, Environment & Sustainability
3. Next Generation Materials & Technologies
4. Social Policy, Government & Health Policy
5. ICT, Informatics & Robotics
6. Business, Law & Finance

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BIOMEDICAL SCIENCES

BIOMEDICAL SCIENCES

- HIV/AIDS, Hepatitis & Immunology
- Cancer Research
- Brain Science, Neurosciences and Mental Illness
- Cardiovascular diseases
- Ageing
- Biomedical Engineering
- Biotechnology

- Supported by
  - National Centre in HIV Epidemiology and Clinical Research
  - Centre for Infection & Inflammation Research
  - Centre for Immunology
  - Lowy Cancer Research Centre
  - Children's Cancer Research Institute of Australia
  - Brain Sciences UNSW
  - Prince of Wales Medical Research Institute
  - Black Dog Institute
  - Centre for Vascular Research
  - Clive & Vera Ramaciotti Centre for Gene Function Analysis
  - Health & Human Rights Initiative
  - Dementia Collaborative Research Centre
  - Affiliated Medical Research Institutes
    - Garvan Institute of Medical Research
    - Victor Chang Cardiac Research Institute
  - 1 Federation Fellow

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WATER, ENVIRONMENT & SUSTAINABILITY
DANGER
HOT
CERAMIC ENGINEERING

WATER, ENVIRONMENT & SUSTAINABILITY

- Climate Change
- Environmental Modeling
- Rainfall, Rivers & Water
- Sustainable Materials & Recycling
- Alternative Energies & Fuels
- Water Use and Re-Use
- Water Purification
- River & Wetland Ecology
- Marine Biology & Oceanography
- Conservation Biology & Biodiversity
- Sustainable Cities
- Bushfire Research

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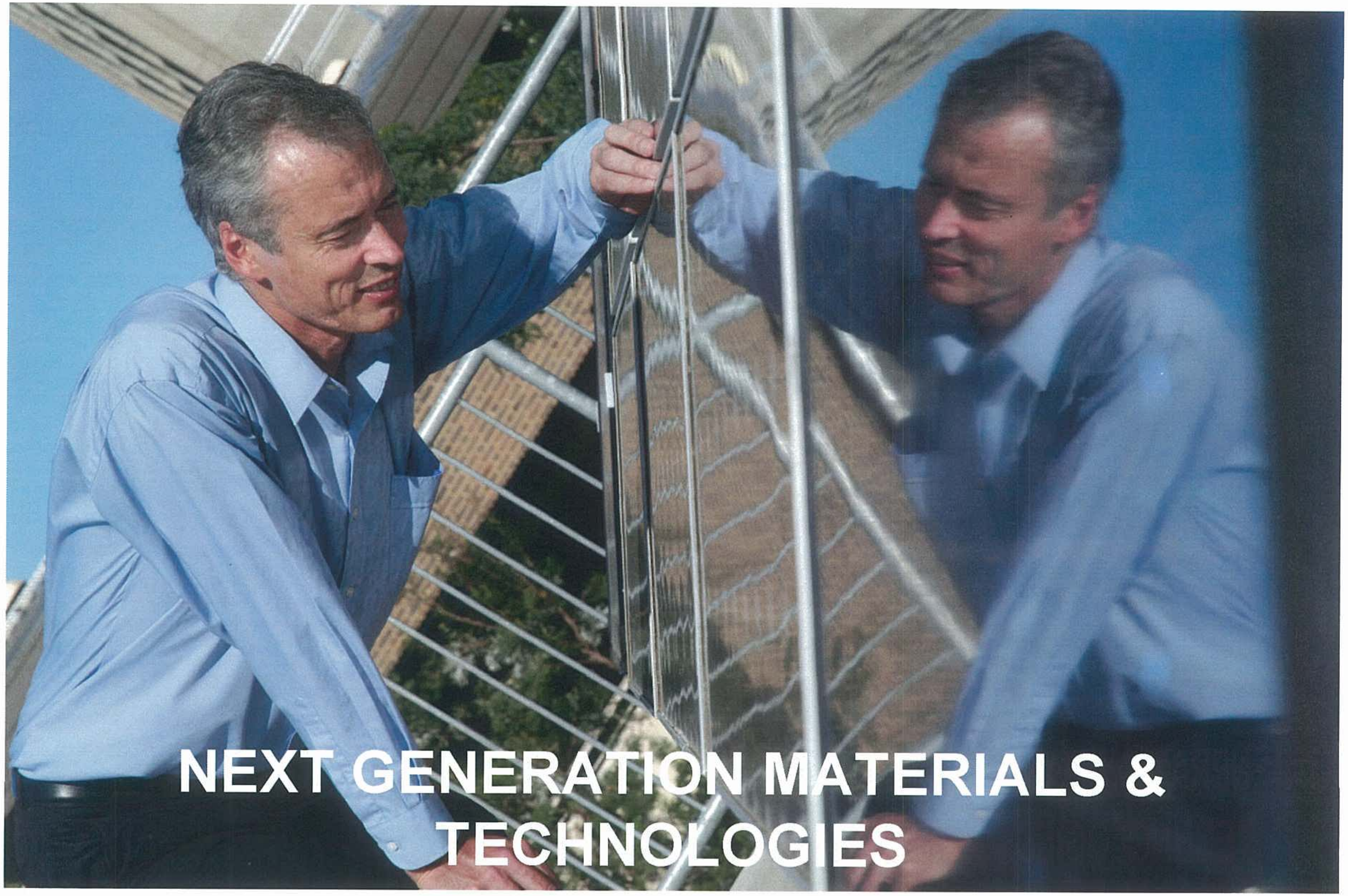
- Supported by
  - Universities Climate Consortium
  - Climate Change Research Centre
  - ARC CoE for Advanced Silicon Photovoltaics & Photonics
  - Sustainable Materials Research & Technology Centre (SMaRT)
  - Evolution & Ecology Research Centre
  - Water Research Centre
  - CRC for Water Quality & Treatment
  - UNESCO Centre for Membrane Science & Technology
  - Sydney Institute for Marine Sciences (SIMS)
  - Future of Australia's Threatened Ecosystems Program (FATE)
  - Centre for Marine Bioinnovation
  - CRC for Greenhouse Gas Technology
  - City Futures Research Centre
  - Centre for Energy & Environmental Markets
  - Bushfire CRC
  - Australian Human Rights Centre
  - CRC for Environmental Biotechnology
  - CRC for Cotton Catchment Communities
  - CRC for Coal in Sustainable Development

  - 2 Federation Fellows


NEXT GENERATION MATERIALS &
TECHNOLOGIES

NEXT GENERATION MATERIALS & TECHNOLOGIES

- Silicon Solar Cells (Photovoltaics)
- Next generation computing (Quantum Computing)
- Nanomaterials
- Advanced plastics (Polymers and membranes)
- Superconductors
- New generation building materials
- Microbial films and biomaterials

- Supported by
  - ARC Centre of Excellence for Advanced Silicon Photovoltaics & Photonics
  - ARC Centre of Excellence for Quantum Computer Technology
  - ARC Centre of Excellence for Functional Nanomaterials
  - Centre for Advanced Molecular Design
  - UNESCO Centre for Membrane Science & Technology
  - Centre for Infrastructure Engineering & Safety
  - CRC for Advanced Composite Structures
  - CRC Polymers
  - Centre for Marine Bioinnovation
  - Centre for Materials Research in Energy Conversion
  - UNSW Analytical Centre
  - 5 Federation Fellows

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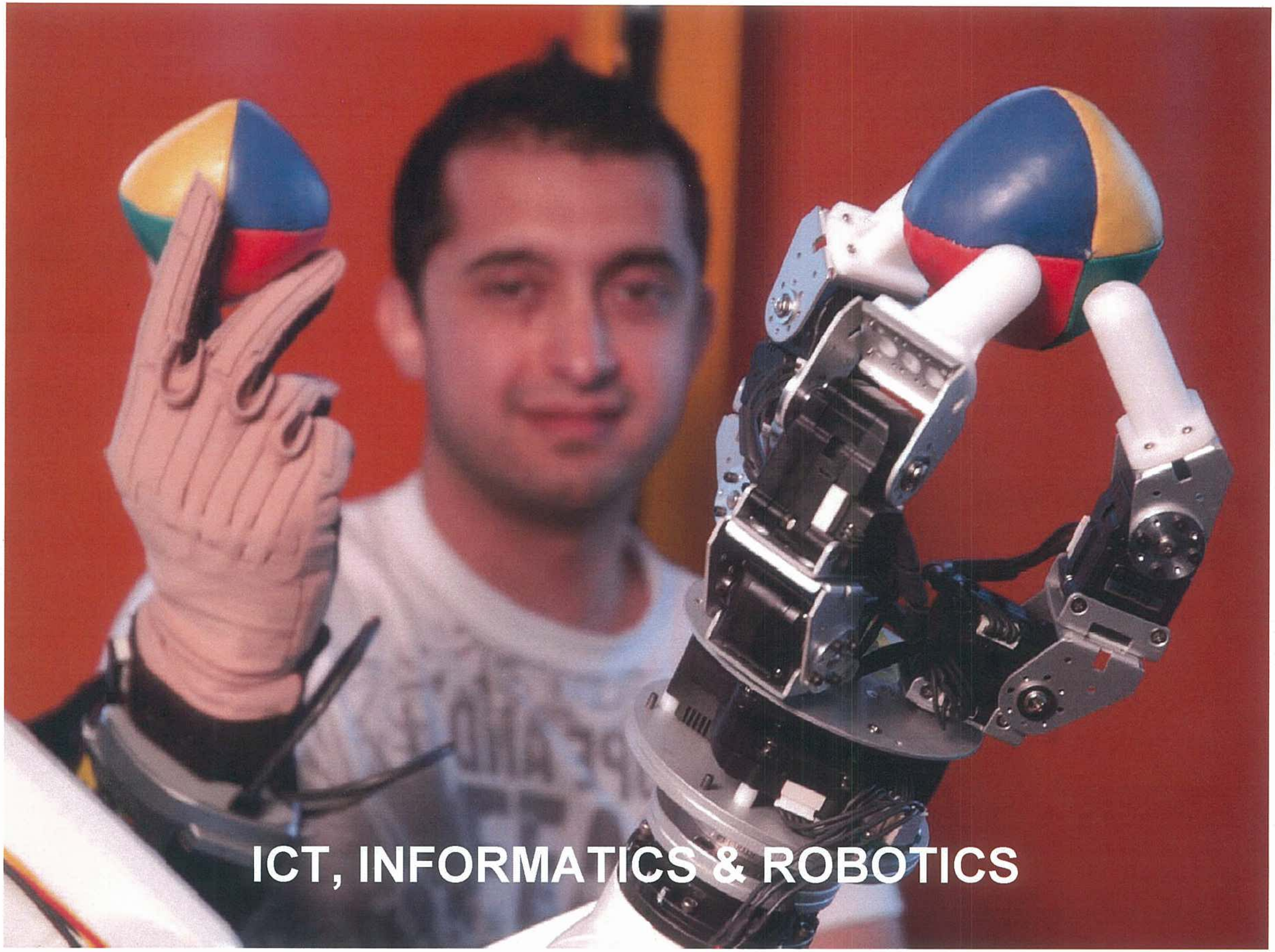
SOCIAL POLICY, GOVERNMENT & HEALTH POLICY

