2011 ANNUAL REPORT

INSTITUTE FOR TECHNOLOGY
RESEARCH AND INNOVATION

DEAKIN
UNIVERSITY AUSTRALIA

GEELONG & MELBOURNE | VICTORIA | AUSTRALIA

CONTENTS

CHAIRPERSON'S REPORT

The year 2011 was another one of growth and achievement for ITRI with both national and international accolades for staff and students. It is pleasing to see this type of recognition of both our most experienced professors as well as our emerging researchers.

The quality of ITRI research was demonstrated by the Australian Research Council's 2010 Excellence in Research for Australia (ERA) scores. Deakin was the only university to receive the highest scores given to any Australian university for both Materials Engineering (5-outstanding performance well above world standard) and Manufacturing Engineering (4-performance above world standard). These scores confirm the excellent and world-class standard of research conducted in ITRI and indicate our leading position in these fields.

ITRI'S reputation for quality research facilities and outputs has grown world-wide. In 2011, ITRI expanded its international partnerships, not only in India and China where a number of important partnerships have been developed, but also in Europe and America where there continues to be enormous interest in our work in carbon fibre composites.

In 2011, work commenced on the Australian Future Fibres Research Innovation Centre (AFFRIC) on the Geelong Campus at Waurn Ponds. AFFRIC is a collaboration between CSIRO-Materials and VCAMM (Victorian Centre for Advanced Materials Manufacturing), funded by the Commonwealth's Education Investment Fund. It includes the co-location of CSIRO Belmont Fibres Research group in new lab facilities in the Geelong Technology Precinct (GTP), a new Fibre Processing Facility and the establishment of the Australian Carbon Fibre Research Facility (ACFRF).

Fibre research is core to ITRI through the Centre for Materials and Fibre Innovation (CMFI); AFFRIC will support both the existing research in natural, nano and functional fibres as well as developing carbon fibre and composite research.

CHAIRPERSON'S REPORT

The ACFRF will house a $10M pilot commercial scale carbon fibre research line funded by the Victorian Government, the only one of its type in the world, and will play a crucial role in helping develop new manufacturing opportunities in Victoria. We anticipate that ACFRF will have an important role in stimulating access to the carbon fibre supply chain for the Geelong region, for the state of Victoria and for Australia generally.

Throughout 2011, we also took the opportunity to review ITRI and its structure. Late in the year the Executive and the ITRI Board agreed on a new structure that would take effect on 31 December 2011. The Centre for Intelligent Systems Research, led by Professor Saeid Nahavandi, would leave ITRI to become one of Deakin University's Strategic Research Centres.

Likewise, the Centre for Biotechnology and Interdisciplinary Sciences (Biodeakin) will also leave from ITRI as an independent Strategic Research Centre. CMFI itself would undergo a metamorphosis, becoming the Institute for Frontier Materials (IFM) and focus more on advanced materials like lightweight metals and new fibres.

So in 2011, I thank not just those people who have contributed to our success over the past 12 months, but those who have done so since ITRI's creation in 2008.

Professors Hodgson, Wang and Nahavandi have overseen exceptional growth and high achievement. They have attracted an incredible population of talented researchers, postdoctoral fellows and PhD students over a very short time.

Many of these people will become the core of IFM as we move into the next era for the Institute. As ITRI transitions its respective research entities, it passes on a legacy of which we can all be proud.

2012 will be a year of great opportunity for all research and engagement and I look forward to the new discoveries, collaborations, connections and aspirations that will undoubtedly emerge.

Professor Lee Astheimer
Deputy Vice-Chancellor (Research) and Chairperson, ITRI Board

Below:
The formal launch of the Centre for Automotive Steel Research and Innovation (CASRI), March 2011.

Professor Peter Hodgson, Director ITRI and Professor Lee Astheimer, Deputy Vice Chancellor (Research) with Mr Liangchuan Fu, Chief Engineer WISCO and Mr Yanghu Jiang, Executive Director, R&D Centre WISCO.

DIRECTOR'S REPORT

2011 proved to be a year of recognition of research excellence for both ITRI staff members and students.

Professor Maria Forsyth joined seventeen of Australia's world-class researchers to be named a 2011 Australian Laureate Fellow by Senator the hon Kim Carr, former Minister for Innovation, Industry, Science and Research.

The Australian Laureate Fellowships scheme is awarded by the Australian Research Council and supports outstanding research leaders in solving the world's biggest problems and passing on their skills to the next generation of researchers.

As Chair in Electromaterials and Corrosion Sciences and Associate Director of the ARC Centre of Excellence for Electromaterials Science, Professor Forsyth leads a research team looking at solutions to storing power generated from renewable energy sources. We are indeed fortunate to have such a high calibre researcher as Professor Forsyth, driving forward our strategic research program.

ITRI's leading researchers have also been recognised internationally. Professor Xungai Wang and Professor Ying Chen have won one of China's most prestigious honours – being named in the "One Thousand Talents Program". This will further strengthen the collaboration with partners Wuhan Textile University and Central Iron and Steel Research Institute in Beijing.

I have also been honoured as a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE).

In April, Professor Lingxue Kong along with Dr Bernard Rolfe from the School of Engineering was a member of a group of eight "outstanding mid-career researchers" visiting China as participants in the 2011 Australia China Young Scientists Exchange Program. The program is described as targeting "mid-career researchers who have shown both technical expertise and leadership potential in science and technology."

DIRECTOR'S REPORT

It is of note that in late 2010, Professor Lingxue Kong was awarded a prestigious Endeavour Executive Award to study environmental remediation in China. One of the aims of this award is to establish enduring ties between Australia and its neighbours. Professor Kong has collaborated with scientists from two leading Chinese institutions – The Chinese Academy of Sciences and The Chinese Academy of Tropical Agricultural Sciences.

Recognition has also been forthcoming for our Early Career Researchers. In October 2011, Dr Mandy de Souza was awarded a Victoria Fellowship in recognition of her international reputation in the field of automotive composite materials. Dr de Souza accepted her award at a ball at the Governor's residence in Melbourne on November 15th.

In October 2011, Nisa Salim was the recipient of the Early Career Researcher category for the Smart Geelong Network Researcher of the Year Award. Nisa's PhD research, conducted under the supervision of Professor Qipeng Guo investigates the development of new generation drug carriers that are effective for anticancer drug delivery.

Another PhD student in the same area, Nishar Hameed, received an Alfred Deakin Medal for the Best Doctoral Thesis in 2011. Research on bamboo fibres, undertaken by PhD student Ms Tarannum Afrin, was featured in ABC TV Catalysts, ABC Radio Tasmania, Radio 702 Sydney, The Age, Herald Sun and Geelong Advertiser newspapers.

In the mid-year finals of the Deakin University three minute thesis competition, PhD student Olga Kartachova was voted the People's Choice for her concise explanation of her research work into the development of supercapacitor materials that can be used in energy storage devices.

2011 was also a year where we continued to both consolidate and expand our international partnerships. The collaboration with Chinese research institutions was enhanced by the formal establishment of a joint Deakin – Wuhan Iron and Steel Group Corporation (WISCO) Centre for Automotive Steel Research and Innovation (CASRI).

Moreover, our links with the Chinese Academy of Tropical Agricultural Sciences (CATAS) and Heifei University of Technology (HFUT) were further strengthened at our annual forum.

Below:
Ankita Bedi presenting her poster to Professor Peter Hodgson at the DIRI/TERI Symposium, November 2011.

DIRECTOR'S REPORT

The Energy and Resources Institute (TERI) in New Dehli, India was formally opened in August 2011 by Minister for Tertiary Education and Skills, Senator The Hon. Chris Evans along with Vice-Chancellor, Professor Jane den Hollander and Dr Pachauri, Director General TERI. I look forward to continued growth in both the number of researchers and PhD students at the Institute and their combined quality research output.

In summary, ITRI has welcomed large groups of internationally renowned scientists to visit and conduct collaborative research with our research fellows and HDR students in 2011. Our reputation for quality research facilities and outputs has grown world-wide. Pursuing a research career at ITRI is now an attractive proposition for talented young engineers and scientists.

Finally, this will be the last ITRI Annual Report. In a review of ITRI commissioned by the DVC (Research) and conducted by an external consultant, restructuring of the Institute was recommended.

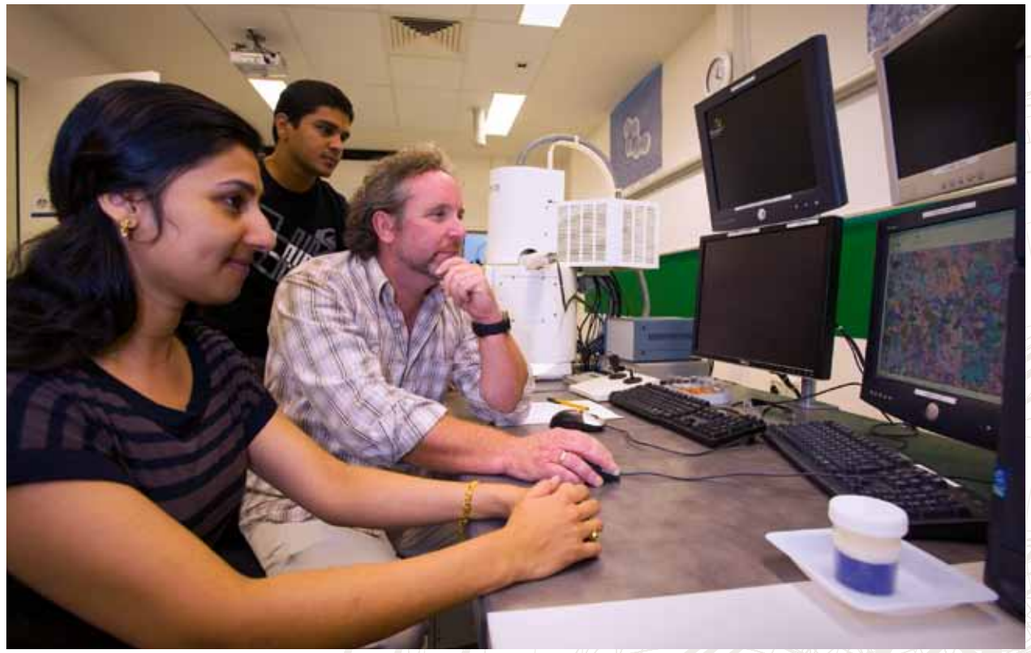
From January 1 2012, three separate research entities will operate:

- The Institute for Frontier Materials (IFM) under the directorship of myself (Professor Peter D Hodgson). IFM will replace the Centre for Material and Fibre and Innovation (CMFI). Professor Xungai Wang will be the Deputy Director, IFM and in addition, the Director of the Australian Future Fibres Research and Innovation Centre (AFFRIC).
- The Centre for Intelligent Systems (CISR), now an independent Strategic Research Centre under the directorship of Professor Saeid Nahavandi.
- The Centre for Biotechnology and Interdisciplinary Sciences (Biodeakin) - a Strategic Research Centre under the directorship of Professor Colin Barrow.

I would like to pay tribute to all staff and students who have contributed to the success of ITRI since its inception in 2008. In particular I would like to thank Professor Xungai Wang, Professor Saeid Nahavandi and Professor Colin Barrow, without whom our vision would not have been realised.

Professor Peter D Hodgson
Director of ITRI

Below:
Professor Peter Hodgson working with PhD student Nisa Salim and Dr Nishar Hameed.



INSTITUTE FOR TECHNOLOGY RESEARCH AND INNOVATION (ITRI) BOARD MEMBERS

PROFESSOR JANE DEN HOLLANDER
Vice-Chancellor

PROFESSOR ANDREW SINCLAIR
Vice-Chancellor's Nominee

PROFESSOR LEE ASTHEIMER
Deputy Vice-Chancellor (Research) and Chairperson

PROFESSOR JOHN CATFORD
Pro Vice-Chancellor of the Faculty of Health or Nominee

PROFESSOR CHRIS GRAY
Pro Vice-Chancellor of the Faculty of Science and Technology or Nominee

PROFESSOR PETER D HODGSON
Director of the Institute for Technology Research and Innovation

DR ANITA HILL
Independent Director (external to Deakin University) appointed by the Vice-Chancellor

DR NEVILLE ROACH
Independent Director (external to Deakin University) appointed by the Vice-Chancellor

PROFESSOR GEOFF STEVENS
Independent Director (external to Deakin University) appointed by the Vice-Chancellor

DR BREE GORMAN-HOLZ
Ex Officio member

MS CATE SIMANDL
Ex Officio member

MS VIRGINIE HOAREAU
Ex Officio member

MS KIM DURRANT
Secretariat

ITRI PEFORMANCE TARGETS

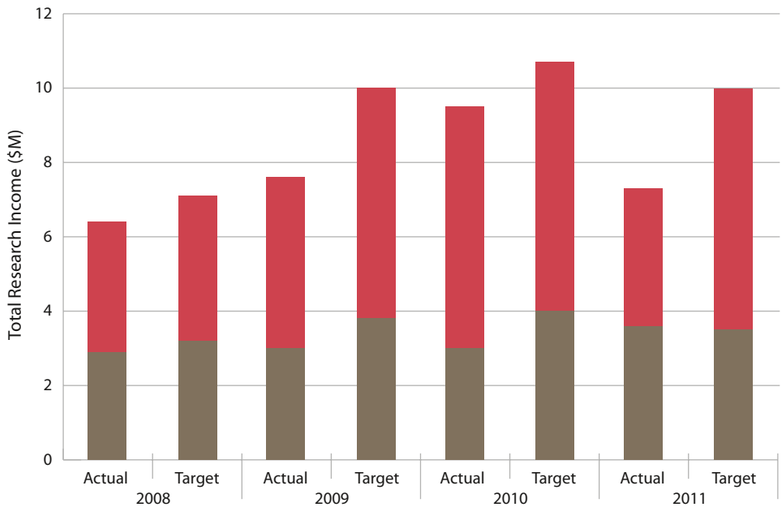
TOTAL RESEARCH INCOME BY CATEGORY ($M)

CATEGORY	2008		2009		2010		2011	
	ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET
ACG	2.9	3.2	3.0	3.8	3.0	4.0	3.6	3.5
Other	3.5	3.9	4.6	6.2	6.5	6.7	3.7	6.5
Total $M	6.5	7.1	7.6	10.0	9.5	10.7	7.3	10.0

2011 results do not include $.5M infrastructure and excluded research income.

TOTAL RESEARCH INCOME BY CATEGORY ($M)

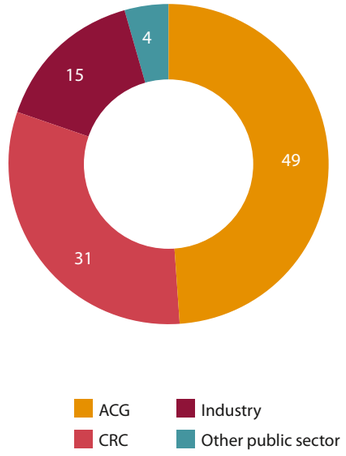
CATEGORY	ACG	CRC	Industry	Other Public Sector
ACG	3.6	2.3	1.13	0.31



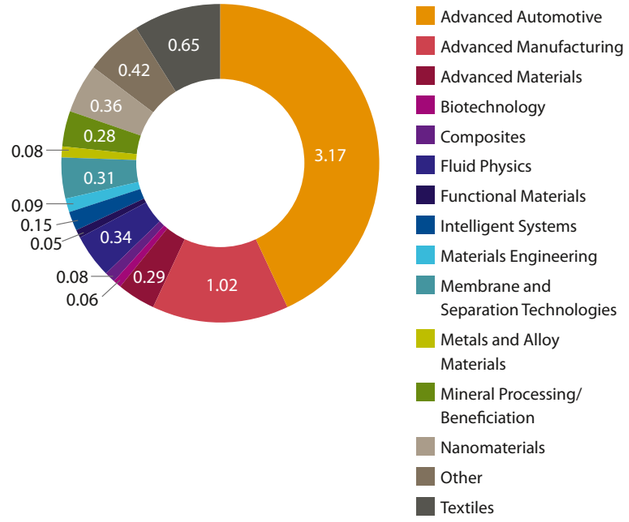
- ***ACG (Australian Competitive Research Grants – Category 1)*** gives the income obtained in national competitive grants, the term used to describe a group of some 70 research grant schemes to which all universities can apply and where awards are based on merit of the application and the research team. The ARC and NHMRC are two of the major funding bodies included in this list.
- ***Other public (Other Public Sector Research funding – Category 2)*** is government funding, Federal or State, from schemes not included in the ACG group and not necessarily determined through a competitive process; it includes contract research and research-related consultancies.
- ***Industry (Industry and Other Funding – Category 3)*** includes all research funding from industry, international sources, donations, bequests and foundations, and Higher Degree by Research fee income for domestic and international students.
- ***CRC (Category 4)*** is a university's research income from Cooperative Research Centres excluding their own contribution. Note: CRC income is based on financial year results.