SOCIAL POLICY, GOVERNMENT & HEALTH POLICY

- Community Medicine
- Drug & Alcohol Policy
- Social Impact of Disease
- Ageing & Retirement
- Indigenous Policy
- Defence & Homeland Security
- Criminology
- Human Rights

- Supported by
  - Social Policy Research Centre
  - National Centre in HIV Social Research
  - National Drug & Alcohol Research Centre
  - National Cannabis Prevention & Information Centre
  - Centre for Clinical Governance Research in Health
  - Centre for Primary Health Care & Equity
  - Institute of Health Innovation
  - Injury Risk Management Research Centre
  - Centre for Health Informatics
  - Centre for Health Assets Australasia
  - Australian Institute for Population Ageing Research
  - Indigenous Law Centre
  - Centre for Contemporary Art & Politics
  - Defence & Security Applications Research Centre
  - ARC Research Network for a Secure Australia
  - Gilbert & Tobin Centre for Public Law
  - Crime and Justice Research Network
  - Industrial Relations Research Centre
  - Centre for Refugee Research
  - Australian Human Rights Centre
  - Centre for Gender Violence Related Studies
  - Initiative for Health and Human Rights
  - Gifted Education Research, Resources & Information Centre

UNSW


ICT, INFORMATICS & ROBOTICS

ICT, INFORMATICS & ROBOTICS

- Robotics & Autonomous Systems
- Unmanned Aerial Vehicles (UAVs)
- Simulation & Modelling
- Interactive Media & Electronic Art
- Embedded Systems & Communications
- Programming Languages
- Software Engineering
- Fuzzy logic
- Defence & Security
- Optical Fibre Communications (Photonics)
- Biomedical Engineering

- Supported by
  - ARC Centre of Excellence for Autonomous Systems
  - ARC Centre for Complex Systems
  - iCinema Centre for Interactive Cinema Research
  - National ICT Australia (NICTA)
  - Smart Services CRC
  - ARC Research Network for a Secure Australia
  - Defence & Security Applications Research Centre
  - CRC for Spatial Information
  - Cyberspace Law and Policy Centre
  - Centre for Health Informatics
  - 2 Federation Fellows

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BUSINESS, LAW & FINANCE

BUSINESS, LAW & FINANCE

- Business & Management
- Economics
- Capital Markets
- Accounting
- Law and Taxation

- Supported by
  - Capital Markets CRC
  - Securities Industry Research Centre of Asia-Pacific (SIRCA)
  - Centre for Accounting and Assurance Research
  - Centre for Applied Economic Research
  - Centre for Pensions & Superannuation
  - Centre for Energy and Environmental Markets
  - Cyberspace Law & Policy Centre
  - Gilbert & Tobin Centre for Public Law
  - UNSW Crime & Justice Network
  - Australasian Legal Information Institute
  - Centre for Interdisciplinary Studies of Law

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UNSW RESEARCH STRENGTHS IN NANOTECHNOLOGY

- Silicon Solar Cells (Photovoltaics)
- Next generation computing (Quantum Computing)
- Nanomaterials
- Advanced plastics (Polymers & membranes)
- Superconductors
- New generation building materials
- Microbial films & biomaterials
- Alternative Energies & Fuels
- Water Purification
- Biomedical Engineering
- Optical Fibre Communications (Photonics)

- Supported by
  - ARC Centre of Excellence for Advanced Silicon Photovoltaics & Photonics
  - ARC Centre of Excellence in Quantum Computing
  - ARC Centre of Excellence for Functional Nanomaterials
  - UNSW Centre for Advanced Molecular Design
  - UNESCO Centre for Membrane Science & Technology
  - CRC for Advanced Composite Structures
  - CRC Polymers
  - Centre for Marine Biofouling & Bio-Innovations
  - Centre for Waste Water Technology
  - CRC for Water Quality & Treatment
  - UNSW Analytical Centre
  - 4 Federation Fellows

ATTACHMENT 3 – UNSW RESEARCHERS WITH RECENT ARC DISCOVERY PROJECTS IN THE AREA OF NANOTECHNOLOGY

Project Name	Researchers undertaking the Project	Project Summary
Doped Nanocrystalline TiO_2 - Synthesis and application for photoreduction reactions	A/Prof R Amal; Dr D Beydoun; A/Prof T Tran	The proposed project aims to develop a novel photocatalyst, prepared by doping nanocrystalline TiO_2 with noble metals, for use in photoreduction reactions. The ability of this photocatalyst to reduce heavy metals and its potential to generate H_2 in an inert environment will be explored. The project will benefit the environment by removing toxic compounds from polluted wastewaters as well as potentially generating substantial levels of H_2 (an attractive energy source). Project outcomes include the development of an economical and cleaner process for treating waters contaminated with heavy metals and providing a valuable knowledge base from which photoreductive efficiencies can be drawn.
The thermal stability of nanocrystalline alloys produced by severe plastic straining	Dr M Ferry; Dr CH Davies; Prof FJ Humphreys	An exciting class of materials has emerged with grain sizes two orders of magnitude finer than that produced by conventional processing. These nanocrystalline alloys are produced by intense plastic straining termed equal channel angular extrusion (ECAE). The aim of the project is to incorporate novel experimental techniques, using single crystals, in situ annealing and 3-D computer simulation to develop a fundamental understanding of microstructural stability during ECAE and subsequent thermal treatment. Such advances in our understanding of boundary mobility in fine-scale microstructures is important for evaluating their stability and, hence, the possible commercial exploitation of these materials.
Preparation of nanostructured surfaces by electrochemical deposition through lyotropic liquid-crystal templates	Prof DB Hibbert	Hexagonal-phase lyotropic liquid crystals may be used as templates to deposit metals on electrodes. The sizes of the structures made by this method are a few nanometres. We propose to exploit both the aqueous and non-aqueous parts of the liquid crystal to deposit different metals, polymers or metals and polymers. Thin metal wires (nano-wires) sheathed in polymer will be the thinnest insulated wires ever made. Carbon nanotubes will also be aligned in the hexagonal hole in the template allowing exploitation of these unique species. The structures that will be fabricated will be candidates for catalysts, sensor arrays and electronic devices.
Development of Nanocrystalline Transition Metal Oxide and Polymer-Transition Metal Oxide Composite Materials for Rechargeable Lithium Battery Applications	Prof M Skyllas-Kazacos; Dr V Luca; Dr BA Hunter	Recent work by the applicants has shown that nanocrystalline titanates and aluminates hold considerable promise as lithium battery electrodes. Nanocrystalline anatase materials showed considerably greater lithium intercalation ratios compared with their microcrystalline counterparts, and doping with vanadium showed further improvements in capacity. Sol-gel synthesised V-doped anatase materials produced an initial discharge capacity of 428 Ah/kg compared with only 280 mAh/kg for the undoped anatase electrode in the same Li test cell.In this project different dopants and preparation conditions will be investigated to produce nanocrystalline rutile and aluminate materials as potential candidates for high capacity lithium battery applications.
Nanofabrication of Organic (Plastic) Semiconductor and Superconductor Devices	Dr AP Micolich	Organic crystals and thin-films are the first known materials to display all four regimes of electrical conduction - insulator, semiconductor, metal and superconductor. Additional properties such as self-assembly, biocompatibility, molecular level control over properties and flexibility give them exceptional prospects for future industrial applications. We will fabricate organic transistors and conduct detailed investigations of their electrical and magnetic properties to develop a fundamental understanding of these new materials. Most significantly, we will make the first use of an atomic force microscope-based oxidation lithography technique to fabricate nanoscale quantum devices that exploit the full range of conduction in a single material.