ITRI PEFORMANCE TARGETS

2011 RESEARCH INCOME BY CATEGORY (%)



TOTAL RESEARCH INCOME BY FIELD OF RESEARCH – ACTUAL 2011 ($M)



HDR STUDENT - EFTSL 2008 - 2011

2008		2009		2010		2011	
ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET
49	49	96	100	117	118	138	118

PUBLICATIONS 2009 - 2011

2009		2010		2011	
ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET
120	88	171	100	293	123

2011 GRANT APPLICATIONS

GRANTS	APPLIED	SUCCESS	% SUCCESS	AMOUNT AWARDED*
Reportable - Category 1 Applications	37	12	32	$4,684,972
Reportable - Category 2-4 Applications	24	18	32	$1,015,691
Non-Reportable - Other	62	28	45	$2,764,305

*The amount awarded is over the total life of the project as initially communicated by the funding agency.

INTERNATIONAL COLLABORATIONS

2011 was a year where we continued to both consolidate and expand our international partnerships.

The collaboration with Chinese research institutions was enhanced by the formal establishment of a joint Deakin – Wuhan Iron and Steel Group Corporation (WISCO) Centre for Automotive Steel Research and Innovation (CASRI). The Deakin University hub of the joint centre was opened when the WISCO delegation led by Professor Lianchun Fu, Chief Engineer of WISCO visited Deakin University in March 2011. The Wuhan node was opened when Deakin Vice-Chancellor Professor Jane den Hollander visited Wuhan in August 2011.

The establishment of CASRI has facilitated the development of a number of innovative projects. Deakin University has formed a team with leading international corporations including WISCO, Australian Rollforming Manufacturers Pty Ltd, Blue Scope Steel Limited and data M Sheet Metal Solutions to study new flexible roll forming process of advanced high strength steel sheets. This research has been supported by an ARC Linkage project.

Deakin University and WISCO have also been developing strategies for the cold stamping of Advanced High Strength Steels (AHSS) and ITRI welcomed four research scientists from WISCO to work at the GTP for 6 months. In addition, WISCO and Deakin University held the inaugural joint Forum on Advanced High Strength Steels in May 2011 in Wuhan.

In 2011, ITRI held its annual forum with Chinese Academy of Tropical Agricultural Sciences (CATAS) and Hefei University of Technology (HFUT), demonstrating Deakin's commitment to the joint centres of Advanced Materials with CATAS and the Sino-Australia Initiative for Automotive Materials and Technologies (iAMT) with HFUT.

INTERNATIONAL COLLABORATIONS

ITRI continued to strengthen its partnerships within India in 2011.

The TERI Deakin Bio Nanotechnology Research Centre was formally inaugurated in August 2011 by Senator the Hon. Chris Evans, Minister for Tertiary Education and Skills, Professor Jane den Hollander, Vice-Chancellor Deakin University and Dr R. K Pachauri, Director General TERI.

This Centre brings together the expertise of Deakin University, TERI (The Energy and Resources Institute) and Biotechnology and Management of Bioresource Division's (BMBD) in the design and characterisation of novel nanomaterials in biotechnological applications such as pharmacology, food, agriculture and environmental areas. It is envisaged that within five years, the Centre will have approximately 70 research staff, including 50 PhD students enrolled at Deakin University and co-supervised by both Deakin University and TERI staff.

Currently there are 11 PhD students at the Centre. The Centre is unique and is the only facility that has been established in India to carry out leading edge Nano-bio research in Agriculture and Health.

Deakin India in association with TERI organised a three day symposium entitled 'DIRI Symposium 2011 – Frontiers in Science' from 21 to 23 November. The symposium brought together Deakin University's research partners across India to discuss ongoing research and strategies for future collaborations. The event was held at the TERI-Deakin Bio Nanotechnology Research Centre at Gual Pahari, Gurgaon. 35 research scholars and 25 supervisors from both India and Australia participated in the symposium.

During 2011, a number of MOUs were signed with both companies and institutions in India. Professor Peter D Hodgson visited Bharat Forge Ltd (BFL) and held discussions with senior management and engineers to explore the possibilities of collaboration between BFL and Deakin University. As the flagship company of the Kalyani Group, which has significant presence in the key sectors of the Indian economy, BFL is one of India's emerging multinationals.

Main Image:
Professor Lee Astheimer, Deputy Vice Chancellor (Research) with Mr Yanghu Jiang, Executive Director, R&D Centre WISCO.

Below:
Dr Rajan Mookken, General Manager at Indian Oil Corporation Limited in discussion with Associate Professor Jagat Kanwar during Dr Mookken's recent visit to ITRI.

INTERNATIONAL COLLABORATIONS

The company is the largest exporter of auto components from India and the leading chassis component manufacturer in the world. The MoU was signed in February 2012 with the aim of enrolling the students within the following six months and it was agreed that two PhD students who are BFL employees would enrol into the DIRI program.

A similar partnership exists with Indian Oil Corporation Ltd and four DIRI PhD students are based with the company. Indian Oil is the 18th largest petroleum company in the world and the number one petroleum trading company among the national oil companies in the Asia-Pacific region. In addition, the company has entered into an agreement with the Indian Government's Department of Biotechnology and has established the DBT – IOC Centre for Advanced Research on Bio-Energy. This Centre is based at Indian Oil's R&D hub near New Delhi. This new Centre will initially host PhD scholars plus senior investigators and researchers from both India and abroad.

Joint research programs in the areas of materials, automotive, product design, IT, microbiology and cell biology have been identified for collaborations between the Indian Institute of Science (IISC) and Deakin University. The IISC is one of the most prestigious institutes of science in India and offers a variety of postgraduate programs in both science and engineering.

A similar collaborative agreement is in place with B S Abdur Rahman University, the largest Indian engineering institution based in the south of the country and also the Indian Institute of Chemical Technology (IICT), a national-level research laboratory located in Hyderabad.

Collaborative research continues to strengthen with the Department of Metallurgical and Materials Engineering, Indian Institute of Technology (IIT), Madras regarding research projects and internships. Discussions are also underway regarding a joint IIT Madras/Deakin University Grand Challenge bid for 2012. Professor Peter D Hodgson is also working closely with IIT Bombay, another important Deakin University partner.

Below:
DIRI and TERI students at the November 2011 Symposium held at the TERI Habitat Centre, Delhi, India.

CENTRE FOR

MATERIAL AND FIBRE INNOVATION

Director's Report

2011 will mark the last year for CMFI as a research centre at Deakin University. The significant growth of CMFI will necessitate its transition from a Centre to an Institute in 2012. The Institute will be known as the Institute for Frontier Materials (IFM). The new Australian Future Fibres Research and Innovation Centre (AFFRIC) will sit within IFM.

As in the previous year, CMFI had a record number of successes in 2011, the most notable of which are highlighted below:

EXCELLENCE IN RESEARCH FOR AUSTRALIA (ERA) RANKING

In the inaugural national assessment on research excellence in Australian universities, our research in both materials engineering and manufacturing engineering achieved the highest national ranking of 5 (well above world standard) and 4 (above world standard), respectively. Deakin was the only university in Australia to achieve the highest national ranking in both fields.

AWARDS AND RECOGNITIONS

Dr Mandy de Souza was awarded a highly prestigious Victoria Fellowship. She was one of just six researchers to receive the award in 2011.

Professors Ian Chen and Xungai Wang were both awarded a prestigious One Thousand Talents fellowship by the Chinese Government.

Ms Nisa Salim, a PhD student in the polymers area, received a Smart Geelong Researcher of the Year Award in the Early Researcher category. Another PhD student in the same area, Nishar Hameed, received an Alfred Deakin Medal for the Best Doctoral Thesis in 2011. Research on bamboo fibres, undertaken by PhD student Ms Tarannum Afrin, was featured in ABC TV Catalysts, ABC Radio Tasmania, Radio 702 Sydney, The Age, Herald Sun and Geelong Advertiser newspapers.

CENTRE FOR MATERIAL AND FIBRE INNOVATION

ARC GRANTS SUCCESSES

In 2011, our researchers were awarded a number of ARC grants under the Discovery, Linkage and LIEF schemes, as listed below:

- Understanding the composite structures and properties of wild silk cocoons, Professor Xungai Wang, Dr Rangam Rajkhowa, Dr Jingliang Li (ARC Discovery project, in collaboration with Professor Xiangyang Liu at the National University of Singapore).
- Toughening thermosets by highly ordered nanostructures, Professor Yiu-Wing Mai, Professor Qipeng Guo (ARC Discovery project, in collaboration with the University of Sydney).
- Future electrochemical energy storage technologies, Professor Maria Forsyth (ARC Discovery project).
- Engineering a silk fibroin based ear drum with optimum acoustic properties, Professor Xungai Wang, Dr Rangam Rajkhowa, Dr Robert J Marano, Professor Marcus D Atlas (ARC Linkage project, in collaboration with Ear Science Institute Australia Incorporated).
- Flexible roll forming of advanced high strength steel sheet, Professor Peter D Hodgson, Professor Matthew Barnett, Dr Bernard Rolfe, Dr Chunhui Yang ARC Linkage project, in collaboration with Australian Rollforming Manufacturers Pty Ltd, Blue Scope Steel Limited, Research and Development Centre of Wuhan Iron & Steel (Group) Corporation, and data M Sheet Metal Solutions).
- Developing an environmentally friendly, low cost solution to reduce wear and improve productivity in metal forming, Dr Bernard Rolfe, Professor Peter D Hodgson, Professor Maria Forsyth, Associate Professor Yong Xiang, Dr Matthew Doolan, Dr Michael Pereira (ARC Linkage project, in collaboration with Ford Motor Company of Australia Ltd).
- Infrared and Raman microspectroscopic equipment for biomolecular and nanostructural analysis, Professor Colin J Barrow, Professor Donald McNaughton, Professor Raymond A Cas, Professor Ying I Chen, Dr Luke C Henderson, Associate Professor Bronwyn L Fox, Dr Bayden R Wood, Dr Jitraporn Vongsvivut (ARC LIEF grant, in collaboration with Monash University).
- Investigating materials on the atomic scale using 3-dimensional atom probe tomography, Dr Nicole Stanford, Professor Peter D Hodgson, Professor Cuie Wen, Professor John H Beynon, Professor Ying I Chen, Professor Elena Pereloma, Professor Geoffrey A Brooks, Dr Hossein Beladi, Professor Nicolas H Voelcker, Associate Professor Christopher R Hutchinson, Dr Ilana Timokhina, Professor Rian J Dippenaar, Associate Professor Paul J Pigram, Professor Christopher H Davies, Professor Jian-Feng Nie, Associate Professor Andrzej Calka (ARC LIEF grant, in collaboration with La Trobe University, Monash University, Swinburne University of Technology, The Flinders University of South Australia, University of Wollongong).
- An aberration corrected analytical Transmission Electron Microscope for nanoscalecharacterisation of materials, Professor Elena Pereloma, Professor Shi Xue Dou, Professor Peter D Hodgson, Professor Gordon G Wallace, Dr David Wexler, Professor Graeme E Murch, Dr Zhixin Chen, Dr Ilana Timokhina, Dr Hossein Beladi, Dr Nicole Stanford, Dr Pavel Cizek, Dr Dhriti Bhattacharyya, Professor Irina V Belova, Dr Frank J Barbaro (ARC LIEF grant, in collaboration with University of Wollongong, ANSTO, The University of Newcastle, Blue Scope Steel Limited, and Defence Materials Technology Centre).
- Advanced surface imaging and spectroscopy facility: Scanning auger nanoprobe, Associate Professor Paul J Pigram, Professor Andrew G Peele, Dr Christopher I Pakes, Dr Grant A Van Riessen, Professor Maria Forsyth, Professor Matthew R Barnett, Dr Patrick C Howlett, Professor Cuie Wen, (ARC LIEF grant, in collaboration with La Trobe University, CSIRO and Swinburne University of Technology).
- Macromolecular characterisation and purification facility, Professor Greg G Qiao, Professor Qipeng Guo, Professor George P Simon, Professor Xungai Wang, Associate Professor Sandra E Kentish, Associate Professor Tong Lin, Professor Wayne D Cook, Associate Professor George V Franks, Dr Anton Blencowe, Dr Paul A Gurr, Dr Yan Zhao, Dr Nishar Hameed (ARC LIEF grant, in collaboration with the University of Melbourne and Monash University).

CENTRE FOR MATERIAL AND FIBRE INNOVATION

DEAKIN INTERNAL GRANTS SUCCESSES

The Central Research Grants scheme is a highly competitive internal grant scheme, designed to support early to mid career researchers at Deakin University. Researchers who are successful with these internal grants often progress to being awarded national competitive grants. The following projects were successful in 2011:

- Roll forming automotive structures from ultrafine-grained aluminium (Dr Matthias Weiss).
- Printable solar cells on cellulose nanofibre paper (Associate Professor Takuya Tsuzuki).
- Optimising Electrocatalytic Activity on $PrMnxCoyFe1-x-yO_3$- for Electrochemical Applications below 200˚C (Dr Jaka Barry Sunarso).
- Moisture-Sensitive Colour-Changing Fabrics Using Organic/Inorganic-Hybrid Dyes (Dr Yan Zhao).
- Organic Ionic Plastic Crystal composite electrolytes incorporating functional polymer nanofibre supports (Dr Patrick Howlett).
- Synthesis ternary metal nitrides with novel nanostructures and tunable properties (Dr Wei Wei Lei).
- Development of novel separation membranes with tailorable ion channels using cyclic peptides (Dr Nolene Byrne).
- Patternable, Electrically Conductive, Superhydrophobic/Superolephobic Coating for Fibrous Materials (Dr Hong Wang).
- Design and production macroscopically strong nanoporous metal films (Dr Jianyu Xiong).
- Nanotoughening of renewable polymers via a green process (Mr Nishar Hameed).
- Piezoelectricity of Boron Nitride Nanotubes (Dr Luhua Li).
- Thin film microelectrodes for electrochemical supercapacitors (Dr Alexey Glushenkov).
- Intelligent Decision Support for Renewable Energy Systems (Dr Abbas Khosravi).

The Alfred Deakin postdoctoral fellowship scheme also attracted four excellent researchers to join CMFI research teams. The fellowships were awarded to: Dr Jun Liu, Dr Abdullah Kafi, Dr Nam Nguyen Dang, Dr Li He and Dr Ming-hui Cai.

The following pages provide more details on our research achievements in the key research program areas under CMFI. Since its inception in 2006, CMFI has stayed at the forefront of both national and international material and fibre research. With the establishment of the new Institute of Frontier Materials (IFM) and the Australian Future Fibres Research and Innovation Centre (AFFRIC) at Deakin University in 2012, our material and fibre research is entering an exciting new phase.

Professor Xungai Wang
Director

Professor Matthew Barnett
Deputy Director

Below left:
Miniature knitting machine for the manufacture of small diameter synthetic vascular grafts.

Below:
Example of material treated to give superhydrophobic properties.

CARBON FIBRE AND COMPOSITES

The carbon fibre and composites research group is part of the $28 million Australian Carbon Fibre Research Facility (ACFRF), which is supported through the Victorian Government's Science Agenda Strategic Project Fund.

The ACFRF focuses on the development of new products, processes and technologies for the manufacture of carbon fibres, textile preforms and composites.

This includes materials characterisation, applied analysis of process-property relationships and research on innovative manufacturing concepts along with the optimisation for affordability, product performance and quality expected by industry. The group has expertise in understanding the process science involved in carbon fibre and composite manufacture, including modelling and simulation to predict and improve the performance of the materials.