Development of a Model Relating Aggregate Properties with Aggregation Conditions for Design and Control Purposes	Prof R Amal; Dr C Selomulya	The project aims to understand the role of shear and other important parameters in the aggregation of nano- and micron-sized particles through fundamental studies on different particulate systems and shear environments. The knowledge will be used to develop an engineering model relating the floc properties to system conditions, thus allowing the utilisation of experimental data to full-scale operations without eschewing their relevance. Project outcomes include a comprehensive guideline to set optimum conditions required to generate flocs with desirable properties for control and design purposes, with applicability extending from solid-liquid separation to nano-material synthesis, and various processes involving particle aggregation.
The Enhancement of heat transfer in microchannels by microelectomechanical devices	Adj/Prof JA Reizes; Prof E Leonardi; A/Prof F Stella; A/Prof CY Kwok	A perennial and extremely important problem in computer chip technology is the provision of adequate cooling. This project is a rare combination of multi-disciplinary activities which will lead to new knowledge in a number of poorly explored areas in heat transfer, whilst at the same time permitting the development of the necessary theoretical and practical fabrication skills for the manufacture of a realistic cooling micro devices. The main goal of this project is therefore to design, manufacture and test a very efficient micro-channel cooling device equipped with a micro electro-mechanical systems (MEMS) synthetic jet generator.
Production and nano-characterisation of II-VI semiconductor quantum dots from plant cell cultures	A/Prof PM Doran; Dr MA Stevens-Kalceff	Nanocrystallites with semiconductor properties have potential applications in medicine, microelectronics and waste treatment. Cheap, reliable methods for producing large quantities of monodisperse nanoparticles are required. Solution techniques have been used most commonly; however, production of stable, high-quality particles remains difficult. Biological synthesis using plant cell culture offers several important advantages. As peptide capping is incorporated into the biological assembly process, the nanoparticles are restricted in size, their stability is improved, and their surfaces are passivated. Application of plant cultures for nanocrystallite production is a novel approach with the potential to yield significant improvements in the quality of manufactured quantum dots.
Silicon based photonic crystals for monitoring biomolecular interactions	Prof M Gal; Dr JJ Gooding; Dr K Gaus	Two great goals of biomolecular science are to monitor biomolecular interactions in real time and with sufficient sensitivity to allow small amounts of biological material to be investigated. The achievement of these goals is limited by the methods of transducing these reactions. The aim of this multidisciplinary proposal is to overcome this limitation by developing photonic devices that exploit the unique properties of nanoporous silicon. The hybridisation of DNA will be used as a model biorecognition reaction. Potential applications of these photonic devices are as highly sensitive affinity sensors and as tools for investigating the kinetics of biomolecular interactions.
Development of Deformation-Mechanism Based Parameters for Improved Design of Hard Coatings	Dr MJ Hoffman; Prof PR Munroe; Dr PJ Martin; Mr Z Xie	The use of thin hard abrasion-resistant coatings is an important method for significantly improving the operational lifetime of components in a wide range of mechanical, biomedical and sensory applications. The optimal design of these coatings is however severely restricted by a lack of detailed knowledge of their material deformation mechanisms. The proposed project will use novel nano-indentation and electron microscope techniques to create a basis for mechanism-based deformation models. These models will then be used to develop new coating architectures with improved operational lifetimes as well as predicting coating lifetimes and developing simple tools for coating assessment.
Biomolecular films on silicon substrates	Prof HG Coster; Dr TC Chilcott; A/Prof KD Barrow; Dr M James	Construction of hybrid carbon-silicon devices in which molecular organic molecular films are covalently linked to silicon wafers. Biomolecular nanostructures on silicon wafers can be studied using unique impedance spectroscopy instrumentation that we have developed as well as X-ray and neutron reflectometry. The system will be used to study a variety of molecular films as well as molecularly tethered lipid bilayer membranes that mimic aspects of cell membranes and these will be used to investigate the effect of sterols on such membranes.

High-Performance Magnesium Diboride-Based Nanocomposite Conductors	Dr C Cheng	Magnesium diborides (MgB2) is a newly discovered superconductor with a record high critical temperature (39 K) among the low-temperature superconductors. Superior properties of MgB2 make it very promising for engineering applications above 20 K. This project aims to develop a novel, low-cost, energy-saving, and industrially-feasible technique to make MgB2-based nanocomposite conductors that may overcome the critical problems existing in the material. The outcomes of this project will be the development of a new fabrication method and improved performance of MgB2-based conductors. The results also will increase our understanding of flux pinning at the nanoscale.
Nanoscale networks of organic polymer/c60 fullerene blends for high efficiency solar cells	Dr NT Kemp; A/Prof R Newbury	Recent demonstrations of increased efficiencies in polymer-fullerene blend plastic films provide the prospect of low cost photovoltaic elements with the potential for widespread application. Further progress with these materials is strongly indicated. We will characterise these materials at the nanoscale to make further improvements in film morphology and employ our expertise in experimental investigation of transport properties to gain a more complete understanding of the electronic and photonic processes underlying photovoltaic efficiency. Australia is ideally situated geographically and has a strong tradition of inventive engineering from which we can benefit and capitalise significantly on further improvements in the materials to be investigated.
High efficiency thermoelectric nanomaterials	Dr TE Humphrey	Recent experimental results have shown that nanostructures are extremely promising materials for high efficiency thermoelectric power generation and refrigeration. However, the reason why quantum confinement of electrons results in high thermoelectric efficiencies in nanomaterials such as quantum dot superlattices is not yet well understood. This project will examine the fundamental thermodynamic and quantum mechanical limits upon the efficiency and power of an idealised quantum dot superlattice thermoelectric nanomaterial. The outcome of this work is expected to be a predictive theory which can be used to assist future experimental efforts to produce optimised thermoelectric nanomaterials.
Understanding Electron Transfer through Surface Bound Rigid Molecular Constructs: From Fundamental Studies to New Sensing and Photovoltaic Applications	Dr JJ Gooding; Prof MN Paddon-Row	The role of a surface on electron transfer is not well understood and yet in nanoscale devices such as photovoltaic cells, biosensors and organic circuits electrons are being transferred adjacent to a surface. Rigid molecules, which facilitate electron transfer, will be used to probe the influence of the surface on the electron transfer between a redox active molecule and an electrode through a monolayer containing these rigid molecules. The knowledge gained from this breakthrough science will be exploited in the development of new highly efficient photovoltaic devices and affinity biosensors which has implications for the establishment of new frontier technologies.
3-D investigation of internal interfaces in annealed metals using 3-D focused ion beam tomography	A/Prof M Ferry; Dr JM Cairney	A powerful new technique termed 3-D focused ion beam tomography will be used to carry out one of the first studies of its kind on the nature of interfaces in annealed metals. The technique behaves as a 'nanoknife' whereby parallel slices of a material are cut with a site-specific accuracy of < 100 nm. Multiple slices are imaged and reconstructed to generate 3-D microstructural and crystallographic maps of structural features at sub-micron resolution. This technique will be further developed to study the interfacial structures and orientation relationships between grains in metals during recrystallization to provide new information on mechanisms of grain boundary migration.
Quantum coherence and many-body interactions in inorganic and organic nanoscale electronic devices	A/Prof AR Hamilton; Prof PE Lindelof; Dr Y Hirayama; Prof C Hanna; Prof M Pepper	As semiconductor devices are made ever smaller and approach the nanoscale, two key challenges arise: how to take account of quantum behaviour in the devices, and how to develop new fabrication strategies that allow ever smaller devices to be assembled. This project will use two important classes of devices, and new high sensitivity measurement techniques to address these issues: i) We will investigate the influence of quantum behaviour on the electronic properties of ultra-high purity transistors, using semiconductors supplied by NTT in Japan and the University of Cambridge. ii) We will compare these results with data from carbon nanotube devices (which have potential for self assembly), in collaboration with the University of Copenhagen.

Improvement of Critical Current Density of High Temperature Superconductors by Reforming Microstructure at Nanoscale	Dr Y Zhao; Dr C Cheng; Dr M Murakami	Superconductivity technology is an ultimate technology for saving energy. High-temperature superconductors (HTSs) are the only choice visible so far for commercialisation of superconductivity technology used in high fields (>5T) and at high temperatures (>70K). Insufficient current carrying capacity related to the grain boundary weak-links and flux-pinning degradation remains the most critical barrier. The project aims to solve the problem in a new approach involving reformation of local electronic structure, microstructure and composition modulation, at nanoscale. Except for a better understanding of mechanisms underpinning the performance, new techniques for making high-performance HTS bulk materials is also to be developed.
Modelling the jet characteristics and process performance for abrasive waterjet micro-machining	Dr J Wang	This project will investigate the sciences associated with a new abrasive waterjet technology for micro-cutting and nanometer-scale polishing. This technology will make a significant contribution to the precision machining of 3-D micro geometrical features found in micro systems and optical devices for which other technologies are found handicapped. The study involving computational fluid dynamics simulations and particle image velocimeter experiments will provide a fundamental understanding of jet dynamic characteristics and arrive at the optimum jet performance for micro-machining. Predictive cutting performance models and process optimization strategies will also be developed which will ensure the effective use of the new technology.
Development of Acid Degradable Polymeric Nanoparticles for Intracellular and Tumour Site Selective Delivery of Drugs	Dr V Bulmus; Dr M Kavallaris	Our study will generate advanced nanomaterials for a novel drug delivery strategy for tumour chemotherapy. We will work in a multidisciplinary collaboration to design and synthesize an acid cleavable polymeric nanoparticle system and evaluate its performance on delivering anticancer drugs selectively at tumour cells. As no one has previously investigated such a system for tumour chemotherapy, this project is novel and offers the potential to increase drug efficacy while reducing unwanted side effects. It has the potential to compensate some delivery problems present in many other strategies such as gene therapy and vaccines, as it can be adapted for relevant therapies.
Development of Advanced Diluted Magnetic Semiconductors for Spin Transistors	Dr SS Li; Dr D Yu; Dr WT Klooster	Spin-transistor is a device that will change the perspective of information technology in this century. Future progress in development of the device will be largely driven by advances in materials. But lack of suitable diluted magnetic semiconductors (DMS), allowing spin-polarized carriers to be efficiently injected, transported and manipulated in semiconductor heterostructures, has impeded the progress. This program is aimed at development of novel DMS materials having spin transport properties at ambient temperature with high injection efficiency and carrier concentration by understanding fundamental spin interactions in the materials as well as the roles of doping, dimensionality, defects, and band structure in modifying these dynamics.
"Metal dusting" of austenitic alloys: mechanisms and interventions	Prof DJ Young; Dr J Zhang; Dr D McGrouther	This project will establish the mechanism of "metal dusting" of austenitic alloys, a process in which carburising, reducing gases destroy heat resisting alloys, converting them into a conglomerate of metal nanoparticles, graphite and carbon nanotubes, and metal oxide fragments. The mechanism is not well enough understood to allow optimal alloy design. This project will determine the effects of gas composition on reaction rate, graphite nucleation and growth, and formation of metal particles. Dusting will be slowed by alloying with aluminium and copper. Improved alloys are essential to successful development of Australia's natural gas processing industries.
Fundamental conduction mechanisms in atomic-scale silicon devices	Prof MY Simmons; Dr G Scappucci; Asst Prof F Rosei	Miniaturisation is the driving force behind the microelectronics industry, but beyond 2015 there is no known route to reduce device sizes below 10nm. This project will launch a new initiative to understand the fundamental electrical conduction mechanisms of silicon electronic devices at the atomic-scale. In particular the project will exploit recent advances in scanning probe techniques to study conduction mechanisms in periodically doped one and two dimensional transistors. Using different dopants and metallisations it will also develop smaller and faster conventional transistors, nanoscale integrated circuits, and a better understand of the role that surface and interface chemistry has on device operation.