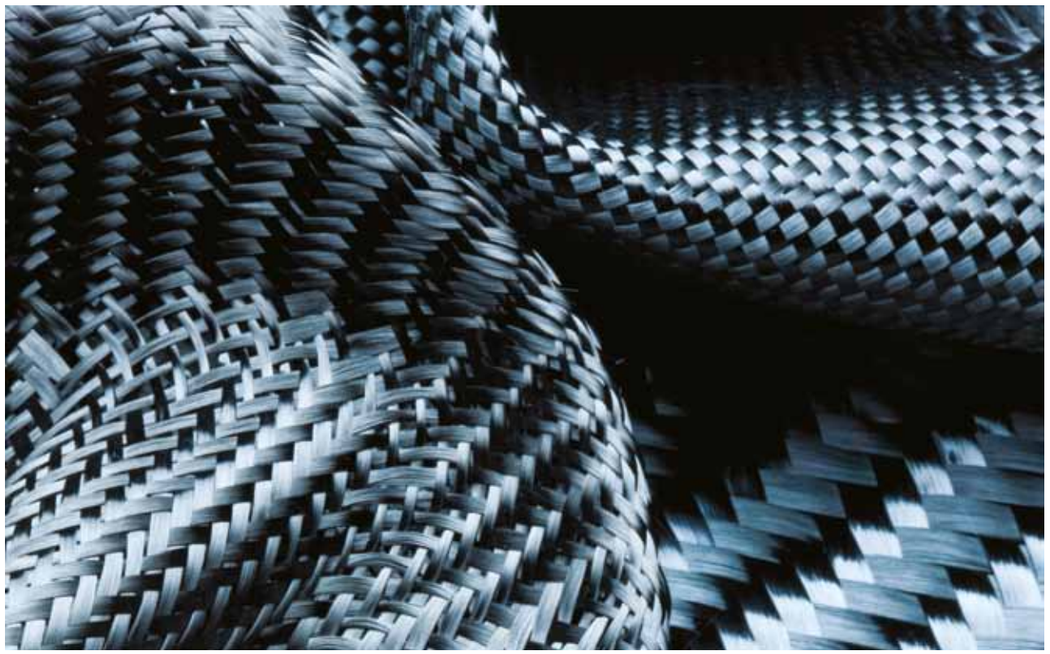
The ACFRF will incorporate a pilot scale research plant capable of producing industry relevant quantities of aerospace grade carbon fibre and facilitate research into the chemical, mechanical and nano-scale characteristics of the carbon fibre product.

Research in this field focuses on the effect of process variables on the structure and properties of fibres, the improvement of materials performance as well as reduction in cost, production cycle times and environmental impact.

KEY RESEARCH AREAS INCLUDE:

- Out-of-autoclave composite manufacture
- Surface treatment of carbon fibres for enhanced fibre matrix adhesion
- Structure property relationships in carbon fibres
- Infusion of carbon fibre preforms
- Nanocomposites and composites toughened with nanofibres
- Functionally graded materials
- Self-healing of composites

Below:
Carbon fibre weave.



CARBON FIBRE AND COMPOSITES

CARBON FIBRE FUTURE DIRECTIONS CONFERENCE

In February 2011 with the support of the Victorian Government, Deakin University and the Victorian Centre for Advanced Materials Manufacturing (VCAMM) jointly organised "Carbon Fibre - Future Directions", an international conference designed to position Australia as a key player in the carbon fibre composite materials field in the future. International experts shared their knowledge with Australian companies and researchers and helped to devise a path for Australia to become integral to this high technology field. The fully subscribed event held in Geelong attracted both industry experts from high profile aerospace manufacturers and materials producers as well as researchers who have had extensive involvement with the development and application of carbon fibre materials.

Invited speakers at the Carbon Fibre Future Directions conference included:

- Steve Christensen
  - Technical Fellow, Boeing, USA
- Wen-Fang Hwang, Spirit Aerosystems, USA
- Peter Wu, Spirit Aerosystems, USA
- Slade Gardener, Lockheed Martin
- Chris Wilkinson, The Manufacturing Institute, UK
- Dan Pichler, AKSA, Turkey
- Robert Norris, Oak Ridge National Laboratory, USA
- Jeff Wiggins, University of Southern Mississippi, USA
- Professor Andrew Walker, University of Manchester, UK
- Professor Frank Jones, University of Sheffield, UK

VICTORIA FELLOWSHIP SUCCESS FOR DEAKIN

Dr Mandy de Souza was awarded a highly prestigious Victoria Fellowship. Dr de Souza, who works at the Institute for Technology Research and Innovation (ITRI) on the Waurn Ponds campus, was one of just six researchers to receive the award in 2011.

Victoria Fellowships are awarded to emerging leaders in science, technology and engineering. Each Fellow receives a travel grant of up to $18,000 to undertake a short-term overseas study mission to assist in developing a commercial idea, undergo specialist training or career development. This is the first time that this highly prestigious fellowship has been awarded to someone from Deakin University.

Dr de Souza's research interests include the surface finish of painted carbon fibre composites for the automotive industry, out-of-autoclave processing of carbon fibre composites, automotive composites for Class A surfaces and the aging of painted carbon fibre composites.

She has previously held a Research Fellow position working on an Advanced Manufacturing CRC project investigating the manufacture of a complex composite component with a Class A surface finish using out-of-autoclave technologies. The project involved working with two industry participants: the Victorian Centre for Advanced Materials Manufacturing (VCAMM) and Bellmont Nominees.

KEY PAPERS FOR 2011

The following papers are highlights from those published in 2011.

Nuhiji, Betime, Attard, Darren*, Thorogood, Gordon*, Hanley, Tracey*, Magniez, Kevin and Fox, Bronwyn (2011) The effect of alternate heating rates during cure on the structure-property relationships of epoxy/MMT clay nanocomposites, Composites science and technology, vol. 71, no. 15, pp. 1761-1768, Elsevier, Amsterdam, The Netherlands [C1]

Gilbert, Michael J.*, Awaja, Firas, Kelly, Georgina L., Fox, Bronwyn L., Brynolf, Russell* and Pigram, Paul J.* (2011) Tailoring the surface chemistry of carbon fibre and E-glass composites for improved adhesion, Surface and interface analysis, vol. 43, no. 5, pp. 856-864, John Wiley & Sons Ltd, Oxford, England [C1]

Herring, M. L. and Fox, B. L. (2011) The effect of a rapid curing process on the surface finish of a carbon fibre epoxy composite, Composites part b : engineering, vol. 42, no. 5, pp. 1035-1043, Pergamon, Oxford, U. K. [C1]

Kafi, Abdullah A., Magniez, Kevin and Fox, Bronwyn L. (2011) Effect of manufacturing process on the flexural, fracture toughness, and thermo-mechanical properties of bio-composites, Composites part a : applied science and manufacturing, vol. 42, no. 8, pp. 993-999, Pergamon, Oxford, U. K. [C1]

Magniez, Kevin, Chaffraix, Thomas and Fox, Bronwyn (2011) Toughening of a carbon-fibre composite using electrospun poly(Hydroxyether of Bisphenol A) nanofibrous membranes through inverse phase separation and inter-domain etherification, Materials, vol. 4, no. 11, pp. 1967-1984, M D P I AG, Basel, Switzerland [C1]

Magniez, Kevin, Fox, Bronwyn Louise and Lonney, Mark Graham* (2011) Effect of drawing on the molecular orientation, polymorphism, and properties of melt-spun nanocomposite fibres based on nylon 6 with polyhedral oligomeric silsesquioxane, montmorillonite, and their combination, Polymer composites, vol. 32, no. 4, pp. 604-614, John Wiley & Sons, Hoboken, N. J. [C1]

Kafi, Abdullah A., Magniez, Kevin and Fox, Bronwyn L. (2011) A surface-property relationship of atmospheric plasma treated jute composites, Composites science and technology, vol. 71, no. 15, pp. 1692-1698, Pergamon, Oxford, United Kingdom [C1.1]

FORMING AND COMPUTER MODELLING

The CMFI Forming/Modelling group supports much of the research that is happening across the CMFI (composites, metals, and nano-technology).

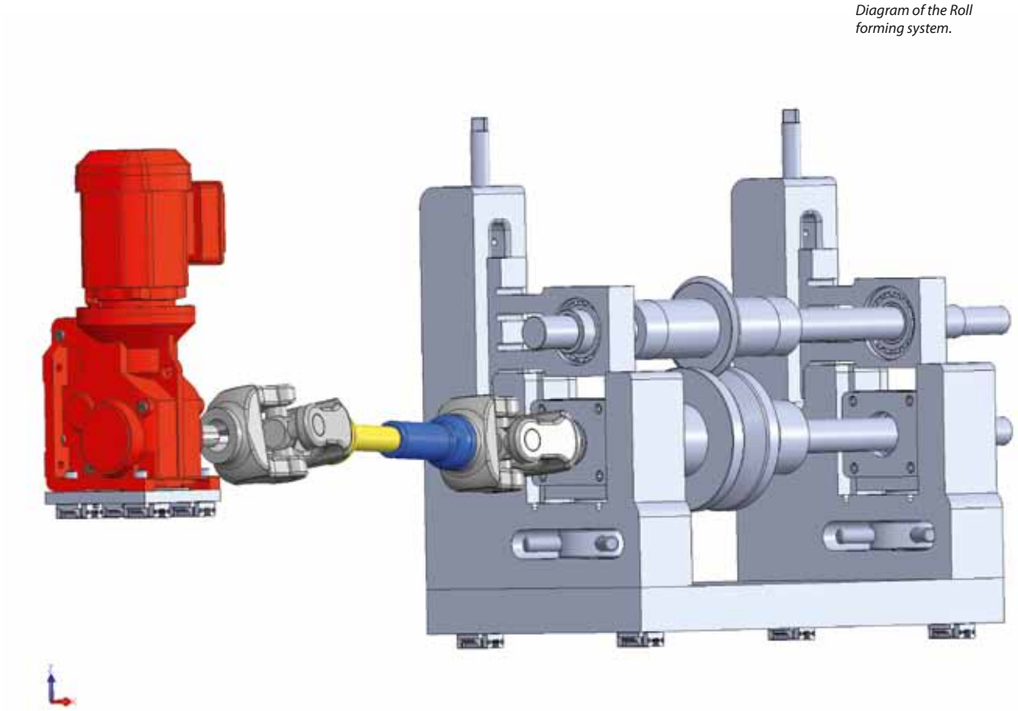
The group (led by Dr Bernard Rolfe) has three main themes: Roll Forming, Stamping and Tool Wear, and Lightweight Design. The group makes use of experiments and computational modelling algorithms (such as Molecular Dynamics, Finite Element Analysis, and Crystal Plasticity) to solve both fundamental and applied forming and material-based problems.

The group is involved in ARC Discovery and Linkage projects, two AutoCRC projects and also leads many of ITRI's product development projects.

THE KEY RESEARCH THEMES INCLUDE:

- Roll Forming
- Stamping
- Tool wear/Tribology
- Lightweight Structures
- Multi-scale modelling of metals
- Chemical Molecular Modelling of Nano-Materials
- Modelling Deformation Behaviour of Magnesium
- Bio-Mechanics Modelling
- Novel Product Development

Below:
Diagram of the Roll forming system.



FORMING AND COMPUTER MODELLING

HIGHLIGHTS FROM 2011 FOR THE CMFI MODELLING GROUP INCLUDE:

THE LIGHTWEIGHT MODULAR VEHICLE PLATFORM (LMVP) CONCEPT

The LMVP project is a visionary project of the AutoCRC, and consists of 5 research institutions with an overall budget of $2M. Dr Tim de Souza is driving the design, which aims to tackle the problem of mass reduction by beginning at the vehicle level rather than at component or subsystem level.

In contrast to traditional OEM vehicle programs there are few imposed design constraints (carry over components, existing manufacturing process infrastructure etc.). The design space is open to the innovative application of emerging materials, new manufacturing and joining processes, and alternative design philosophies. Design, material and manufacturing process decisions will be based on holistic life cycle and sustainability assessments, in order to significantly reduce the impact of climate change.

The LMVP body structure concept (finalised at the end of 2011) comprises of four distinct, functionally decomposed modules. Initial structural analysis of the lower body structure shows promising results with torsional and bending stiffness on par with current class leaders. The current weight estimate is 148kg and it meets 75% of the aggressive stiffness targets.

ROLL FORMING

Roll forming is a fast growing group within the CMFI, led by Dr Matthias Weiss. Roll forming is a traditional incremental bending process that is commonly used to manufacture building products (such as gutters).

Due to its incremental nature, roll forming is a process that is suited to materials that are strong but not necessarily ductile. The continuing light weighting trend towards lighter and stronger materials has shifted research focus from readily formable materials with low strength to the development of material types with extreme and tailored properties generally at the expense of formability.

The group has six PhD students, two research fellows and two academic staff. The group was successful in being awarded an ARC Linkage grant with industry partners Wuhan Iron and Steel (Group) Corporation (WISCO), data M Software GmbH, Australian Rollforming Manufacturers and BlueScope to investigate flexible roll forming.

LONG TERM STAMPING EXCELLENCE

STAMP is a research collaboration between Deakin University, ANU and Ford Australia to develop excellence in research of the stamping process. It was started 15 years ago in 1997. STAMP has investigated topics such as: Springback, Die wear, Advanced High Strength Steels, and Computational Modelling of stamping. This group had their funding renewed through an ARC Linkage grant with Ford Australia as the industry partner. The project will investigate novel lubricants with Professor Maria Forsyth's ionic liquids group, as well as developing new methods to monitor the stamping process. In addition, Dr Michael Pereira has been working on some cutting-edge thermo-mechanical simulations of stamping.

WUHAN IRON AND STEEL CORPORATION (WISCO) – MULTI-SCALE MODELLING OF STEEL

In 2011 Deakin University and WISCO signed a historic collaborative agreement. Four WISCO research staff joined ITRI for six months at the start of this collaboration. Two of the group were from the modelling section of WISCO R&D. A joint project between Deakin University (led by Dr Alireza Asgari) and WISCO has been initiated to develop a platform for multi-scale steel research.

Below:
Lightweight Modular Vehicle Platform conceptual design.

FIBRES AND TEXTILES

This area covers a range of fibres and fibrous materials, with a strong focus on multidisciplinary research.

THE KEY RESEARCH AREAS ARE:

- Nanofibres and spinning
- Green natural fibres and powders
- Functional fibrous materials
- Emerging materials having potential applications for fibres or textiles

This research group and the composites research group have now combined to form the Australian Future Fibres Research and Innovation Centre (AFFRIC), in collaboration with CSIRO Materials Science and Engineering, and the Victorian Centre for Advanced Materials Manufacturing (VCAMM).

RESEARCH GRANTS

ARC Grants

In 2011, the fibre and textile team were awarded one ARC Discovery grant and one ARC Linkage grant.

1. Understanding the composite structures and properties of wild silk cocoons, Professor Xungai Wang, Dr Rangam Rajkhowa, Dr Jingliang Li, Professor Xiangyang Liu (National University of Singapore), ARC Discovery Grant (2012-2014).
2. Engineering a silk fibroin based ear drum with optimum acoustic properties, Professor Xungai Wang, Dr Rangam Rajkhowa, Dr Robert Marano and Professor Marcus Atlas (Ear Science Institute of Australia, University of Western Australia), ARC Linkage Grant (2011-2014).

Below:
PhD student Charanpreet Singh operating a multiple feed knit braider machine for manufacturing biomedical prostheses.

FIBRES AND TEXTILES

DMTC Grants

Two projects have been approved by Defence Materials Technology Centre in 2011.

1. Power Generation and Managements (with nanofibres), Dr Jian Fang, Associate Professor Tong Lin, Professor Xungai Wang (in collaboration with the electromaterials group led by Professor Maria Forsyth).
2. Directional Water Transport Fabrics, Associate Professor Tong Lin.

In addition, research funding was also received from the Sheep CRC and Rural Industries R&D Corporation (RIRDC), to support our research into wool and rare animal fibres.

In collaboration with CSIRO MSE and Hong Kong Polytechnic University, the group also received project funding from the Cotton Research and Development Corporation (CRDC), to work on new processing technologies for Australian cotton.

INTERNAL GRANTS

Three Deakin Central Research Grants (CRGs) were awarded in 2011, as listed below:

1. Associate Professor Takuya Tsuzuki, Eco-friendly carbon nanofibre production from green nanomaterials.
2. Dr Hongxia Wang, Patternable Electrically Conductive, Superhydrophobic/ Superolephobic Coating for Fibrous Materials.
3. Dr Yan Zhao, Moisture-Sensitive Colour-Changing Fabrics Using Organic/Inorganic-Hybrid Dyes.