Separating Subtle Interplay between Competing/Cooperating Superconductivity and Magnetism in YBa2Cu3O7-x with Nanotechnology	Dr SS Li; Dr TM Silver; Dr D Yu	There is still no widespread agreement as to the origin of high-Tc superconductivity although the materials seem to share the same feature of antiferromagnetic ordering. This is due to lack of substantial understanding in subtle interplay between competing/cooperating superconductivity and magnetism in these materials. This program is aimed at experimental and theoretical investigations to understand the subtle interplay in YBa2Cu3O7-x by isolating the key superconducting and magnetic phenomena in molecular scale with nanotechnology for study. Success of this program will provide new insights into fundamental mechanisms of high-Tc superconductors and indicate a way to search new superconductors for practical applications.
Electronics with spin: Investigating spin-dependent electrical properties of semiconductor nano-devices	Dr RJ Danneau	Electronics and semiconductors underpin trillion dollar industries. Most electronic devices rely on the fact that electrons are charged; their intrinsic magnetic properties (their spin) plays no role. Spin-based semiconductor devices could offer significant speed and power advantages over conventional electronics. There is growing interest in devices in which electric currents can be controlled by the spin of the electrons. The aim of this project is to study spin related quantum effects in semiconductor nano-scale devices. We will study a new generation of p-type transistors in which spin can be controlled by electrical voltages. This could be a step toward the fabrication of the next generation of electronics - spintronics.
The Enhancement of Heat Transfer in Micro-Chips by MEMS actuator: Parametric Study	Adj/Prof JA Reizes; Prof E Leonardi; A/Prof F Stella; A/Prof CY Kwok	A perennial and extremely important problem in computer chip technology is the provision of adequate cooling. This project will develop an innovative technique for cooling micro-chips based on the concept of building a cooling device as an integral part of the micro-chip. This technology is based on the combined used of MEMS actuators, micro-channels and micro-jets. The goals of this project are to develop a suitable technique for the mass production of such micro-devices and to optimize the cooling system of the micro-device from the heat transfer and fluid dynamic point of view.
Highly efficient X-ray storage phosphor for medical and scientific imaging	A/Prof HA Riesen	A novel X-ray storage phosphor will be optimised so that it will potentially allow a hundredfold reduction of the X-ray dose in medical and dental imaging using computed radiography. Metastable electron-hole pairs are created upon X-ray exposure in conventional storage phosphors, yielding latent images that can be read out by photostimulated broad luminescence. The storage phosphor described in this proposal is based on photoexcitation of very narrow luminescence lines of relatively stable optical centres that are created upon X-ray exposure, yielding much higher contrast and better signal-to-noise ratios. Moreover, the nanosized particles will allow scientific imaging at highest resolution.
Surface Chemistry meets Cell Biology: Molecular Level Control of Surface Architecture for Cell Adhesion and Migration	A/Prof JJ Gooding; Dr K Gaus	We aim to study the role of spatial cues on cell adhesion and migration. To do so requires surface chemistries, which mimic the in vivo environment and allow specific factors to be varied without affecting others. We will modify nanostructured silicon surfaces with self-assembled monolayers, via the hydrosilylation of alkenes, to investigate (i) the role of surface topography, (ii) ligand density and clusters, (iii) dynamic ligand presentation on switchable surfaces, (iv) the importance of soluble versus adhesive cues and (v) sense secreted molecules. The research will contribute to fundamental insights into cell biology with a view to biomaterial and biotechnological applications.
Engineering Ultra-low Disorder Semiconductor Quantum Nanostructures	Dr AP Micolich; A/Prof AR Hamilton; Dr U Zuelicke; Prof RP Taylor; Dr Y Hirayama	The fundamental properties of quantum wires and dots, and how they can be coupled together is an area receiving significant international focus for testing the foundations of quantum mechanics, and for potential quantum information technologies of the future. However the presence of dopant atoms in devices provides a significant source of disorder, limiting the stability and complexity of the circuits that can be built. This project will develop quantum dots without the use of dopants thereby eliminating the leading sources of noise and disorder. We will perform the first studies of quantum dots in the ultra-clean limit, using both electrons and holes to study fractal behaviour, effects of strong interactions, and how shape affects spin.

Nanospintronics Spin Transport in Semiconductor Nanostructures	Dr AP Micolich; Dr U Zuelicke; Prof Dr A Wieck	Electronics and semiconductors underpin billion dollar industries. Most electronic devices rely on the fact that electrons are charged; their intrinsic magnetic properties or 'spin' plays no role. Spin-based semiconductor devices could offer significant speed and power advantages over conventional electronics. There is growing interest in devices in which electric currents can be controlled by the spin of the electrons. The aim of this project is to study spin-related quantum effects in semiconductor nano-scale devices. We will study a new generation of 'p-type' transistors in which spin can be controlled by electrical voltages. This could be a step toward the fabrication of the next generation of electronics - spintronics.
Developing a new nano-surfacing and micro-fabrication technology for complex part features using micro-abrasive jet	Dr J Wang; Prof X Li; Dr T Nguyen	This project will develop an advanced nano/micro-fabrication technology and gain new knowledge of micro- to nano-scale material removal mechanism to enable the analysis of the micro/nano-processes. It will be of great value to the development of high-integrity, high-density systems, such as high-performance electronic and photovoltaic devices that require the precision fabrication of super-finish surfaces and micro-part features of complex shape. The outcomes will increase Australia's international research standing in the precision/ultra-precision discipline, while the new technology created will enable the Australian fabrication industry to enhance the performance of high-integrity systems and develop revolutionary new generations.
Function-driven Synthesis and Assembly of Two-dimensional Metal Nanostructures	Dr X Jiang	Nanotechnology is one of the cutting-edge areas in Australia's National Research Priority. Design and construction of nanostructures for properties and applications control are of paramount significance in nanoscience. This project aims to develop novel strategies to produce two-dimensional metal nanoparticles with monodisperse size distribution and shape, to organize functional assemblies, and to understand the underlying fundamentals. The outcomes of this project will open new venues to control synthesis and assembly of the nanostructures for desired functional properties which will find a wide range of civil and environmental applications in Australia.
Towards Quantum Electromechanical Devices with Semiconductor Nanowires	Dr A Fuhrer	We will investigate novel quantum electromechanical devices fabricated using catalytically grown semiconductor nanowires in order to elucidate three different effects: the nature of the electron-phonon coupling in semiconductor nanostructures towards the realization of phonon cavity engineering in nanowires; the spin-orbit interaction in InAs nanowires and its implications on spin relaxation and spin manipulation and the use of nanowires as nano electromechanical systems towards quantum limited displacement sensing. Nanowire based one-dimensional electronics is a highly topical novel research field, which will ideally complement strong existing research in condensed matter physics in Australia.
Development of high-performance Si/Ge superlattice thermoelectric materials with optimization of lattice periodic thickness	Dr C Yang	The proposed program is aimed at experimental and theoretical investigation of high-performance Si/Ge superlattice thermoelectric materials, which have high energy conversion efficiency and thermal stability over today's state-of-the-art thermoelectric materials. Such high-efficiency thermoelectric materials play an important role in developing alternative energy to reduce the dependence on fossil and reduce greenhouse effect. The practical application of thermoelectric technology could potentially offer significant fuel economy improvements. The expected outcome of this program includes developing of high-performance superlattices with optimization of lattice periodic thickness and better understanding of their thermoelectric properties.
New Strategies for Monitoring DNA-Anticancer Drug Interactions	Dr EL Wong	This research aims to provide a stepping stone towards achieving a more rational platinum anticancer drug design, thus improving the chances in developing a more effective drug, by developing new electrochemical methodologies for monitoring DNA-drug interactions. The proposed project will involve the development of an electrochemical DNA biosensor (surface bound DNA), and utilise long-range charge transfer chemistry in DNA duplex to probe cisplatin and cisplatin analogue compounds that induce DNA damage. The long range charge transfer approach will also be used to monitor oxidative damage to DNA and repair of DNA by DNA repair enzymes.

Novel nanostructured InVO4 and related vanadates photocatalysts for water splitting under visible light irradiation	Dr B Chi	This project aims to develop a new generation of photocatalysts for water splitting under solar energy irradiation. Current photocatalysts for water splitting are of low efficiency under visible light irradiation. This novel material system, coupled with nanotechnology, is of great interest for solar energy application and is anticipated to have a disruptive impact in the areas of sustainable energy supply, environmental purification, and advanced materials. The outcomes of this project will provide high efficiency photocatalysts for water splitting and impart a comprehensive understanding of the design and application of nanomaterials in sustainable energy and environmental fields.
Molecular modelling of the structure and mechanical properties of clay-based polymer nanocomposites	Dr Q Zeng	Polymer nanocomposites have demonstrated dramatically improved mechanical and thermal properties. However, molecular origins of such improvement are not well understood, which severely hinders the design and manufacturing for low cost, light weight and high performance materials. The project aims to quantify at the molecular level the structure and mechanical properties of clay-based polymer nanocomposites using novel computer simulation and experimental techniques. The study will bring new knowledge and strategies to nanoparticle dispersion in a targeted polymer and establish the structure- property relationship of such nanocomposites. It will enhance Australia's strength in the innovation and development of advanced materials.

ATTACHMENT 4 – UNSW NANOTECHNOLGY RESEARCH IN PRESS

Summary of recent UNSW Nanotechnology Research in the media

- "Scientists to build world's first molecular motor"
- "A bathroom that cleans itself"
- "Holey wire wins Australasian Science Prize"
- "Quantum leap"
- "Lighting the way"
- "Aquatic antibiotic"
- "Every last drop"
- "The great white hope"
- "Nanomaterials & nanotechnologies"
- "Molecular-scale biosensors and responsve materials"
- "Nanoelectronics"
- "Surfaces and interfaces"

Scientists to build world's first molecular motor

Cells use tiny "molecular motors" to make, assemble and move materials around inside them: now an international team of scientists aims to build an artificial version to drive a tiny vehicle that rolls like a tumbleweed along a strand of DNA.

A molecular motor is only a few billionths of a metre in size, yet these tiny engines can transport essential cargo to and from specialized "factories" inside cells by walking in a step-like fashion along pathways made from slender protein filaments.

Many scientists are probing their form and function so that they might be co-opted or re-engineered for use in areas such as medicine, pharmaceuticals, electronics, computing and materials science. Medical scientists, for example, want to understand the processes that regulate molecular motor activities because "dysfunctional" molecular motors are at the heart of diseases such as cancer, Alzheimer's disease and motor neuron degeneration.

But now Professor Paul Curmi, of the University of New South Wales, and colleagues from the University of Oregon (Eugene, USA), Simon Fraser University (Vancouver, Canada) and the University of Bristol (UK) have set out to design and build from scratch the first synthetic protein-based motor that can run itself.

"Molecular motors drive essential tasks like muscle contraction, chromosome movement during cell division, and reloading nerve cells so they can fire repeatedly," says research team member Paul Curmi, a molecular biophysicist with UNSW's Biophysics Department.

Using powerful microscopes, scientists have observed molecular motors of all shapes and sizes transporting their loads in highly regulated ways. Different motors have an inclination to walk in different directions, but when they attach to a cell structure they cooperate so their crucial cargo reaches its intended location inside a cell.

"Proteins are the fundamental molecular machines in any living system," Professor Curmi says. "The handful of molecular motors made by scientists to date are really mutants made by tinkering with existing design in nature.

"However, our goal is to use a bottom up approach design, build and characterise an artificial protein motor that uses chemical energy to move along tracks of synthetic DNA."

"First, the 'tumbleweed' component will be a multi-protein complex comprising three flexibly linked ligand-dependent DNA-binding proteins. It will 'roll' along a DNA track with repeating binding sites for the heads. This motion will be achieved by appropriately timing the addition of ligands. *See Figure 1 below.*

"Second, we will build a 'burnt bridges' motor comprising a DNA clamp linked to a DNA modifying enzyme. It will move by biased one-dimensional diffusion along a DNA track of repetitive enzyme target sequences.

"Our approach involves a multidisciplinary approach that integrates numerical modelling, protein engineering to create the motors, peptide synthesis, molecular biology and self-assembly to generate and fuse proteins, and fluorescence and optical trapping experiments to characterize the motor's performance.

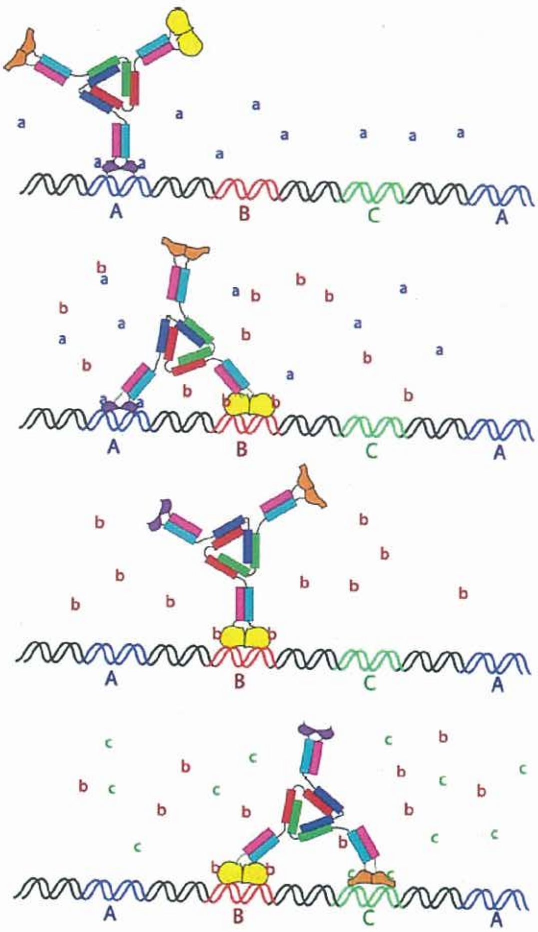
"Our long-term goal is to create self-running equivalents to classic biological motors such as the kinesins or myosins, by incorporating enzymatic function and conformational changes in our designs."

The ambitious project is funded by a $US450,000 grant from the Human Frontiers in Science Program that supports novel research uniting international scholars from diverse disciplines.

Nobel Laureate Richard Feynman first raised the prospect of designing and building molecular motors nearly 50 years ago.

Media contacts: Paul Curmi: tel 02-9385 4552

Figure 1 – Tumbleweed concept



Three ligand-dependent DNA binding proteins will be connected via coiled-coils to a three-way hub. Each arm of the tumbleweed will bind to a specific target site on the DNA track (A, B, C). The arms only bind in the presence of a specific ligand (a, b, c). Selective supply of ligands in appropriate temporal order results in translational motion of the tumbleweed. Its direction is biased by the asymmetry of the track DNA sequence and can be externally controlled by the sequence of ligand supply using nanofluidics. Note: this figure is a cartoon and elements are not drawn to scale.

MEDIA, NEWS & EVENTS

A bathroom that cleans itself

07 February 2006

Cleaning bathrooms may become a thing of the past with new coatings that will do the job for you.

Researchers at the University of New South Wales are developing new coatings they hope will be used for self-cleaning surfaces in hospitals and the home.

Led by Professor Rose Amal and Professor Michael Brungs of the ARC Centre for Functional Nanomaterials, a research team is studying tiny particles of titanium dioxide currently used on outdoor surfaces such as self-cleaning windows.

The particles work by absorbing ultraviolet light below a certain wavelength, exciting electrons and giving the particles an oxidising quality stronger than any commercial bleach.

These nanoparticles then kill microbes and break down organic compounds. And because surfaces coated with titanium dioxide have another property called 'superhydrophilicity' -- meaning droplets do not form -- water runs straight off the surface, washing as it goes.

Presently, titanium dioxide can only be activated by the UVA present in sunlight. But the UNSW team is working on ways to activate titanium dioxide with indoor light.

The team is modifying titanium dioxide nanoparticles with other elements such as iron and nitrogen so they can absorb light at longer wavelengths.

Lab trials show that glass coated with the new nanoparticles can be activated by visible light from a lamp to kill Escherchia coli.

"If you've got this on tiles or shower screens you don't need so many chemical agents," says Professor Amal.

So far the team has been working at laboratory scale. "It's probably a year before we can talk to industry and test outside the lab," says Professor Amal.

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MEDIA, NEWS & EVENTS

Holey wire wins Australasian Science Prize

10 November 2006

Tiny wires could unleash a new world of super-fast quantum computers.

Associate Professor Alex Hamilton

UNSW research with the potential to revolutionise the storage and processing of information has earned Associate Professor Alex Hamilton the Australasian Science Prize for 2006.

Alex Hamilton and his team at the Quantum Electronic Devices (QED) Group have found ways to manipulate the magnetic spin of holes in semiconductors, which are 100 times narrower than a human hair.

Known as a "hole quantum wire", the breakthrough exploits the gaps between electrons and can carry a current without need for electrons.

The remarkable properties of these tiny wires could unleash a new world of super-fast, low-powered transistors and powerful quantum computers.

The other members of the QED group are: Dr Warrick Clarke, Dr Romain Danneau, Mr Lap-Hang Ho, Mr Oleh Klochan, Dr Adam Micolich, Prof Michelle Simmons, Mr Tom Sobey and Dr Carlin Yasin.