AWARDS AND INTERNATIONAL RECOGNITION

- Professor Xungai Wang was awarded a prestigious One Thousand Talents fellowship by the Chinese Government. Professor Wang's fellowship is hosted by Wuhan Textile University, which has long standing research collaboration with researchers at Deakin University.
- The project, "Production of carbon nanofibres from plant-based cellulose nanofibres", won the 2nd place in Nanovic award. The project was undertaken by a Masters student Mr Eshan Jazaeri, supervised by Associate Professor Takuya Tsuzuki.
- The project, "Eco-friendly production of bamboo fibres having antibacterial and UV-screening properties", was featured in ABC TV Catalysts, ABC Radio Tasmania, Radio 702 Sydney, The Age, Herald Sun and Geelong Advertiser newspapers. The project was undertaken by a PhD student, Ms Tarannum Afrin, supervised by Associate Professor Takuya Tsuzuki and Professor Xungai Wang.
- Dr Jian Fang's paper on nanofibre nonwoven power supply was chosen as a hot article on the journal's Blogs webpage (http://blogs.rsc.org/jm/2011/07/27/hot-article-electrical-power-generator-from-randomly-oriented-electrospun-polyvinylidene-fluoride-nanofibre-membranes/).
- Dr Hongxia Wang's paper on self-healing super water/oil resistant fabric coating was selected as a hot article of the journal (Angewandte Chemie International Edition).

Below:
Untreated wild silk cocoon.

FIBRES AND TEXTILES

PUBLICATIONS IN TOP MATERIALS AND FIBRE-RELATED JOURNALS

In 2011, the teams also published a record number of papers in high impact factor journals, as listed below.

Wang H, Xue Y, Feng L, Wang X, Lin T, Durable, self-healing superhydrophobic and superoleophobic surfaces from FD-POSS and hydrolysed FAS, Angewandte Chemie International Edition, 50, 11433-11436 (2011).

Wang J, Sutti A, Wang X, Lin T, Fast responsive and morphologically robust thermo-responsive hydrogel nanofibres from poly(N-isopropylacrylamide) and POSS crosslinker, Soft Matter, 2011, 7, 4364-4369 (2011).

Huang C, Tang Y, Liu X, Sutti A, Ke QF, Mo XM, Wang X, Morsi Y, Lin T, Electrospinning of Nanofibres with Parallel Line Surface Texture for Improvement of Nerve Cell Growth, Soft Matter, 7(22) 10812–10817 (2011).

Tang B, Tao J, Xu SP, Wang JF, Hurren C, Xu WQ, Sun L and Wang X, Using hydroxy carboxylate to synthesize gold nanoparticles in heating and photochemical reactions and their application in textile colouration. Chemical Engineering Journal, 172 (2011) 601-607.

Zhang J, Wang X, Lin T, Synergistic Effects of Polyetherketone Cardo (PEK-C)/Carbon Nanofibre Composite on Epoxy Resins, Composites Science and Technology, 71, 1060-1067 (2011).

Fang J, Wang XG, Lin T, Electrical power generator from randomly oriented electrospun poly(vinylidene fluoride) nanofibre membranes, Journal of Materials Chemistry, 21, 11088-11091 (2011).

Naebe M, Cookson P, Denning R, Wang XG, Use of low-level plasma for enhancing the shrink resistance of wool fabric treated with a silicone polymer, The Journal of the Textile Institute , Vol. 102, No. 11, 948-956 (2011).

LI JL, Liu XY, Wang XG, Wang RY, Controlling nanoparticle formation via sizable cages of supramolecular soft materials, Langmuir, 27, 7820-7827 (2011).

Xu WL, Xia ZG, Wang X, Chen J, Cui WG, Ye WX, Ding CL, Wang XG, Embeddable and locatable spinning, Textile Research Journal, 81(3) 223-229 (2011).

Niu HT, Zhang J, Xie ZL, Wang XG, Lin T, Preparation, structure and super capacitance of bonded carbon nanofiber electrode materials, CARBON, 4 9, 2380-2388 (2011).

Zhao Y, Yang WD, Xue YH, Wang XG, Lin T, Partial exfoliation of layered double hydroxides in DMSO: a route to transparent polymer nanocomposites, Journal of Materials Chemistry, 21 (13), 4869-4874 (2011).

Tang B, Wang JF, Xu SP, Afrin T, Xu WQ, Sun L, Wang XG Application of Anisotropic Silver Nanoparticles: Multifunctionalization of Wool Fabric Journal of Colloid & Interface Science 356 (12), 513-518 (2011).

Wang HM, Mahar T, Liu X, Swan P, Wang XG, Modelling of Diameter-scatter to Determine Diameter Corrections for Colour Measurement of Wool, The Journal of the Textile Institute, 102(12), 1031-1043 (2011).

Tang YW, Wong C, Wang HX, Sutti A, Kirkland M, Wang XG, Lin T, Three-dimensional tissue scaffolds from interbonded poly(e-Caprolactone) fibrous matrices with controlled porosity, Tissue Engineering Part C, 17(2), 209-218 (2011).

Rajkhowa, R.; Levin, B.; Redmond, S. L.; Wang, L.; Kanwar, J. R.; Atlas, M. D.; Wang, X., Structure and properties of biomedical films prepared from aqueous and acidic silk fibroin solutions, Journal of Biomedical Materials Research, part A, 97A(1), 37-45 (2011).

Li Q, Hurren CJ, Ding CL, Wang LJ, Lin T, and Wang XG, Ultrasonic scouring of wool and its effects on fibre breakage during carding, Journal of the Textile Institute, vol. 102, no. 12, pp. 1059-1064 (2011).

Rockwood, DN., Gil ES., Park, S., Kluge, JA., Grayson, W., Bhumiratna, S., Rajkhowa, R., Wang, XG., Kim, SJ., Vunjak-Novakovic, G., Kaplan, DL. , Ingrowth of Human Mesenchymal Stem Cells into Porous Silk Particle Reinforced Silk Composite Scaffolds: An In Vitro Study, Acta Biomateriala, 7, 144-151 (2011).

Deng ZM, Wang LJ and Wang XG, An integrated method of feature extraction and objective evaluation of fabric pilling, Journal of the Textile Institute, 102: 1, 1-13 (2011).

Li Q, Brady PR, Hurren CJ, Wang XG, Rapid fibre diameter measurements in aqueous solutions with OFDA2000, Journal of the Textile Institute, Vol. 102, No. 6, 500-504 2011).

Li Q, Hurren CJ, Wang LJ, Lin T, Yu HX, Ding CL and Wang XG, Frequency dependence of ultrasonic wool scouring, Journal of the Textile Institute, Vol. 102, No. 6, 505-513 (2011).

Afrin T, Tsuzuki T, Wang X. (2011) "UV absorption property of bamboo", Journal of the Textile Institute, DOI: 10.1080/00405000.2011.580543.

Afrin T, Kanwar RK, Wang X, Tsuzuki T. (2011) "The origin of the antibacterial property of bamboo" Journal of the Textile Institute. DOI: 10.1080/00405000.2011.614742.

H Wang, Y Xue, T Lin, One-step Vapour-Phase Formation of Patternable, Electrically Conductive, Superamphiphobic Coatings on Fibrous Materials, Soft Matters, 2011, 7, 8158-8161.

E Nuhiji, F Amar, H Wang, N Byrne, T Nguyen, P Mulvaney, T Lin, Whispering Gallery Mode Emission Generated in Tunable Quantum Dot Doped Glycerol/Water and Ionic Liquid/Water Microdroplets Formed on a Superhydrophobic Coating, Journal of Materials Chemistry, 2011, 21, 10823-10828.

PATENTS ISSUED IN 2011

T. Afrin, T. Tsuzuki, R. Kanwar, X. Wang, "Process for Preparing bamboo fibres", Australia Provisional patent AU2011902451, 23 June 2011

METALS AND LIGHT METALS

"Sustainable" metals of the future will be stronger, lighter, cleverer and fully recyclable. They will be produced using new techniques with small environmental footprints.

The Metals group aims to make this future a reality. To do this, we develop new metal alloys and grades, conceive new energy-efficient metal processing routes and extend the state of knowledge of metal behaviour.

RESEARCH AREAS INCLUDE:

- Strip casting simulation
- High strength steels
- Texture control
- Magnesium and titanium alloys
- Nano-bainite
- Twinning
- Bio-metals
- Architectured materials

Funding sources for 2011 included an Australian Laureate Fellowship, an ARC Future Fellowship, the ARC Centre for Excellence for Design in Light Metals, the CAST and Auto CRCs, WISCO steel, ARC Discovery and Linkage grants and the Alfred Deakin Post-Doctoral scheme.

FULL PATENT FOR NEW STEEL GRADES

Value added steel products such as stainless steel, copper containing steels and high Si steels present significant challenges to the traditional manufacturing plant and their cost is high.

We have recently developed a method for producing these grades using rapid solidification technology. This approach promises to pave the way for novel cost effective strip-cast steels for use in high value niche applications. This approach also has an attractively small environmental footprint, providing sheet a few millimetres thick directly from molten metal, without the need for a multi unit integrated steel plant. The new grades have been patented jointly with our commercial partners.

Below:
PhD students undergoing SEM instrument training.

METALS AND LIGHT METALS

EQUIPMENT ADDITION

The future's demand on new metal alloys with enhanced performance requires design at the atom level. In 2011 we were awarded an ARC LIEF grant for an atom probe microscope capable of producing three dimensional atomic reconstruction of fine test samples. Pulses of high voltage are employed to "boil" off atoms from the sample. These are then accelerated in a known manner towards a detector. Upon their arrival it is possible to reconstruct their path and determine their location in the sample with an exceptional degree of accuracy. With this equipment it will be possible to determine the clustering and segregation tendencies of atomic species, even in complex multi-component metallic systems.

INTERNATIONAL ENGAGEMENT

This year marked the formal establishment of the joint Deakin – Wuhan Iron and Steel Group Corporation, Centre for Automotive Steel Research and Innovation (CASRI). As part of this centre we hosted four visiting researchers for six months to work on the forming and development of high strength steels. Future researcher exchanges will focus on new steel grade development, modelling, sheet forming and coating defect investigations. This Centre marks a significant investment in the metals group and will support both fundamental and applied studies.

One of our senior researchers – Dr Beladi – spent five months with a top US characterization and modelling group at Carnegie Mellon University. Dr Beladi's work focussed on developing a three dimensional understanding of microstructure development in advanced steels.

EIGHT PAPERS IN PREMIER METALLURGICAL JOURNALS

Acta materialia is the premier metallurgical journal for physical metallurgy and in 2011 the metals team was pleased to have eight papers appear within its pages.

1. Alireza Ghaderi, Matthew R. Barnett, Sensitivity of deformation twinning to grain size in titanium and magnesium, Acta Materialia, Volume 59, Issue 20, December 2011, Pages 7824-7839
2. I.B. Timokhina, H. Beladi, X.Y. Xiong, Y. Adachi, P.D. Hodgson, Nanoscale microstructural characterization of a nanobainitic steel, Acta Materialia, Volume 59, Issue 14, August 2011, Pages 5511-5522
3. Shokoufeh Malekjani, Peter D. Hodgson, Pavel Cizek, Timothy B. Hilditch, Cyclic deformation response of ultrafine pure Al, Acta Materialia, Volume 59, Issue 13, August 2011, Pages 5358-5367
4. A.S. Taylor, P. Cizek, Peter D. Hodgson, Comparison of 304 stainless steel and Ni–30Fe as potential model alloys to study the behaviour of austenite during thermomechanical processing, Acta Materialia, Volume 59, Issue 14, August 2011, Pages 5832-5844
5. N. Stanford, K. Sotoudeh, P. S. Bate, Deformation mechanisms and plastic anisotropy in magnesium alloy AZ31, Acta Materialia, Volume 59, Issue 12, July 2011, Pages 4866-4874
6. Hossein Beladi, Ilana B. Timokhina, Subrata Mukherjee, Peter D. Hodgson, Ultrafine ferrite formation through isothermal static phase transformation, Acta Materialia, Volume 59, Issue 10, June 2011, Pages 4186-4196, ISSN 1359-6454
7. J.D. Robson, N. Stanford, M. R. Barnett, Effect of precipitate shape on slip and twinning in magnesium alloys, Acta Materialia, Volume 59, Issue 5, March 2011, Pages 1945-1956
8. Hossein Beladi, Pavel Cizek, Peter D. Hodgson, New insight into the mechanism of metadynamic softening in austenite, Acta Materialia, Volume 59, Issue 4, February 2011, Pages 1482-1492

ELECTROMATERIALS AND CORROSION SCIENCE

Professor Maria Forsyth and her research group joined ITRI from Monash University in mid-2010 and have since made a flying start at Deakin University; new laboratories, new staff, an ARC Laureate Fellowship and LIEF grant successes, as well as increased interactions with industry groups have characterised the group's first full year at Deakin University.

Australian Laureate Fellow Professor Maria Forsyth is a leading researcher in the area of Electromaterials and Corrosion Science and is recognised by her position as Deputy Director of the Australian Centre of Excellence in Electromaterial Science.

The group has grown to over 30 staff and students and has developed a number of collaborative projects with other groups within ITRI.

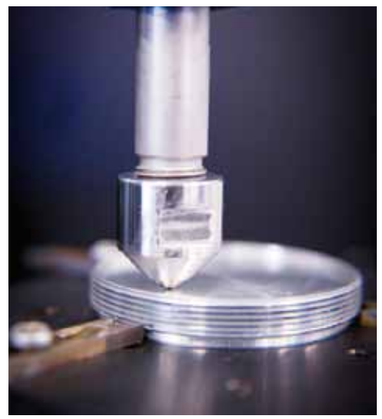
ARC grants awarded for the Nuclear Magnetic Resonance (NMR) facility and the Laureate Fellowship have funded new positions within the group. All of these positions have recently been filled and this presents another exciting period of growth.

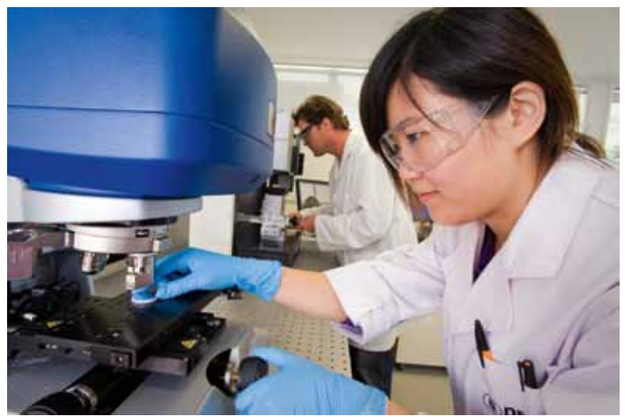
Some other highlights from 2011 include:

- Visits by leading local and international researchers including Professor Masahiro Watanabe (Yokohama), Professor Herman Terryn (Belgium), Associate Professor Arjun Mol (Delft Uni), Dr Alison Davenport (Birmingham), Professor Clare Grey (Stony Brook), Dr Melanie Britton (Birmingham), Dr Tony Cook, (Manchester), Dr Guangling Song (Queensland), Dr Dirk Fiedler (Cochlear).
- Research visits and internships by international guests - Dr Jan Novak (Birmingham), Ms Maureen Tsagouria (Strasbourg), Ms Nahid Iranipoor (Sahand) and Mr Hui Zhou (Binghamton).
- Members of the group attended and presented invited and keynote talks at national and international conferences including; ICMAT 2011 (Singapore), SSI 18th, International Conference on Solid State Ionics (Poland), COIL-4 Congress on Ionic Liquids (Washington), and 18th International Corrosion Congress (Perth).
- Several graduate students, namely Steven Lin, Tristan Simons, and Rainier Catubig received awards for their research presentations at local conferences.

Below left:
Tribometer for conducting wear tests on steel and aluminium and also experiments with artificial cartilage.

Below:
Optical profiler in use for obtaining 3D images of samples.





ELECTROMATERIALS AND CORROSION SCIENCE

SELECTED PUBLICATIONS IN 2011

1. Khoo, Timothy, Howlett, Patrick C., Tsagouria, Maureen, MacFarlane, Douglas R. and Forsyth, Maria 2011, The potential for ionic liquid electrolytes to stabilise the magnesium interface for magnesium/air batteries, Electrochimica acta, vol. 58, no. 1, pp. 583-588.
2. Neil, W. C., Forsyth, M., Howlett, P. C., Hutchinson, C. R. and Hinton, B. R. W. 2011, Corrosion of heat treated magnesium alloy ZE41, Corrosion science, vol. 53, no. 10, pp. 3299-3308.
3. Armel, Vanessa, Pringle, Jennifer M., Wagner, Pawel, Forsyth, Maria, Officer, David and MacFarlane, Douglas R. 2011, Porphyrin dye-sensitised solar cells utilising a solid-state electrolyte, Chemical communications, vol. 47, no. 33, pp. 9327-9329.
4. Latham, Julie-Anne, Howlett, Patrick C., MacFarlane, Douglas R. and Forsyth, Maria 2011, Electrochemical reactivity of trihexyl(tetradecyl)phosphonium bis(2,4, 4-trimethylpentyl)phosphinate ionic liquid on glassy carbon and AZ31 magnesium alloy, Electrochimica acta, vol. 56, no. 15, pp. 5328-5334.
5. Armel, Vanessa, Forsyth, Maria, MacFarlane, Douglas R. and Pringle, Jennifer M. 2011, Organic ionic plastic crystal electrolytes; a new class of electrolyte for high efficiency solid state dye-sensitized solar cells, Energy and environmental science, vol. 4, no. 6, pp. 2234-2239.
6. Bayley, Paul M., Best, A. S., MacFarlane, D. R. and Forsyth, M. 2011, The effect of coordinating and non-coordinating additives on the transport properties in ionic liquid electrolytes for lithium batteries, Physical chemistry chemical physics, vol. 13, no. 10, pp. 4632-4640.
7. Jin, Liyu, Howlett, Patrick, Efthimiadis, Jim, Kar, Mega, MacFarlane, Doug and Forsyth, Maria 2011, Lithium doped N,N-dimethyl pyrrolidinium tetrafluoroborate organic ionic plastic crystal electrolytes for solid state lithium batteries, Journal of materials chemistry, vol. 21, no. 27, pp. 10171-10178.
8. Forsyth, Maria, Seter, Marianne, Hinton, Bruce, Deacon, Glen, Junk, Peter, New 'Green' Corrosion Inhibitors Based on Rare Earth Compounds, Australian Journal of Chemistry 64 (2011) 812–819.
9. Howlett, Patrick, Sunarso, Jaka, Shekibi, Youssof, Wasser, Etienne, Jin, Liyu, Kar, Mega, MacFarlane, Douglas and Forsyth, Maria, On the use of Organic Ionic Plastic Crystals in all solid-state lithium metal batteries, Journal of Solid State Ionics 204-205 (2011) 73-79
10. Rana, Usman Ali, Vijayaraghavan, R., MacFarlane, D.R. and Forsyth, Maria 2011, An organic ionic plastic crystal electrolyte based on the triflate anion exhibiting high proton transport, Chemical communications, vol. 47, no. 22, pp. 6401-6403.

(ACES) AT THE MELBOURNE CAMPUS

The Australian Research Council Centre of Excellence for Electromaterials Science (ACES) brings together eminent scientists to develop the nano-science and nanotechnology related to the movement of electric charge within and between materials. The Centre focuses on the design, preparation and characterisation of novel electromaterials and their application in energy and bionic fields.

Deakin University recently joined ACES as a partner investigator when Professor Maria Forsyth and Dr Patrick Howlett arrived from Monash University. The new ACES laboratories established at Deakin University house a range of state-of-the-art electrochemical and characterisation equipment, as well as wet chemistry and solid-state synthetic facilities and equipment.

The primary research focus of the Deakin University ACES team, in collaboration with Monash University, is upon energy storage. Researchers are working on novel electrolytes and interfaces for advanced metal batteries, including Mg/air and solid state lithium cells. Advanced characterisation techniques using the synchrotron and NMR continue to be developed which will aid in the understanding of the materials structure of devices.

Establishment of the new NMR facility at the Geelong Campus was initiated with the purchase of two dedicated solid-state wide-bore NMR instruments. These instruments possess leading capabilities for materials (and even device) imaging as well as advanced solid-state materials characterisation.

INTERFACIAL CONTROL OF REACTIVE METALS

The core activities of the ACES group at the Deakin University, Melbourne Burwood campus involve the investigation of the role of interfacial processes in corrosion and energy storage applications. The research encompasses materials science, electrochemistry and surface science and their application to the problems which occur at a surface where electrochemical processes are taking place e.g. at a battery electrode during charge or at a metal surface that is corroding in salt water.

ELECTROMATERIALS AND CORROSION SCIENCE

BATTERY RESEARCH ACTIVITIES

To meet the increasing demand for higher performance battery technologies, considerable research effort is directed at; lithium metal, zinc-air and magnesium air batteries. The biggest challenge facing battery technology is the safety of these devices, typically employing flammable electrolytes and potentially causing problems for large scale applications such as in electric vehicles.

Lithium metal batteries are currently the best performing available system and provide the energy density required by tomorrow's applications. Magnesium air batteries require less costly materials and can generally be considered much less toxic than their lithium counterparts. However, these batteries remain primary, non-rechargeable devices.

On the other hand the promise of rechargeable zinc-air batteries presents exciting possibilities for high energy density, long life and inexpensive energy storage. Focusing on the electrolyte material, our approach is to apply and optimise room temperature Ionic Liquids (ILs) and Organic Ionic Plastic Crystals (OIPCs) for these devices. Both these classes of material are non-volatile and have been shown to support the electrochemistry of the targeted battery systems.

CORROSION RESEARCH ACTIVITIES

Associate Professor Mike Tan joined the team at Deakin University, taking a leadership role in Corrosion research, and bringing strengths in novel monitoring methodologies and established industry links. The team was successfully awarded a three year grant funded by NCED aimed at understanding corrosion processes and corrosion performance of materials for desalination.

The research in novel chemical methods for corrosion protection of alloys of the light metals magnesium (Mg) and aluminium (Al) continues. These alloys suffer severe corrosion in saline environments, where they are often employed. Previously chromate conversion coatings have been used as they offer excellent paint adhesion and corrosion resistance. However, chromium (VI) is extremely toxic and carcinogenic and hence there is a need for green alternatives.

Rare earth Inhibitors (Ce, La and mischmetal coupled with an organic anion – e.g. diphenyl phosphate) have been investigated for use on Al alloys and steels. Their corrosion protection is significant and ongoing research is being conducted to fully understand their manner of inhibition and film formation.

Ionic liquids (ILs) have only recently been discovered to form corrosion inhibiting films on both Mg and Al alloys. Corrosion resistant films have been prepared and the influence of chemistry, applied potential, temperature and treatment time are being investigated. Research into the use of ILs as electrolytes for anodisation and to control corrosion of Mg alloy stents used to treat coronary artery disease is also underway.

TRIBOLOGY

The use of aluminium alloys in areas such as the automotive industry, aviation and space technology is increasing due to their high strength to weight ratio, corrosion resistance and high thermal conductivity. Unfortunately the tribological performance of aluminium and its alloys is considered to be poor. In particular, when steel and aluminium alloys come into contact high wear and seizing is likely to occur.

ILs have been investigated as lubricants for these systems because of their low volatility. They can be used in reduced pressure applications and their non-flammability and thermal stability means that they will be able to safely withstand increased temperatures in a high friction environment.

The wear performance in a pin-on-disk test of a range of ILs is being studied in the ACES labs. Subsequently, the surface interactions of the IL and metal substrate are being investigated using a range of surface characterisation techniques including XPS, ToF-SIMS, FTIR spectroscopy and Optical Profilometery.

Below:
Lithium disc batteries displaying the effects of corrosion.

MICRO AND NANO SYSTEMS

Manipulation of micro and nanometer scale objects such as molecules for diagnostics and nanoparticles for targeted drug delivery are of significant importance to biomedical and environmental applications.

The group has made the following breakthroughs in molecular diagnostics:

- The development of a point-of-care diagnostic device
- Membrane fabrication and characterisation by developing membranes with aligned nanostructure for improved performance
- Exploring new nano tomographic characterisation technology
- Targeted drug delivery systems with micro and nano encapsulations.

ENDEAVOUR AWARD TO FIND TECHNOLOGICAL SOLUTION

Water shortage due to drought, water and soil contamination from mining and industrial activities has been a common challenge for Australia and China. A prestigious Australian Award – Endeavour Executive Award – was awarded to Prof Lingxue Kong for him to collaborate with leading Chinese environmental scientists in Chinese Academy of Sciences and Chinese Academy of Tropical Agricultural Sciences.

This collaborative research will aim to develop technological and engineering solutions, which are complementary to biological ones for environmental remediation.

The award is of strategic importance to both Australia and China and will lead to improved understanding of the key environmental issues such as the impact of drought on water and land. It will also explore new collaborative opportunities between Australia and China on remediation of contaminated water and land.

Following this award, a group of environmental research leaders from China will visit Australia in 2012 under another prestigious Australian Awards program – AusAid Australian Leadership Award (ALA) Fellowships to jointly develop innovative environmental remediation technologies through interdisciplinary collaboration.

MOLECULAR DIAGNOSTICS

An ageing population and increasing pandemics of contagious diseases for example in recent world-wide outbreaks of H1N1 and SARS urgently require the development of point-of-care diagnostic technologies.

The employment of microengineering and nanotechnology such as microfluidics and nanomolecule design have led to the unprecedented potential of developing and deploying portable detection systems close to the patients.

The group is developing a new polymerase chain reaction technology that requires small reagent and sample sizes, resulting in significantly reduced detection time for major diseases. A prototype machine funded by the UBS foundation's Global Health Research program has been developed and will potentially revolutionise the diagnostics to disadvantaged societies.

Below:
Dr Sugamar Dharmalingham using the Molecular Diagnostic Device designed and developed at ITRI.

MICRO AND NANO SYSTEMS

SYNTHESIS AND CHARACTERISATION OF MEMBRANES

The widely used polymeric membrane materials for wastewater treatment and desalination consume enormous energy, leading to expensive construction and maintenance cost and consequently, a higher price to the customers. We have successfully fabricated a new class of polymeric membrane with locally well aligned nanopores of about 2nm templated from hexagonal lyotropic liquid crystals (LLC).

The breakthrough has been highlighted in the front cover of the leading materials journal of Soft Matter in 2012. The membranes have the potential to match the performance of nanotube membranes. Their performance is three orders of magnitude higher than conventional membranes in permeability which significantly improves the efficiency of wastewater treatment and desalination processes.

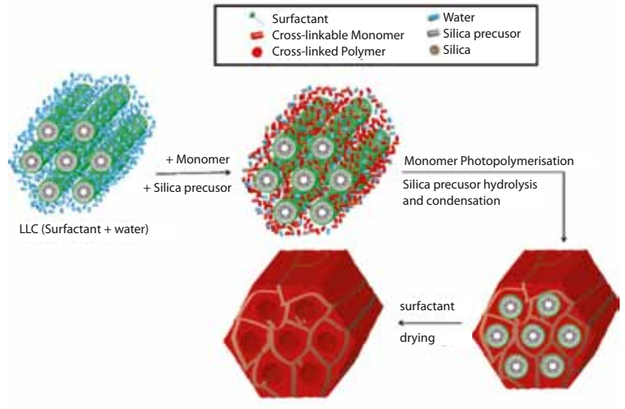
We have also explored the high resolution of transmission electron microscopy for tomography analysis, pioneering the quantitative characterisation of membrane porous structures. It becomes the most reliable and accurate three dimensional quantitative characterisation technology with a potential to reach atomic level resolution offered by TEM.

Below:
Front cover of 'Soft Matter' showing the retention of nano structures templated from LLC.

TARGETED DRUG DELIVERY

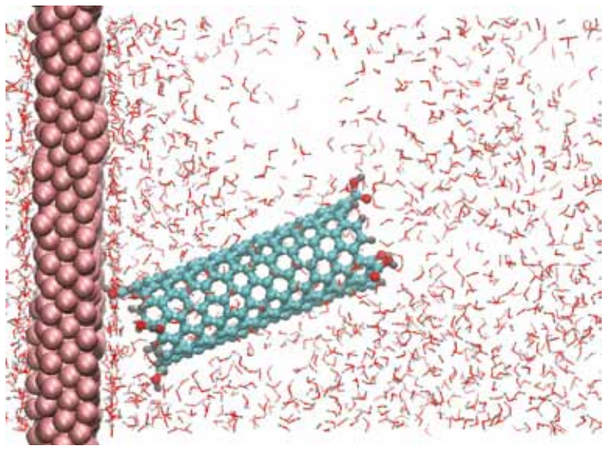
Colon cancer is one of the leading causes of deaths in Australia and the world, accounting for 655,000 deaths every year. To achieve efficient chemotherapy, the anticancer drug concentration in the blood should be maintained between the minimum effective therapeutic level and the maximum tolerable level for prolonged time interval.

We have introduced an integrated micro and nano encapsulation process that can fabricate novel conjugates for targeted drug delivery. By encapsulating widely used anticancer drugs into biodegradable polymers such as nano PLGA-folate and chitosan-folate conjugates and mesoporous silica nanoparticles, cellular uptake of these nanoparticles by cancer cells has been significantly improved.



Above:
Schematic process of LLC membrane.

Below:
Molecular dynamic simulation of molecular movement within carbon nanotubes.



POLYMERS

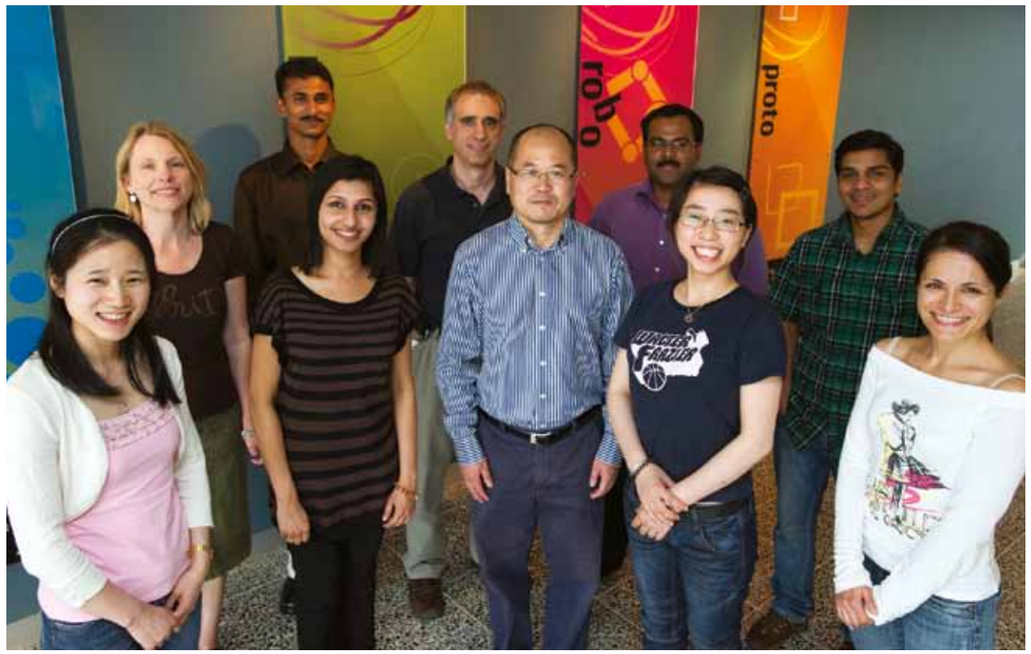
Polymers have significant impact on the world today. Applications for polymers extend from adhesives, coatings, paints, foams and packaging to structural materials, composites, textiles, electronic and optical devices, biomaterials and many other uses in industry and our daily life.

The polymers research group at ITRI is involved in studying both theoretical and experimental fundamental principles in polymer science, developing new polymeric materials and conducting commercial research with industry partners.

RESEARCH AREAS INCLUDE:

- Block copolymer self-assembly and physics
- Nanostructure toughening of thermosets
- Polymer composites and nanocomposites
- Polymer blends and modified plastics
- Self-healing polymers and nanocomposites
- Biodegradable polymers
- Green processing of natural polymers
- Rubber recycling

Below:
Professor Qipeng Guo (centre) with members of the Polymer Research Group.



POLYMERS

RESEARCH PROJECTS AND RECOGNITION

In 2011, Professor Qipeng Guo successfully completed an ARC Discovery Project "Nanostructure Design and Toughening Mechanisms of Novel Thermosets" and a large ($1.06M) Advanced Manufacturing CRC Project "Rubber Waste Recycling". He was also awarded an ARC Discovery grant for investigation into "Toughening Thermosets by Highly Ordered Nanostructures".

In the completed Discovery Project, Professor Guo and co-workers investigated a concept of nano-toughening of thermosets, such as epoxies, with block copolymers and tailored nanostructures to provide high toughness and optical transparency. The work established processing-structure-property relationships. This provided the design strategies and guidelines for a class of novel nanostructured thermosets, enabling new applications in the transportation, construction and microelectronics industries.

In collaboration with CSIRO, the Polymers Research Group have developed a simple approach to the fabrication of novel porous polysiloxane membranes of controlled morphology. Given that porous PDMS membranes are important materials for numerous biomedical and other technological applications, the ability to control membrane properties such as pore structure, modulus and transparency through relatively subtle manipulations of the precursor microemulsion phase represents a facile approach to developing new 'fit for function' siloxane based materials.