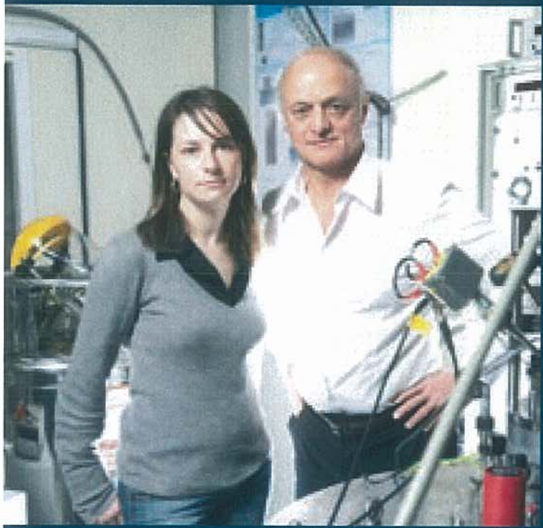
The award comes on the back of recent good news for the group. Dr Micolich and Associate Professor Hamilton were recently awarded a discovery grant of $1.3 million from the Australian Research Council to extend their research on GaAs nanostructure devices.

Further, Associate Professor Hamilton has been awarded a 5-year ARC Professorial Fellowship, and Dr Micolich was awarded a "Young Tall Poppy" Award from the Australian Institute of Policy & Science.

Meanwhile, the research continues with PhD student Lap-hang Ho conducting a unique series of experiments on coupled hole devices, and Oleh Klochan continuing experiments on a new generation of hole quantum wires.

A story on the team's research is published in the current issue of Australasian Science

quantum leap



A detour in doctoral studies has led to fascinating findings on a device that has broad research applications.

Nadia Court and Professor Bob Clark
Photo: Adam Taylor

Imagine having a powerful computer performing incredibly complex calculations but not being able to see the result without destroying it. It's one of the big challenges in the emerging field of quantum computing and Nadia Court has taken it up.

Ms Court, a PhD student in UNSW's Centre for Quantum Computer Technology (CQCT), is studying the use of Single Electron Transistors.

Her ultimate goal is to design the best possible device for extracting information from qubits, the atom-sized basic data units of quantum computers.

"But the exciting aspect of my work is that it can't be pigeon-holed into just research for quantum computers," says Ms Court.

Quantum computing is a challenging concept. Today's computers use zeroes and ones to represent data in binary code – a basic unit of data, called a bit, can be a zero or a one.

Quantum computers use the multiple and parallel positions occupied by particles at atomic and sub-atomic level. The basic quantum data unit, the qubit, can be a zero, a one or, because of a quirk of particle behaviour known as superposition, it can be both at the same time and this allows a massive increase in data-handling speed.

The problem is attempting to directly observe the results of superposition activity, which basically destroys it and that's where Ms Court's study can provide a way to see the unseeable.

"Single Electron Transistors (SET) are detectors, rather like transistors in today's computers. I can see many avenues for application. You could think about using this device to detect photons (light) from a distant star or even cells and proteins. Incoming photons create extra electrons which can be detected by the SET giving you an indication of the light coming in."

In the first years of her experimental work her focus was to look at a "holy grail" in this field – coupling these highly sensitive quantum detectors with a quantum amplifier in an international collaboration with the University of California, Berkeley. It slowly emerged that this was a challenge beyond the normal time frame of a PhD.

"Other international efforts towards this project had met similar difficulties and while we had achieved some success, realisation of the final experiment proved beyond the scope of my thesis," she says.

It was then that guidance from supervisor Professor Bob Clark, the director of CQCT, proved invaluable in helping make a very important decision. With advice from him, Ms Court changed her focus to optimally engineer the SET and is now planning to write up her thesis on quantum measurement this year.

Professor Clark says he views the work being done at CQCT as being "of national strategic significance" and teamwork is an essential element.

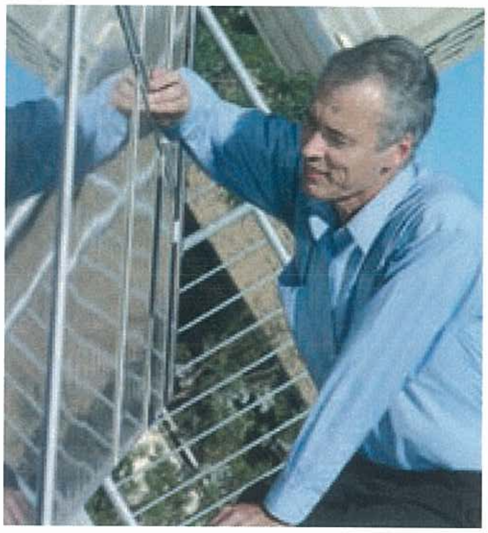
"The sort of students that are attracted to our centre are very good students – they are extremely intelligent, they are independent thinkers and they are very highly motivated," Professor Clark says.

Nature of research:
The use of Single Electron Transistors as devices to extract information from qubits – making sub-atomic quantum computer activity readable to the outside world.

Funding:
Principal CQCT funding from ARC. Also from NSW, Qld and Vic state governments; federal departments of Defence, Industry, Communications and Education; US Government agencies; industry.

Commercialisation:
Substantial patent portfolio.

lighting the way



Many of the world's leading solar-cell manufacturers are basing their future on UNSW technology.

Professor Stuart Wenham
Photo: Martin Baker

For more than 25 years, the ARC Photovoltaics Centre of Excellence and its predecessors have led the world in the science and technology of converting the sun's energy into electricity using silicon solar cells. In that time, its achievements in research, development and commercialisation of silicon solar cells have been without peer.

Led by Professors Martin Green and Stuart Wenham, the Centre of Excellence has held the world record for solar-cell efficiency and licensed its technology to solar cell manufacturers with global sales exceeding $1 billion.

UNSW benefits from the commercialisation of the research through licensing fees, royalties, and equity stakes in manufacturing companies that have earned millions of dollars for the University.

The Centre has joint research and business agreements with leading developers and manufacturers of solar technology across Asia, USA and Europe. In business circles, the Centre's most well-known alumnus is Dr Zhengrong Shi. The CEO and Chairman of Suntech Power Holdings, Dr Shi is the inventor for 11 patents in photovoltaic technologies and completed a PhD degree in electrical engineering at UNSW in 1992.

An Australian citizen, Shi founded Suntech in 2001 and five years later took the company public, listing it on the New York Stock Exchange (NYSE). The company rocketed up the bourse and last year, Dr Shi was ranked No.7 on the Forbes magazine list of China's richest tycoons. Suntech is now the world's fourth-largest solar cell maker.

"Our relationship with Suntech continues to be fruitful in many ways," says Professor Wenham, the Centre's Director. "In 2006, Dr Shi generously donated $1.5m to UNSW to support its ongoing photovoltaic research. In 2007 we signed a research agreement with Suntech affirming our commitment to jointly develop an innovation that could further boost solar-cell efficiency."

If this proves successful, the University's commercialisation arm, NSi, will start to receive royalties from Suntech in 2008.

In March 2007, NSi signed a $1.7m licensing agreement with Taiwanese solar-cell manufacturer, E-Ton Solar Tech, that included a collaborative research program to develop two of UNSW's latest high-efficiency solar cell technologies for commercial production.

NSi also signed a $1.4 million licensing agreement with CEEG Nanjing PV Tech in China. The agreement includes a collaborative research program to adapt UNSW's world record-holding PERL solar-cell technology to suit large-scale commercial production.

In May 2007, the Centre announced that it could dramatically improve the absorption of light into thin films of silicon in a breakthrough that could make solar power more affordable.

"Most thin-film solar cells are between eight and 10 percent efficient but our new technique could increase efficiency to between 13 and 15 percent," says Kylie Catchpole, a research co-author. "Once a technology approaches 15 per cent efficiency, it becomes commercially viable."

Global warming and energy security are driving governments to adopt energy policies that support renewable energy sources. The technical and commercial achievements of solar-cell technology, such as those being driven by UNSW, should see it become a clear energy of choice for the 21st century and beyond.

aquatic antibiotic

Diving into a study on chemicals found in seaweed lands a research scientist an international position.

Dr Rebecca Case
Photo: Eddie Safarik

Imagine being able to stop bacterial infections without creating antibiotic resistance, using a chemical from seaweed?

Professors Staffan Kjelleberg and Peter Steinberg and their team at the Centre for Marine Bio-Innovation have discovered compounds, known as furanones, produced by the seaweed *Delisea pulchra*.

The researchers discovered that furanones don't kill bacteria, but instead "block" the chemical signals that they use to communicate with each other.

Since their discovery, furanones have been synthesised and have a wide range of applications, such as coatings for surgical equipment, orthopaedic implants, contact lenses and combating cholera.

Dr Rebecca Case, who has just begun her post-doctoral fellowship at Harvard University, investigated the relationship between furanones and bacteria forming on aquatic plants.

"What I wanted to know was why the algae produced them. Were they active against the bacteria in the environment, inhibiting things that would cause disease?" says Dr Case.

"I found that if you removed the 'antibiotic' system from the seaweed, specific bacteria are actually able to infect and kill the seaweed. "We proved that the furanones have a purpose and that they're not just produced there by chance."

Her research also confirmed a relationship between furanones and bleaching of marine plants. Higher than normal temperatures allow bacteria to infect plants and induce bleaching, similar to what is seen in corals.

Dr Case says working with Professor Kjelleberg as her PhD supervisor gave her room to be creative and pursue research that helped her grow as a research scientist.

"The freedom he allowed me to pursue what I was interested in was fantastic. It was what attracted me to working with him," says Dr Case.

Despite initially having plans to complete her PhD overseas, being able to conduct her research in world-class facilities in Australia was a factor in her choosing UNSW.

"The research the Centre does is truly international. It has a great mix of research that is internationally relevant, based on Australian natural habitats," says Dr Case.

Dr Case believes a lot of prospective PhD students spend too much time focusing on the topics they want to investigate. She believes that it is also important to think about the research supervisor because the relationship you develop with them will dictate the research you undertake for the next three or four years of your life.