Professor Guo and his teams' successful partnership with VCAMM and VR TEK Global via the Advanced Manufacturing CRC project on tyre rubber recycling has led to the development of a new cost-effective and environmentally friendly solution for tyre recycling. A pilot plant has been established at the Deakin University Geelong Waurn Ponds campus which will enable the industry partner, VR TEK Global to launch a new factory. (http://theconversation.edu.au/recycling-helps-tyred-out-rubber-hit-the-road-again-3982).

The completion of this large commercial project with a high satisfaction of the industry partner has gained trust and reputation for Professor Guo and the polymers research group in the Australian industry. As a result, Professor Guo has been approached by several other companies.

In 2011, Professor Qipeng Guo received an honourable professorship from the University of Ballarat and an honourable professorship from Southwest Petroleum University, China.

PATENTS

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- Guo, Q. and George, G., "Self-Healing Polymers and Process for the Preparation Thereof," US Provisional Patent Application, No 61/499884, filed on 22 June 2011.
- Guo, Q. and George, G., "Self-Healing Polymer Nanocomposite and Process for the Preparation thereof," International (PCT) Patent Application, PCT/AU2011/001459, filed on 11 November 2011.

JOURNAL PAPERS

- Salim, N. V. and Guo, Q., "Multiple vesicular morphologies in AB/AC diblock copolymer complexes through hydrogen bonding interactions," Journal of Physical Chemistry B 2011, 115, 9528-9536.
- Peng, S., Guo, Q., Hughes, T. and Hartley, P. G., "In situ synchrotron SAXS study of polymerizable microemulsions," Macromolecules 2011, 44, 3007-3015.
- Hameed, N., Guo, Q., Tay, F. H. and Kazarian, S. G., "Blends of cellulose and poly(3-hydroxybutyrate-co-3-hydroxyvalerate) prepared from the ionic liquid 1-butyl-3-methylimidazolium chloride," Carbohydrate Polymers 2011, 86, 94-104.
- Byrne, N., Hameed, N., Werzer, O. and Guo, Q., "The preparation of novel nanofilled polymer composites using poly(l-lactic acid) and protein fibres," European Polymer Journal 2011, 47, 1279-1283.
- Ding, Y., Wang, J., Wong, C. S., Halley, P. J. and Guo, Q., "Synthesis, characterization and biocompatibility of novel biodegradable crosslinked copolymers based on poly(propylene oxide) diglycidylether and polyethylenimine," Journal of Biomaterials Science, Polymer Edition 2011, 22, 457-473.

CENTRE FOR INTELLIGENT SYSTEMS RESEARCH

The mission of the Centre for Intelligent Systems Research (CISR) at Deakin University is to make a substantial difference for society through our research.

CISR investigates and develops state-of-the-art algorithms and methodologies, providing practical solutions to real world problems that are encountered by systems operating with uncertainty, variability and change. This practical approach encompasses research on next generation robotic and haptic control systems and force emulation methodologies that improve process reliability, product quality and operator safety in complex environments.

CISR research aims to extend the capability of human decision-makers and operators through increased autonomy of sensors and data collection, data fusion and processing, system identification, estimation, analysis methodologies, control, and novel communication interfaces and actuators.

The approach is from a system perspective by providing solutions to all aspects of the problem space. The common set of characteristics shared across these domains include incomplete, incorrect and imprecise data; very large state-spaces and datasets; transient behaviour; time lags/latency; dynamic processes and stochastic processes. The centre is home to over 50 researchers and is directed by Alfred Deakin Professor Saeid Nahavandi.

2011 was a highly successful year for CISR and some of the highlights are outlined as follows.

Professor Saeid Nahavandi
Director

Dr Doug Creighton
Deputy Director

CENTRE FOR INTELLIGENT SYSTEMS RESEARCH

NATIONAL COMPETITIVE AWARDS

CISR was awarded both an ARC Discovery and two Linkage Project grants in 2011. The Discovery Award will be used to conduct research into the development of new interval type-2 fuzzy logic system-based tools for quantifying uncertainties present in complex systems. The outcome of this project will greatly help all Australian industries and organisations that directly or indirectly use model-based estimation for prediction and forecasting purposes.

The first of the two ARC Linkage Project awards will be used to research adaptive scenario generation and performance evaluation for virtual training of helicopter pilots. This project will develop effective pilot training methods by virtual simulation delivery for the purposes of improving aviation safety. This research is in partnership with YTEK.

The second of the two ARC Linkage Project awards is in partnership with two of the world's most recognised companies namely Boeing and General Motors. The research project will be used to develop methods for optimising and scheduling networks of smart and traditional cameras used for capturing knowledge in a manufacturing environment. The project will also extend to managing network performance and identifying causes of quality degradation. This research will assist Australian manufacturers to stay competitive in the dynamic global market. CISR's proposal was the only successful proposal in the Manufacturing Engineering field of research.

CISR SUCCESSFUL IN COLLABORATIVE RESEARCH NETWORK (CRN) PROJECT BID.

A joint 'Self-sustaining Regions Research and Innovation Initiative' involving Deakin University and the University of Ballarat was announced in 2011. This Collaborative Research Network (CRN) project is aimed at strengthening regional 'well-being' and driving regional rejuvenation through an alliance of research excellence in regional landscape change; regional social connectedness and health; and regional information use and systems optimisation. Deakin University, including CISR, will contribute expertise in modelling and optimisation, visualisation and material research.

RESEARCH AWARDS

CISR post-doctoral research fellow, Dr Khashayar Khoshmanesh was awarded the prestigious 2011 American Australian Association Fellowship to join Professor Juan G. Santiago's group at Stanford Microfluidics Laboratory, Stanford University, USA. Khashayar will investigate rapid detection of bacterial infections in blood samples using microfluidics.

The American Australian Association awards individual fellowships for advanced study in the United States of up to US$30,000 each year. The fellowships build on existing strong social and economic partnerships and foster intellectual exchange between the United States and Australia. The recipients are named Sir Keith Murdoch Fellows after the association's principal founder.

CISR's senior research academic, Dr Asim Bhatti was awarded Australian Endeavour Fellowship to design an improved multielectrode array at Georgia Institute of Technology. Dr Asim Bhatti, senior research academic at CISR worked on a multidisciplinary research collaboration with renowned Georgia Institute of Technology researchers. The joint research with Professor Hamid Garmestani (Laboratory of Micromechanics of Materials) and Associate Professor Steve Potter (Potter Lab - Laboratory for Neuroengineering) focused on the design and development of improved multielectrode arrays.

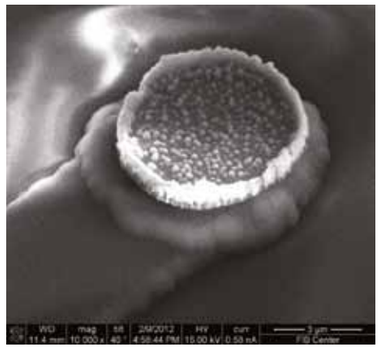
Microelectrode arrays are electronic devices used to integrate with living neuron cells in order to investigate their working principles and behaviour in response to different environmental influences and stimulations. In vitro multichannel recordings from neurons have been used as important evidence in neuroscientific studies to understand the fundamentals of neural network mechanisms in the brain. They are also used to study the effect of structural, biochemical and electrical abnormalities on the overall capabilities of the brain.

CENTRE FOR INTELLIGENT SYSTEMS RESEARCH

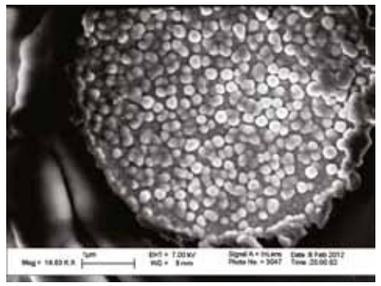
Dr Bhatti's research developed an improved multielectrode array architecture featuring:

- Improved electrode geometry for better adhesion and interfacing with neurons
- High conductivity for improved signal to noise ratio and biocompatible materials allowing long-term neural studies without making the environment inhospitable
- Higher resolution and scale of electrodes for better neural mapping and the ability to investigate larger neural networks collectively.

This ongoing collaboration has facilitated the design of new Ti/SiN/Ag multielectrode arrays with improved cage-like electrode geometry to better interface with neurons.

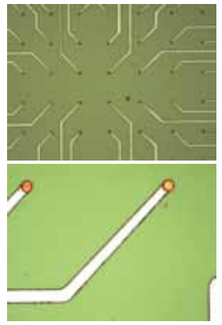


Left:
Fabricated MEA electrode.



Above:
Close-up MEA.

Below:
MEA optical electrodes.



Above:
MEA optical electrodes zoom.

Below:
Dr Asim Bhatti with MEA.

CENTRE FOR INTELLIGENT SYSTEMS RESEARCH

Dr Nong Gu was awarded an Endeavour Australia Cheung Kong Research Fellowship to travel to the Institute of Automation, Chinese Academy of Sciences to work with international research leaders in Signal Processing.

As part of his Alfred Deakin Post Doctoral Fellowship, Dr Abbas Khosravi visited the University of Toronto, University of Calgary, University of Waterloo and University of Southern California to explore joint research on fuzzy logic system-based decision support systems. CISR is already collaborating on projects with research leaders in the National University of Singapore and University of Essex (UK), to develop intelligent decision-making systems for the energy sector.

Dr Abbas Khosravi was also the recipient of a Central Research Grant award on Intelligent Decision Support for Renewable Energy Systems. This research projects aims to develop a hierarchical multi-criteria decision-making system to automate the process of assessing renewable energy alternatives.

INNOVATIONS

CISR's OzBot™ mobile platform was featured in the November issue (2011) of the Qantas inflight magazine.

"a diminutive mechanical superhero - the OzBot™, a nimble machine that can check for explosive devices using 3D stereovision, tow a 4WD vehicle or using X-ray equipment, approach an armed offender during a hostage situation".

Below:
Dr Mick Fielding and Dr James Mullins with the OzBot™ mobile platform - Qantas in flight magazine, November 2011.

Doctors Johnstone and Creighton have been working with the Geelong Quality Council to create a software tool that will give manufacturing SMEs the ability to better understand the performance of their production processes. The tool can be used to identify areas for improvement, determine the cause of defects and monitor production. This project was in partnership with two local SMEs, Air Radiators and Backwell IXL.

CISR Research Fellow Dr Samer Hanoun has created an Advanced Scheduling System for industry-partner Informatic. This tool has been developed as part of an ARC Linkage Project collaboration investigating Multi-objective Scheduling for Joinery Manufacturing Processes. The software improves company productivity and responsiveness by minimising tardiness and material cost of jobs, and narrowing the cycle time distribution to achieve greater repeatability.

CISR PhD student Kyle Nelson collaborated with Boeing Research & Technology-Australia to develop an intelligent non-invasive measurement system. Such a system must operate in a changing factory environment and perform automated, in-situ quality control measurement of large parts at various stages during production. A novel in-process geometric measurement system was designed comprising uncalibrated Pan-Tilt-Zoom (PTZ) cameras and a laser scale projection. Image processing techniques were then used to extract geometric measurements based on information contained in the laser projection.

The use of high-zoom cameras and a structured laser scale feature allowed accurate and repeatable performance from a distance of up to nine metres. In-factory experimental results showed automatic and detailed analysis of part geometry to an accuracy of approximately one millimetre.

CISR PhD student Aung Kyaw Soe is exploring the challenges in designing Lab on a Chip (LOC) platforms for neuroscience research and has highlighted the instrumentation requirements in a Scholarly paper recently published by CISR team on "Neuroscience goes on Chip".

VISITING RESEARCHERS:

Professor Anthony A. Maciejewski (IEEE Fellow) visited the Centre for Intelligent Systems Research in August 2011 as part of an ongoing research collaboration between CISR and the Articulated Motion (ArM) Laboratory at Colorado State University. Joint research between the groups has focused on kinematic redundancy and fault tolerant robotics.

CENTRE FOR INTELLIGENT SYSTEMS RESEARCH

CISR UNIVERSAL MOTION SIMULATOR LAUNCH BY SENATOR KIM CARR

The next generation in flight simulation was unveiled at the Centre for Intelligent Systems Research (CISR) by Senator the Hon Kim Carr, former Minister for Innovation, Industry, Science and Research.

CISR's Haptically Enabled Universal Motion Simulator (UMS) will take trainee pilots and drivers through their paces in a safer, cheaper and more realistic training environment than currently available elsewhere in the world.

"Traditional flight simulators have restricted movement and a limited ability to replicate a real flying experience. Robotic experts at CISR have integrated the latest in haptics technology - adding a sense of touch and feel to virtual or remote objects - to produce a commercial system that is ideal for flight simulation," Senator Carr said.

Senator Carr said that the Australian Government is proud to have invested in this technology through the ARC Linkage Infrastructure, Equipment and Facilities scheme. "We are excited that new funding of $210,000 - recently awarded under the ARC Linkage Projects scheme - will help CISR researchers utilise the technology to develop effective pilot training methods and improve aviation safety."

"No other simulator can provide the full experience of flying a military jet with all the gut wrenching G-forces while only seven metres off the ground," explained Professor Saeid Nahavandi, Director of the Centre for Intelligent Systems Research.

"What sets the UMS apart from standard simulators is the integration of haptics technology, which provides a sense of touch and feel to virtual or remote objects, and its ability to move at high speed and in any direction."

"While suited for training pilots, the UMS is also the perfect platform for simulating land based vehicles including tanks and other armoured vehicles, trucks, race cars and motorbikes. Its training capabilities are endless."

PUBLICATIONS

- 19 journal publications
- 16 conference papers
- Granted European patent multi-point haptics

Below:
Dr James Mullins puts the Universal Motion Simulator through its paces.

Left to right: Mr Richard Yanieri - Managing Director YTEK Pty Ltd, Senator the Hon Kim Carr - Minister for Innovation, Industry, Science and Research, Professor Saeid Nahavandi - Director CISR, Professor Lee Astheimer - Deputy Vice Chancellor (Research) and Professor Jane Den Hollander - Vice Chancellor of Deakin University.

CENTRE FOR INTELLIGENT SYSTEMS RESEARCH

KEYNOTES

- Cold Spray Conference, Benefits Gained from Modeling and Simulation for Manufacturing Systems, Melbourne, 16-18 May 2011.
- World Congress on Information and Communication Technology, Knowledge Management in Process Control using Simulation and Modelling Techniques, Mumbai, India, 11-14 December 2011.
- Defence Conference, Haptically Enabled Tele-operation, Sydney, 23-26 May 2011.

SELECTED INVITED TALKS

- Dean's Inaugural Lecture, Modelling of large complex Systems, Sydney, 20 May 2011.
- Industry Advisory Breakfast meeting Speaker sponsored by Thales, talk on Smart Futures: Connecting Physical and Virtual Worlds, Sydney, 20 May 2011.
- Knowledge Management & Manufacturing Enterprise, VCAMM Innovation Series Seminar for 2011, Melbourne, 9 June 2011.
- Co-General Chair, IEEE SMC 2011, Alaska, USA, 9-12 October 2011.

INVITED EXHIBITIONS

- Modern Day Marine, Washington, 27-29 September 2011.
- I/ITSEC, Team Australia (JSF), Orlando, 28 November - 1 December, 2011.

SAMPLE PUBLICATION ABSTRACTS

Fault-Tolerant Force in Human and Robot Cooperation

Fault-tolerant solutions greatly benefit the dependability of robotic systems. This advantage is critical for robotic systems that perform in collaboration with humans.

Dr Abdi's work addresses the fault tolerance of robotic manipulators for cooperatively manipulating an object together with a human. Cooperation occurs for slow lifting or pushing of the object. Reconfiguration of the manipulator is performed to maintain the cooperative force level despite the occurrence of robot joint failures.

Dr Abdi has presented several strategies that can be used for optimally maintaining the required force level for human-robot task cooperation. For each strategy, a reconfiguration control law has been introduced that optimises the fault tolerance of the maintained force level.

Three case studies have been used to validate the proposed reconfiguration laws, demonstrating that this approach results in an optimal fault-tolerant force in human-robot cooperation.

Prediction Interval Construction Using Interval Type-2 Fuzzy Logic Systems

Dr. Abbas Khosravi has proposed a novel non-parametric method for construction of prediction intervals (PIs) using interval type-2 Takagi-Sugeno-Kang fuzzy logic systems (IT2 TSK FLSs).

The key idea in his proposed method is to treat the left and right end points of the type-reduced set as the lower and upper bounds of a PI. This allows us to construct PIs without making any special assumption about the data distribution.

A new training algorithm is being developed to satisfy conditions imposed by the associated confidence level on PIs. Proper adjustment of premise and consequent parameters of IT2 TSK FLSs will be performed through the minimization of a PI-based objective function, rather than traditional error-based cost functions. This new cost function covers both validity and informativeness aspects of PIs. A meta-heuristic method is also applied for minimisation of the non-linear non-differentiable cost function. Quantitative measures are applied for assessing the quality of PIs constructed using IT2 TSK FLSs.

The demonstrated results for four benchmark case studies with homogenous and heterogeneous noise clearly show the proposed method is capable of generating high-quality PIs useful for decision-making.

CENTRE FOR BIOTECHNOLOGY AND INTERDISCIPLINARY SCIENCES (BIODEAKIN)

In 2011 BioDeakin continued to expand in the areas of nanobiotechnology, industrial biotechnology and comparative genomics.

Professor Kevin Nicholas was awarded Grand Challenge Exploration funding by the Gates Foundation and Dr Belinda Appleton joined the comparative genomics team in 2011.

Professor Colin Barrow expanded his nanobiotechnology research under Australia-India Biotechnology funding by appointing Dr Madan Verma. Professor Barrow and Dr Nolene Byrne further expanded their research effort in amyloid materials by the addition of two post-doctoral fellows.

Dr Jelena Stoimenovski was employed to conduct research with Dr Byrne into ionic liquids and their impact on fibre formation.

Dr Richard Williams commenced as an Alfred Deakin Postdoctoral Fellow.

Dr Bo Wang also joined BioDeakin in 2011 as part of a new collaborative program with the University of Ballarat.

The primary focus of this program is to develop improved micro- and nano-encapsulation technology for the stabilisation of unstable omega-3 and probiotic food ingredients.

During 2011 we also strengthened our industrial biotechnology research program by a collaborative ARC Linkage applications with Kemin Nutrisurance and Plant & Food New Zealand. These are primarily in the areas of food biotechnology.

In summary, 2011 was a good year for BioDeakin with a significant expansion of our research efforts, and improved research alignment with other parts of ITRI, particularly nanomaterials and fibres areas. Some of the year's highlights are outlined as follows.

Professor Colin Barrow
Director

Professor Kevin Nicholas
Deputy Director

BIOINFORMATICS AND COMPARATIVE GENOMICS

2011 was the first year that the wallaby enclosure was operational. The Tammar Wallaby has proven to be an excellent model for exploring milk genomics and proteomics relevant to the role of bioactives in human breast milk for signalling development processes in the young.

Use of this model led to an award from the Grand Challenges Explorations fund created by the Bill & Melinda Gates Foundation and was only one of 110 Grand Challenge Exploration Grants awarded world-wide in 2011. This funding will enable Professor Kevin Nicholas and his team to unlock the unique properties of wallaby milk to address the role of milk in signalling development of the gut to reduce the high rate of death in premature and low birth weight babies in developing countries.

The group expanded by appointing Dr Belinda Appleton, who moved from the Department of Genetics at the University of Melbourne. She is an expert in comparative genomics and genetics, particularly of the alpaca.

During 2011 we also established cross-functional research with Professor Ying Chen's group and Professor Barrow's group in using novel amyloid and composite nanomaterials for scaffolds to grow and deliver milk cells and to study the morphology of 3-dimensional mammary acini.

Collaborative research with AAHL, CSIRO continued, including expansion of our bioinformatics platform with Associate Professor Christophe Lefevre and Dr Tamsyn Crowley. Dr Crowley's position is jointly funded by Deakin University and CSIRO.

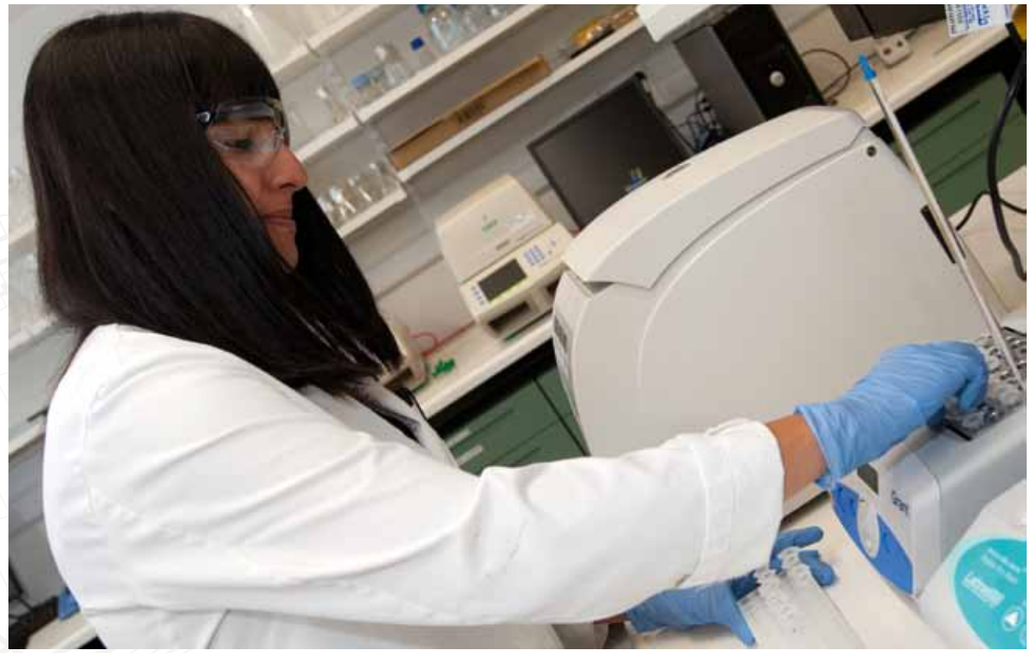
In 2011, the group consisted of 13 PhD students, and two Masters by research students.

In addition, 10 peer reviewed papers were published.

Professor Colin Barrow
Director

Professor Kevin Nicholas
Deputy Director

Below:
Research Assistant Gunveen Kaur preparing samples in the Biological Research laboratory.



NANOBIOTECHNOLOGY

During 2011 our research effort in nanobiotechnology continued to grow.

ARC Fellow Dr Nolene Byrne and Lecturer, Dr Wenrong Yang were joined by Alfred Deakin Postdoctoral Fellows Richard Williams and Madan Verma.

Dr Wenrong Yang continued to work on nanomaterials, biomolecular adsorption and self-assembly involving both of the new Fellows.

Dr Richard Williams has expanded our efforts in amyloid peptide and protein materials into the area of amyloid scaffolds and hydrogels for tissue engineering.

Dr Madan Verma is focusing on the immobilisation of enzymes including cellulases and lipases on nanomaterials.

2011 saw growth in collaborations both within Australia and internationally, including new collaborations with Professor Liming Dai from Case Western Reserve University (USA), Associate Professor Dan Li (Monash University) and Professor Jiangquan Liu at Qingdao University.

All are leading scientists in the field of carbon nanomaterials. These collaborations are being led by Dr Wenrong Yang and have resulted in four joint publications in 2011. Our capabilities in this area were further expanded through two successful RESS bids.

One bid was for a NanoITC and the other for an HPLC suite including 2D HPLC capabilities. ARC LIEF funding was also granted towards the purchase of an FTIR/Raman microscope at Deakin University and NIR/Raman microscope at Monash University.

CRN funding was also awarded for a collaborative program with the University of Ballarat on micro- and nano-encapsulation of functional ingredients, particularly omega-3 oils for functional food delivery.

Two post-doctoral fellows were hired for this program, Dr Bo Wang at Deakin University and Dr Amy Liu at Ballarat University.

INDUSTRIAL BIOTECHNOLOGY

During 2011 we were awarded an Australia-India Biotechnology grant in the area of functional food technology development.

This joint award with Dr Madhu Rao from the Centre for Cellular and Molecular Biology (CCMB) in Hyderabad focuses on the discovery and development of novel lipases for omega-3 produced in food, pharmaceuticals and biofuels.

This program has been expanded to New Zealand lipases in conjunction with Plant & Food New Zealand in Nelson. The research has been funded through joint ARC Linkage and the New Zealand Ministry of Science and Innovation grants.

An ARC Linkage proposal with Kemin Nutrisurance was submitted in 2011. Kemin are a US based company that have a research facility at the Geelong Waurn Ponds campus of Deakin University. The purpose of this work is to develop improved antioxidants for human and companion animal foods.

During 2011 research continued on the use of novel cellulases and lignanes for biofuel production.

Dr Munish Puri was awarded a RESS equipment grant for a multiangle light scattering (MALS) system for advanced molecular weight determination and particle size analysis. This equipment will be used in the the development of novel nanomaterials for immobilizing enzymes, thus enabling a more cost-effective bioenergy production through multi-reuse of enzymes in bioreactors. The project links the groups industrial biotechnology and nanobiotechnology research efforts.

Below:
Dr Munish Puri at work in the Bioprocessing laboratory.

NANOMEDICINE - LABORATORY OF IMMUNOLOGY AND MOLECULAR BIOMEDICAL RESEARCH (NANOMEDICINE - LIMBR)

Nanomedicine - Laboratory of Immunology and Molecular Biomedical Research (Nanomedicine - LIMBR) undertakes fundamental as well as applied molecular biomedical research in the field of nanomedicine based targeted delivery and imaging of cancer and chronic inflammation, including atherosclerosis.

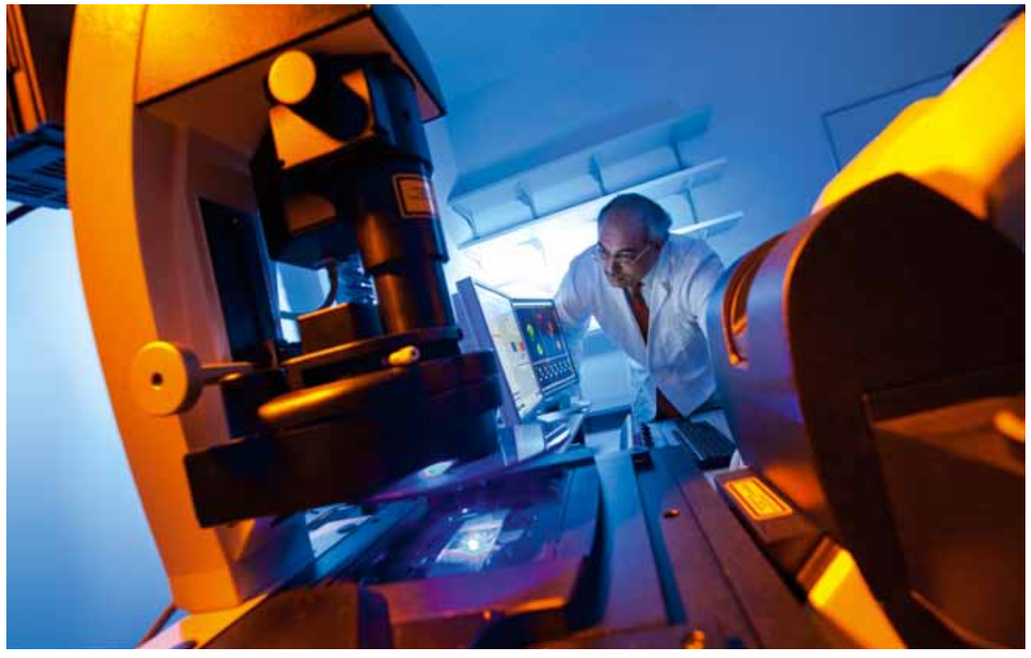
In 2011, the group has provided quality research training to undergraduate and postgraduate students. The group now consists of 14 PhD students and three Masters by research students. Two PhD students have graduated. One PhD and one Masters by research theses have been submitted. The group's research direction is in strategic alignment with Deakin University and ITRIs' future research directions in the field of Bio-Nanotechnology. A number of partnerships have been strengthened in these areas in 2011.

During 2011, the group was awarded an Australia-India Strategic Research Fund (AISRF) grant into the research area of functional food technology development for targeting breast and colon cancers.

The grant is funded by the Department of Industry, Innovation, Science, Research and Tertiary Education.

Associate Professor Jagat Kanwar organized four international conferences in the field of nanomedicine and nanobiotechnology in USA, Australia and India. Research data from the group was presented in high ranked conferences in the fields of nanobiotechnology, inflammation and immunology. HDR researcher, Kislay Roy was awarded the PhD Student Research Award for Excellence in Nanomedicine Research, at the International Nanomedicine Conference in Sydney in 2011.

Below:
Associate Professor Jagat Kanwar using the Confocal Microscope for sample characterisation.



NANOMEDICINE - LABORATORY OF IMMUNOLOGY AND MOLECULAR BIOMEDICAL RESEARCH (NANOMEDICINE - LIMBR)

Osteoarthritis (OA) is one of the most common causes of disability that affects 300 million people world-wide causing a high economic burden to healthcare systems. The group is investigating the problem by the use of naturally derived bioactive proteins such as from milk and plant products that are known to be non-toxic, safe and can be used to help restore damaged cartilage and potentially be used as an alternative treatment option.

Since commencing her research in this field, PhD student Mrs Rasika Manori Dewadinna Samarasinghe has won several awards including the best HDR presenter and poster presentation at the ITRI annual conference 2011.

The group published 12 journal articles, six book chapters and six manuscripts accepted with four more submitted, in the high ranking peer reviewed journals in the fields with ISI impact factor 6.2 to 10.2 of Nanomedicine, Molecular Biology and Medicinal Research. Associate Professor Kanwar contributed to and edited a book on "Recent Advances in Immunology to Target Cancer, Inflammation and Infections" by InTech.

In addition, an International (PCT) Patent Application PCT/AU2012/000456 was filed.

In 2011, four new HDR students have joined the group in Australia and two new HDR students joined through the Deakin India Research Initiative (DIRI) and one other through TERI (The Energy and Resources Institute of India) - Deakin 'Nanobiotechnology Research Centre'.

Below:
Operation of the Flow Cytometer instrument by PhD student Ganesh Mahidhara.

ARC CENTRE OF EXCELLENCE FOR FUNCTIONAL NANOMATERIALS

The highlight for the Centre in 2011 was the opening on 6 June at the Geelong, Waurn Ponds campus of a new Nanotechnology laboratory by Professor Lee Astheimer, Deputy Vice-Chancellor (Research).

This was followed by a one-day workshop attended by 15 external guests. The new facility currently houses equipment for synthesis and processing of nanomaterials, characterisation of nanomaterial electrochemical properties for applications in supercapacitors and lithium-ion batteries, and testing of photoluminescent properties of nanomaterials. The main achievements and research highlights for 2011 are listed as follows:

BORON NITRIDE (BN) NANOSHEETS

BN nanosheets have a similar structure to graphene and attract increasing attention due to this two-dimensional structure and in addition, their excellent thermal, mechanical and chemical properties. BN nanosheets will have a large range of applications in advanced composite materials, radiation shielding and photoelectronics.

A new production method has been developed to produce BN nanosheets in much larger quantities than has been previously achieved. The new process involves fully-controlled milling of hexagonal BN particles with specific milling agents. The shearing forces of the milling mechanically peels BN nanosheets from particles. Under controlled conditions, milling actions of low impact energy induce very little damage to the in-plane crystal structure of the sheets. This effective production method for large quantities of high-quality BN nanosheets is of high importance to the research and application of BN nanosheets. This method has been published in Journal of Materials Chemistry 21 (2011) 11862 and the editor selected it as a "hot article".

Below:
Professor Ying Chen looks on as Professor Lee Astheimer, Deputy Vice Chancellor (Research) opens the new Nanotechnology laboratory.

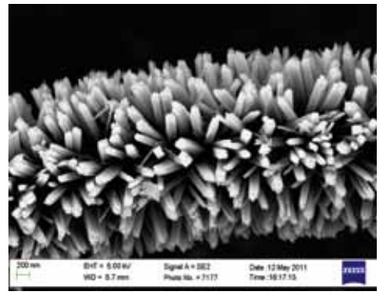
ARC CENTRE OF EXCELLENCE FOR FUNCTIONAL NANOMATERIALS

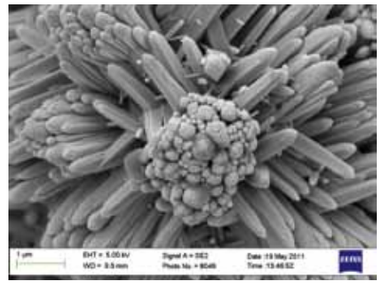
ENERGY STORAGE

A nanocomposite of MoO_3 nanoparticles with a carbon matrix has been produced and the composite acts as a high capacity anode material for lithium-ion batteries as well as exhibiting good cyclic behaviour. Its initial capacity exceeds the theoretical capacity of 745 mAh/g in a mixture of MoO_3 and graphite (1:1 by weight), and 94% of the theoretical capacity is still retained after 120 cycles. The research has been published in Journal of Materials Chemistry 21 (2011) 9350.