Dr Case is now working as a Fellow at Harvard University's Center for the Environment.

For Professor Kjelleberg, the work of Dr Case, like most PhD students, is invaluable to the success of scientific research.

"PhD students are the core of research. A very high percentage of the research that is done in university research laboratories is conducted by the research students," says Professor Kjelleberg.

"They become good at the topic very quickly and invest their soul, heart and imagination into it."

Nature of research:
The application of furanones, isolated from the seaweed *Delisea pulchra*, to stop bacterial infections.

Funding:
ARC and NHMRC grants, national and international research institutes, and international research partners.

every last drop

UNSW researchers are leading the fight to develop sustainable and scientifically robust technology to solve our crippling water crisis.

A decade ago, few would have guessed that water security would become a national priority to rank alongside issues such as employment, security and the economy.

But a once-in-a-century drought has all but dried Australia's once mighty rivers, shrunk its dams and seen the imposition of restrictions on domestic water use. Voters now want governments to initiate environmentally sustainable and scientifically robust actions across a broad policy front, including water security.

UNSW brings to the challenge a wealth of research, development, consultation and policy expertise on water. The University's faculties of Science and Engineering host a range of expert centres and groupings that are attracting major research funding.

The Federal Government has established a $3.6 million multidisciplinary research cluster comprising the CSIRO and nine universities to advance to commercialisation stage energy efficient, environmentally sound technologies for water desalination and water recycling. UNSW is a significant member of the cluster and received nearly $1million to carry out a comprehensive evaluation of existing filtration techniques and develop new energy-efficient technology.

One aim is to learn what nature can teach us and apply it in innovative ways to membrane technology. Using "microfluidic flow visualisation methods" coupled with numerical models, engineers Drs Gary Rosengarten and Associate Professor Greg Leslie are examining the role of pore architecture in the filtration mechanism of select species of plant-like diatoms. Some species of diatoms possess tiny pores smaller than one millionth of a metre in diameter that might be applicable in wastewater recycling, saltwater desalination and preventive health care.

Engineers at UNSW's UNESCO Centre for Membrane Science and Technology are establishing a digital library containing information about the efficiency of a suite of membranes, surfaces, desalination and filtration processes. This first-of-its-kind database will reveal which applications offer the most promise for improving the efficiency of desalination.

Another water-saving advance is being pioneered by chemical engineer Soji Adesina, who is developing a novel process to remediate wastewater using visible light and a titania-based catalyst.

Using a small lab-scale model, Professor Adesina can detoxify wastewater containing organic pollutants at a rate of 300 litres per hour. The process can run continuously, requiring only two grams of catalyst per litre of wastewater each hour to produce water that is clean enough for all non-drinking purposes.

Senior engineer James Carley in the wave basin at the Water Research Laboratory. Photo: Eddie Safarik

The process, known as photocatalysis, occurs when light in the visible range (400–700 nm) strikes the titania catalyst to produce free hydroxyl radicals that break the chemical bonds in typical organic wastewater molecules. Splitting these compounds releases CO2, water and other harmless smaller molecules in solution. The process operates at ambient temperatures and is effective at organic pollutant densities up to 1000 parts per million.

"The process has potential application in domestic and industrial settings and could help reclaim a significant amount of wastewater for other uses," says Professor Adesina. "This form of photocatalysis is very inexpensive and could be done with either small mobile units or large fixed units to decontaminate polluted wastewater in settings such as farms and mines."

At Manly Vale in Sydney's north, the Water Research Laboratory (WRL) has been leading international research in the areas of water, coastal and environmental engineering and groundwater since its establishment in 1959.

It is equipped with a suite of unique facilities including large-scale and sophisticated hydraulic laboratories, a groundwater laboratory, three-dimensional numerical modelling facilities, field-data collection equipment and the largest specialist water research library collection in the southern hemisphere.

WRL has diverse fundamental and applied research expertise, including coastal and ocean engineering, flood engineering, water resource engineering, environmental fluid mechanics, hydrodynamics, sediment transport, river and estuarine hydraulics, groundwater studies, hydrology, hydraulic structures, water and wastewater treatment, environmental monitoring and modelling.

WRL staff form the core of UNSW's Connected Waters Initiative, which is presently undertaking a $1.4 million research contract funded by the Cotton Catchment Communities CRC and the National Water Initiative.

UNSW's Centre for Water and Waste Technology (CWWT), led by Professor David Waite, conducts multidisciplinary research on water and wastewater engineering and develops tools for environmental management and sustainability aimed at improving aquatic and atmospheric environments.

Established 20 years ago, CWWT's core research encompasses five areas: environmental microbiology and risk assessment, physical and chemical processes, sustainable assessment, volatile emissions and trace organics.

CWWT does joint research with industry, government and research groups in Australia and overseas. It has extensive collaborative links with leading international research institutions including Cranfield University, MIT, Stanford, UCLA and Nanyang Technological University. The centre has been active in the water re-use debate, hosting a major international conference on the viability of the strategy.

Nature of research:
Water research covering surface, groundwater, oceans, water filtration and recycling, water and wastewater engineering, sustainable water frameworks.

Funding:
Energy-efficient membrane technology: Federal Government

WRL: Industry, government ARC.

Wastewater remediation: ARC

Connected Waters Initiative: Cotton Catchment Communities CRC; National Water Initiative.

CWWT: ARC, the CRC's Program; the Department of Education and Training and national industry and international competitive funding.

the great white hope

Daily jabs could soon be a thing of the past for diabetics.

PhD student Roderick Sih
Photo: Adam Taylor

Diabetics could be able to dispense with their daily injections if UNSW researchers have their way. Rather than using a needle, diabetics would instead inhale their doses of insulin.

Delivering with the needle results in low patient compliance and the very real potential of overdosing; if too much insulin is administered, diabetics have only precious moments to compensate with dextrose before they plunge into a hypoglycaemic coma.

As well as being less confronting for patients, the pulmonary delivery of insulin would allow for accurate blood-glucose control and less cumbersome dosing implements for patients.

"Inhaled insulin brings the promise of a more rapid onset of action," says PhD student Roderick Sih, from the School of Chemical Sciences and Engineering, who worked on the project with his supervisor Professor Neil Foster.

"This means diabetics would only have to take inhalation doses 10 minutes before meals, instead of injections 30 minutes ahead of time. Doses would be more accurate too – as diabetics could inhale once, then test their blood-glucose levels. If necessary, more doses could be administered."

Roderick holds out a jar filled with white, fluffy powder which seems to float. It is this powdered insulin which could transform the lives of up to 230 million people with diabetes worldwide.

While researchers have long known that the reduction in the particle sizes of pharmaceutical compounds would bring about improvements in their products – from dissolution to convenience – the method to do that had not been refined.

Micronisation, as the process is known, was inadequate in producing respirable particles. Over the past two years, Roderick Sih and Professor Foster have helped it grow up.

"Classical methods of micronisation include the grinding and crushing of larger particles to obtain smaller pieces with physical force. This is like throwing a glass bottle at a brick wall – as a result, there are splinters and shards of different shapes and sizes," says Professor Foster.

"There are a number of problems with this technique, including the fact that it simply would not work with soft and pliable materials that deform, rather than break under physical force."

The researchers have used unique technology that they developed in the lab, known as ARISE (Atomised Rapid Injection for Solvent Extraction) to make the fluffy insulin powder that circumvents such problems. ARISE is improved Supercritical Fluid (SCF) technology.

"The 'fluffy' characteristic of ARISE insulin contributes to its extremely low bulk density. This means that it experiences much higher drag forces in an airstream – like how a sheet of tissue gets blown away a lot more effectively than when it is compressed into a little ball, giving it the inertia needed to drive it deep into the lungs," says Roderick.

The researchers' tests show that ARISE insulin outperforms the only other pulmonary delivery of insulin which is currently on the market.

The technology also has other applications. It could be used to process treatments for asthma and other chronic obstructive pulmonary diseases.

Commercialisation is being handled by Dr Robin Stanley, a Senior Business Development Manager with NewSouth Innovations (NSi). Negotiations are underway with leading pharmaceutical companies to evaluate the behaviour of ARISE insulin powder in a range of proprietary inhaling dispensers.

NSi, in conjunction with the principal inventor Professor Neil Foster, has already established a spin-off company, Nanomed Pty Ltd, as a commercialisation vehicle for the technology.

Nanomaterials and nanotechnologies

WHO WE ARE

Sri Bandyopadhyay, Sammy Chan, Sushil Gupta, Mark Hoffman, Sean Li, Valanoor Nagarajan, Paul Munroe and Yong Zhao.

ABOUT OUR RESEARCH

The study of nanomaterials has always been one of the key research areas in the School of Materials Science and Engineering. Studies span from synthesis and applications of nanoparticles, carbon nanotubes, nano-structured wires and tapes, to nanoscale ferroelectrics and piezoelectrics, nanocoating and bulk materials with nanocrystalline sizes.

MORE DETAIL

Nanotechnology is the design, fabrication, characterisation and utilization of materials, structures and devices, which are less than 100 nanometers in at least one dimension. Nanomaterials, because of their very small sizes, display an array of novel attributes. They respond to light, mechanical stress and electricity quite differently from micron- or millimeter-size materials. They show great promise with many strategic technological advances that will change the ways that we use materials. Our fields of interest include:

- Development of superhard nanocomposites coatings
- Ceramic-based coatings with a hardness approaching diamond using film deposition techniques. They contain nanocrystalline grains in an amorphous matrix.
- Development of advanced diluted magnetic semiconductors for spin transistors
- Investigating the subtle Interplay between competing/cooperating superconductivity and magnetism in YBa2Cu3O7-x with nanotechnology
- Hydrogen storage in carbon nanotubes.
- Nanostructured nickel oxide and hydroxide for high-performance rechargeable alkaline nickel batteries and supercapacitors.
- Nanometric particulate reinforced aluminium matrix composites for high temperature uses.

FUNDING

Australian Research Council Discovery Grant; Department of Education and Training International Science Linkage Grant; Hong Kong Science and Innovation Fund; Commonwealth Scientific and Industrial Research Organisation.

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Molecular-scale biosensors and responsive materials

WHO WE ARE:

Molecular Devices Research Group.

ABOUT OUR RESEARCH

We aim to make biosensors and other functional devices from molecular-scale building blocks. Biosensors allow anyone to detect species - such as disease-markers, pathogens and environmental pollutants - simply by placing a dipstick-like device into the sample to be analysed. Other devices being developed are molecular magnets for data storage and switchable surfaces for biomaterial applications.

MORE DETAIL

Imagine if you could go to the doctor and be told instantly whether your sore throat is due to a bacterial or viral infection, and so whether it can be treated with antibiotics. Or imagine you could simply dip a device in a glass water to tell you whether it was safe to drink. Diabetics already use such a device, a blood glucose biosensor that gives a result in seconds. The key component of a biosensor is a biological molecule that will bind selectively with what you want to detect, the analyte. Suitable molecules include enzymes, antibodies and DNA. To turn this into a device requires a way of monitoring the interaction between the molecule and the analyte, and turning this into an electronic signal the end-user can see, known as signal transduction. Common transducers are electrodes and optical devices. This exciting idea of using biological molecules as the basis of an analytical device anyone can use can be applied to many purposes. We are doing just that. We are developing the next generation biosensors for pesticides in water samples using antibodies coupled to electrodes, biosensors for monitoring protease enzymes as a marker of disease and infection using optical devices. Our focus is to use molecular-scale building blocks to build the biosensors and other responsive materials. This often entails developing new molecular-scale materials. We have developed conducting sheets a single atom thick, molecular wires and molecular units that spontaneously form nanoporous solids. The applications extend far beyond biosensors to molecular magnets for data storage and the production of magnetic films, gas sensing, labels for biological molecules, biomaterials and smart surfaces that change their properties on receiving a given stimulus. The multi-disciplinary nature of this research prompts us to venture far beyond our walls within UNSW and further to the new nuclear reactor at NSW, the new Australian Synchrotron and universities and companies across Australia and internationally.

FUNDING

ARC discovery and linkage grants; ARC Centre of Excellence in Functional Nanomaterials; Australian Nuclear and Science and Technology Organisation; direct industrial funding.

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Nanoelectronics

WHO WE ARE

Department of Condensed Matter Physics.

ABOUT OUR RESEARCH

Microelectronics has changed our world drastically through computers, mobile phones, DVD players and the internet. Nanoelectronics is the next step, harnessing the power of new fabrication technologies and quantum physics to build ultra-small electronic devices.

MORE DETAIL

The driving force behind the expansion of the microelectronics industry has been the ability to pack ever-more features onto a silicon chip, achieved by continually miniaturising the size of the components. But as devices get smaller and smaller two problems emerge. First, as devices get smaller the laws that determine how they operate change from the familiar classical physics to the counter-intuitive and unpredictable quantum physics. Second, after 2015 there is no known technological route to reduce device sizes below 10nm. We are addressing both of these problems. Professor Michelle Simmons is developing revolutionary new techniques for building silicon devices atom-by-atom, using a combination of scanning tunnelling microscopy and atomic precision crystal growth. Her team has achieved major milestones: incorporating a single phosphorus atom in the silicon surface with atomic precision; a technique to make four-terminal electrical contact to STM-patterned devices once removed from the microscope environment; and to correlate electrical device characteristics with dopant placement. Professors Hamilton, Micolich and Newbury are studying nanoscale quantum electronic devices, which harness the quantum properties of electrons, as well as organic semiconductor devices which offer flexible new approaches to electronics.

FUNDING

Australian Research Council: Discovery, Linkage and Fellowship grants since 1991; US Semiconductor Research Corporation; US Army Research Office.

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Surfaces and interfaces

WHO WE ARE

Professors P.R. Munroe, M. Hoffman and D.J. Young, Drs V. Nagarajan and S. Li.

ABOUT OUR RESEARCH

The surfaces of materials play a vital role in the performance of components. Processes such as wear and corrosion are controlled by the nature of a material's surface. The deposition of thin, micron-scale, coatings onto a surface may act not only to improve component performance but may be used as a path to increasing the functionality of a surface.

MORE DETAIL

The deposition of thin films or coatings on to substrates or the surfaces of components is widely used in the materials sciences. These films have broad application in providing resistance to surface damage, corrosion, oxidation or thermal degradation, leading to increased operational life and reliability. Alternatively, the coatings deposited films are used to increase functionality, for example, in the fabrication of devices such as actuators. We have a range of active research programs in this broad area. These include: the development of coatings to prevent corrosion of components operating in hostile environments in, for example, the processing of petrochemicals; the development of biocompatible coatings suitable for use on prosthetic devices; and the development of ferroelectric thin films with potential applications as switches and actuators. Professors Munroe and Hoffman collaborate in the development of nano-composite coatings deposited onto substrates such as silicon or stainless steel. These coatings, based on controlled mixtures of hard, wear-resistant TiN and ductile titanium, have undergone careful structural design to create alternating layers of these phases, which synergistically act to increase resistance against wear and other forms or erosive attach and so lead to significantly improved component lifetimes.

FUNDING

ARC Discovery grants and ARC Linkage grants.

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Advanced composites, polymers and biomaterials

WHO WE ARE

Participants: Alan Crosky, Mark Hoffman, Owen Standard, Sri Bandyopadhyay.

ABOUT OUR RESEARCH

Our research on advanced composites is directed towards the high-end carbon fibre reinforced plastics, polymer nanocomposites and functionally graded materials. Our work on biomaterials encompasses biocompatible materials for body implants, biomimetic design and engineering materials derived from biomass sources.

MORE DETAILS

Our work on carbon-fibre reinforced composites is directed towards optimising the performance of the materials in structures. This includes directed fibre placement, through thickness reinforcement and nano-reinforcement of the matrix resin. It also includes a study of damage development during loading and development of strategies to improve energy absorption during failure. In conjunction with water-pipe manufacturers, recent research has found that the creation of polymer nano-composites through the inclusion of nano-particulate filler enabled the creation of stiffer and tougher pipe. This can reduce production costs enabling the greater use of pipe to avoid water loss through evaporation in surface channels used for irrigation. Our work in functionally graded materials involves creating a graded join of ceramics to metals or polymer to ceramics. This enables the creation of previously unattainable interfaces for biomedical implants, high energy electric switches and thermal barriers.

Biomaterials are being designed to enable tissue to grow quickly and strongly into synthetic materials. This involves creating materials with special types of pores and chemistry. Also, the mechanical properties of biological tissue such as teeth and bone are being investigated to ascertain the effects of factors such as age, disease, diet, medical treatment and lifestyle. This will enable the creation of novel and more effective treatments. A new area of biomaterials research is the development of engineering materials from biomass to enable, for example, the replacement of glass fibres in fibreglass with natural plant fibres and the development of biodegradable fibre reinforced composites based on biomass-derived polymers.

FUNDING

Cooperative Research Centre for Advanced Composite Structures, Australian Research Council, Iplex Pipelines Australia.

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Lighter, stronger metals for the 21st Century

WHO WE ARE

ARC Centre of Excellence for Design in Light Metals

ABOUT OUR RESEARCH

In collaboration with various partner institutions, we are using a novel "design-directed" research approach to maximize the competitiveness of wrought light alloys and light metal hybrids based on aluminium, magnesium and titanium. The research has a focus on innovation in materials design, advances in downstream processing and expansion of application opportunities for light metals through novel approaches in design and application.

MORE DETAIL

We are a core partner in the ARC Centre of Excellence for Design in Light Metals, which includes researchers from six major Australian universities and a host of the best light-metals partner researchers in major institutions globally. The general aim of the Centre is to expand Australia's light metals industry by making light alloys such as aluminium, magnesium and titanium more competitive, providing opportunities to increase the use of light metals in the automotive, aircraft, aerospace, packaging and construction sectors. Our team shares a leading role in the Centre with Professor Michael Ferry, Mark Hoffman and Alan Crosky and Dr Sammy Chan leading several research projects. We also lead two of the Centre's five research programs: Alloy Design and Processing (Ferry); and Design of Light Alloy Hybrids Composites (Hoffman). The former consists of a suite of projects targeted at the design of microstructures through alloying, thermal and mechanical treatment for optimizing the strength, formability and stability of magnesium and aluminium alloys. The latter involves exploiting unique opportunities that can arise by combining materials in the form of composites, hence expanding the "property space" with development of multi-scale composite structures, dispersed phase nanocomposites, micro-truss structures and sandwich structures. Some of our recent milestones are: developing ultra-fine grained aluminium alloys exhibiting high temperature structural stability during both superplastic processing and in-service use; constructing a novel die-casting facility for producing bulk amorphous light alloys for investigations on superplastic nanoforming to produce microdevices and components; creating nanolayered metallic composites; developing superlight and high-contact damage-resistant metal foam-based composites; and developing aluminium matrix composites reinforced with nano-particulates with very high creep resistance.

Funding

Australian Research Council Centre of Excellence Program; ARC Discovery/Linkage Grant Programs; CSIRO Flagship Collaboration Fund; New Air Compact Capability Group, Department of Defence; Australian Defence Force Academy/Faculty of Engineering UNSW Research Collaboration Initiative; Australian Institute of Nuclear Science and Engineering.

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