A major breakthrough has also been achieved in production of new nanomaterials from mineral ilmenite, $FeTiO_3$ for supercapacitors. The nanoscale, flower-like structure is created via a thermal-chemical treatment. This material generates pseudocapacitive properties in aqueous electrolytes. Porous TiO_2 with bimodal pore size distribution has also been synthesized from ilmenite. The pore size distribution can be controlled by altering the synthesis procedure. Photocatalytic properties of porous TiO_2 were found to be catalytically active in mineralisation of phenol. The research has been published in CrystEngComm 13 (2011) 1322, a flagship journal in the field of crystal engineering.

Below:
SEM images of electrospun TiO_2 nanofibres with hierarchical structure.





NANOPARTICLES AND QUANTUM DOTS

In 2011, nanoparticle research has been expanded from the health and biomedical areas into the environmental sector. An investigation into the environmental impact of commercial nanoparticles has commenced in collaboration with the School of Engineering at Deakin University. The use of graphene-nanoparticle hybrids as pollutant scavengers has shown promising results. The use of doped photocatalytic semiconductor nanoparticles has been explored for energy and environmental applications. In addition, a study into the applications of nanoparticles for the diagnosis of atherosclerosis has commenced with help from the Centre for Biotechnology and Interdisciplinary Sciences (BioDeakin).

Participation in the world-wide OECD Program for Safety Testing of Manufactured Nanomaterials was continued through the Australian Consortium in collaboration with the National Measurement Institute and CSIRO Nanosafety Research. The outcomes of nanoparticle research were disseminated in six peer reviewed papers and six conference papers.

PLASMA RESEARCH

Significant achievements have been made in functionalisation and doping of nanomaterials. For the first time, plasma oxygen doping of boron nitride nanotubes (BNNTs) has been achieved. This process has been combined with a non-chemical cleaning of the BNNT surface without damage to the nanotubes. This breakthrough allows tuning of the optical, electrical and magnetic properties of BNNTs, and also opens up exciting opportunities for BN-based nanomaterials, especially in nanodevices. This plasma-BNNT work was published in Nanotechnology 22 (2011) 245301and was assessed as in the top 10% of IOP journal papers. In addition, novel combined plasma mode technology has enabled the highest reported levels of primary amine groups on the surface of Carbon nanotubes (CNTs) and BNNTs. This work will be published as the cover page story of the Journal of Plasma Processes and Polymers.

Important progress has also been made in improving the efficiency of dye sensitised solar cells (DSSCs) using novel plasma technology. The plasma changed the surface charge state of TiO^2 and introduced -OOH surface functional groups, improving the quantum efficiency (QE) by 31%. This improvement in QE can be attributed to improved photon-harvesting and electron transfer. This is an important step forward in the improvement of DSSCs.

Finally, an advanced surface functionalization and fabrication facility, which combines PVD and PECVD in one system, has been developed with Research Equipment Support Scheme (RESS) funding.

ARC CENTRE OF EXCELLENCE FOR ELECTROMATERIALS SCIENCE

The Australian Research Council Centre of Excellence for Electromaterials Science (ACES) brings together eminent scientists from several institutions including University of Wollongong, Monash University, Deakin University, Latrobe University, University of Tasmania and St. Vincent's Hospital, to develop the nano-science and nanotechnology related to the movement of electric charge within and between materials.

The approach provides an alternative to varying the composition of a material to alter physical and biological properties – instead we alter dimensions and shape in the nanodomain. These processes are fundamentally important to a diverse array of phenomena important in medicine and industry.

ACES AT DEAKIN UNIVERSITY (ITRI)

Our main focus at Deakin University is in the area of electromaterials and advanced characterisation with particular emphasis on Energy Storage.

In collaboration with our Monash University ACES colleagues, we have made advances in solid state materials for lithium batteries and Mg/air batteries. For example in the case of lithium batteries, plastic crystal electrolytes have provided a breakthrough in the field of all solid state devices. Continuous and stable cell cycling for periods exceeding 40 days have been achieved.

These materials are similar to ionic liquids and offer the same low volatility and stability, but are solid at operating temperatures and hence enable the possibility of thin film printing of lithium cells.

An ARC LIEF grant has led to the establishment of a state-of-the-art in-situ solid state NMR Facility at the Geelong campus Waurn Ponds with the ability to image devices during operation. Methods for the measurement of the diffusion of ions and molecules in novel electromaterials are being developed across the Centre.

The Australian Synchrotron is also extensively used for materials characterization and for in-situ battery testing to determine the interface that develops on a Mg anode in a Mg/air battery during cycling.

In addition, the Veeco optical profilometer is also proving invaluable for characterizing the structure of electrode and corroded surfaces.

Below:
The new NMR facility at the Geelong Waurn Ponds campus.

ARC CENTRE OF EXCELLENCE FOR DESIGN IN LIGHT METALS

The Centre brings together all of the leading light alloy research groups in the university sector in Australia.

The Deakin Node designs new metal alloys and develops material design principles to underpin "lightweighting". Reducing the weight of the metals employed in transport is one of the most effective means of reducing energy consumption and adverse environmental emissions.

Professor Peter D Hodgson and Professor Matthew Barnett lead the Deakin University effort, which includes projects on all the three light metals: aluminium, titanium and magnesium.

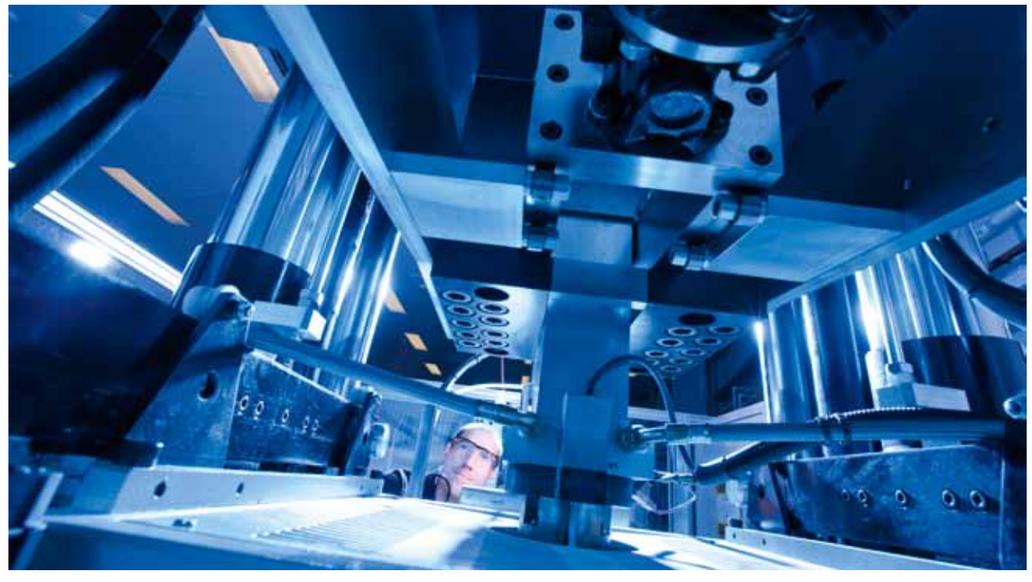
A key challenge for new aluminium alloys is to ensure optimal combinations of properties. In particular, novel advances in strengthening by introducing ultra-fine grains have not been able to guarantee superior fatigue performance. That is, under the application of cyclic loads, failure occurs under lower stresses than desired. This issue was addressed by the group in 2011 and the mechanism for fatigue deterioration was determined. It was also established that a readily implemented solution is an annealing treatment following cyro-rolling.

Titanium is a remarkable metal, displaying superior corrosion resistance and high strength. However, this comes at a considerable cost. In 2011 the group undertook a new project to develop structures with high integrity from powders. With powder feedstock the price per part drops considerably. Initial results reveal the potential of particle stimulated nucleation to promote recrystzallization in order to form uniform fine grain structures.

The lightest of the light metals, magnesium, presents many challenges to conventional manufacturing and design processes. These stem to a large part from its unique plastic response, which is highly anisotropic and still poorly understood.

In 2011, the group made a number of significant findings in respect to how strength can be increased and how anisotropy can be suppressed. In particular, we believe we have found the origin of the grain size strengthening effect when twinning is dominant. It was also discovered, for the first time, that twinning experiences work hardening in similar way to slip. This is a surprising finding that is stimulating considerable discussion. It has been deduced that it must be included to obtain accurate predictions of strength. The models generated in the process of the work are now being coupled to produce a full and general model for the strength of hcp metals undergoing twinning. Once again this year we hosted Professor Bevis Hutchinson from Sweden for three months to support our magnesium research.

Below:
Professor Matthew Barnett looking through a high rate metal deformation simulator.



CAST CRC

CAST Cooperative Research Centre specialises in the industry-driven development of metals technology. CAST is one of the world's leading light metal research institutes and brings industry and research together through a network of Australia's top scientists and engineers in the metals field.

PROCESSING OF A WROUGHT MAGNESIUM ALLOY

Deakin University's partnership with CAST has supported a major collaborative research project, led by Dr Aiden Beer, developing a new magnesium alloy which performs better than its predecessors.

Compared with the most common magnesium alloy, the new alloy, AM-EX1 can be extruded up to five times faster and has similar strength and enhanced ductility. The new alloy's extrusion speed, strength and ductility are comparable to that of a common aluminium alloy.

RESEARCH HIGHLIGHTS OVER THE PAST YEAR INCLUDE:

- The new magnesium alloy has undergone further industrial-scale extrusion trials whereby it was demonstrated that AM-EX1 could be extruded at much higher speeds, and at lower temperatures than the commonly used magnesium alloy AZ31. AM-EX1 also maintained a bright surface finish when extruded at high temperatures.
- AM-EX1 sheet material was successfully produced by extrusion as well as a strip-casting. Rolling schedules were developed for the sheet material to further optimise the final mechanical properties. The amenability of AM-EX1 to sheet production, via various manufacturing routes may open up the possibility of AM-EX1 being used in electronic applications e.g. laptop lids.

MICRO-CAP

This project led by Dr Kannappar Mukunthan is examining the Compact Alloy Processing in a Micro Mill Environment (Micro-CAP) concept for the streamline production of low volume, high value added iron-based flat products.

RESEARCH HIGHLIGHTS OVER THE PAST YEAR INCLUDE:

- Castability and product assessment studies continued to expand the family of alloys that could be suitable for a Micro-CAP facility. Work continued with two new alloy systems - Fe-3Al intermetallics (a special alloy, sometimes produced by powder metallurgy techniques) and Fe-Si electrical steels (presently produced by conventional continuous casting processes).
- A provisional patent covering the production process of specialty alloys (Fe-Cr-Al, Fe-Ni, Fe-Cu-Cr and Fe-3Al) by rapid solidification and cold rolling/annealing (as opposed to conventional ingot casting and processing) was filed.

CAST CRC

MELT HANDLING SYSTEMS AND DROSS GENERATION

Deakin University is participating in the Dross Generation and Melt Handling project.
Dr Bruce Gunn has led the development of a generic discrete-event simulation model for analysing metal flow in the aluminium Casthouse. The model combines a stochastic discrete-event model, with a process model tracking changes in temperature within the furnaces. The model therefore incorporates a combination of stochastic and dynamic elements in order to assess the impact of equipment changes or scheduling optimisation. A comprehensive input parameter interface and output analyser has also been developed to help the ease of use of the model.

The model was delivered to Bell Bay in late 2010, and a number of modifications made on advice from plant personnel. From this, a sensitivity study was performed on the key casting and furnace parameters. The sensitivity study of the plant concluded that the casthouse was very insensitive to change in any of the key parameters investigated. By combining multiple parameters at once, however, the simulation results suggested a more significant change in the casting output on the largest casting station. This was in some agreement with plant information. A technical paper was presented at the 12th Aluminium Cast-house technology conference in Melbourne in September 2011.

INDUSTRY BEST PRACTICE

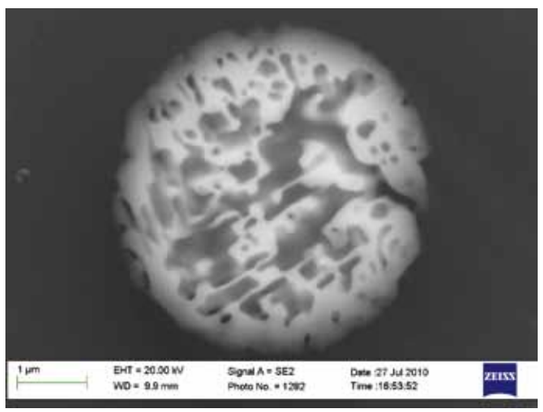
The best practice project, also led by Dr Bruce Gunn, involves undertaking a series of smaller projects with companies in order to enable technology transfer, process improvement and on-the-job training. Most companies worked with are SME's who lack the technical resources to undertake significant innovation projects.

A total of 14 projects were completed in 2011, with technical assistance provided to a number of other companies.

The range of projects completed included:

- The development of 100 front and rear magnesium wheels for go-kart racing vehicles.
- Advice on the use of different phase change materials for storing energy in a solar thermal application.
- A range of projects using casting simulation to assess likelihood of quality defects, or methods to improve productivity.
- Examination of component failure and determining methods to reduce the likelihood of future failure.
- Two projects aimed at improving the coating process for magnesium parts.

Below:
TEM of a eutectic structure found in as-cast Mg – 5wt.% Zn – 1 wt.%Y alloy, heat treated at 400C for 24 hours and quenched in water.



AUTOCRC

The Cooperative Research Centre for Advanced Automotive Technology (AutoCRC) was created in December 2005, as part of a national strategy to secure Australia's position in the global automotive industry.

The Institute for Technology Research and Innovation (ITRI) is involved closely with the AutoCRC through a number of automotive research projects ranging from virtual assembly to tool wear. In 2011 ITRI was involved in two major projects: development of a Lightweight Modular Vehicle Platform (LMVP) to support the next generation of sustainable and safe vehicles ($2M overall project); and the collaboration with Hefei University of Technology (HFUT) China to investigate new automotive technologies and materials.

The LMVP project has created a concept that has significant mass reduction with no major compromise to structural performance, while reducing manufacturing costs. The final concept employs a mix of material and joining alternatives, which are engineered to meet specific functional and structural targets in order to significantly reduce the impact of climate change.

The HFUT collaboration has seen joint work on tool wear research, co-extrusion of magnesium and aluminium alloys, and a major project in polymers and adhesives for a Chinese company (Megabond). Hefei is home to Jianghuai Automobile Company (JAC) and the Chery Automobile Company is based in a smaller city close to Hefei. Thus, this is an ideal region to concentrate on developing light weighting technologies for the Chinese market.

HIGHLIGHTS:

- Announcement of the refunding of the AutoCRC for another 5 years (2012-2017) – Deakin is heavily involved in the sustainable manufacturing theme (lightweighting of vehicles).
- Finalisation of a LMVP concept that meets most of the initial aggressive targets set.

AutoCRC
Smarter Safer Cleaner

ADVANCED MANUFACTURING CRC

The Advanced Manufacturing CRC (AMCRC) aims to set the standard in innovation creation, practice and education. Through our industry and research collaborations we are working to foster the creation of intellectual property in next generation technologies, products and processes.

The AMCRC is part of the Cooperative Research Centres Program where, with funding from the Australian Government, researchers and industries are brought together to develop lasting innovative solutions. With an emphasis on delivering economic, environmental and social benefits, the CRC program combines leading research capabilities with invaluable industry knowledge and intellectual property.

The AMCRC plays a vital role in the development and delivery of cutting edge technologies and a highly skilled workforce to keep Australian manufacturing industries globally competitive and sustainable

NOVEL FLUIDISED BED REACTOR SURFACE MODIFICATION TECHNOLOGY FOR FERROUS AND LIGHT METALS

HARD Technologies and ITRI are exploring the use of fluid bed reactor technology to create novel surface treatment technologies for ferrous and light metals. Through its revolutionary Fluidised Bed Reactor Surface Modification Technology, tools and metal parts surfaces are treated and improved. While its competitors coat the tool's surface, HARD makes the change more durable by transforming the atomic structure.

A duplex process has been developed for aluminium metal forming dies and tooling that has proven to substantially extend die life and increase extrusion speed. The applications therefore can save manufacturers millions of dollars a year in costs.

Work during this project has yielded a new patent and this process is now in the commercialisation phase.

THE QUICKSTEP PROCESS AND RAPID COMPOSITE MATERIALS MANUFACTURING

The Advanced Manufacturing CRC project in collaboration with Quickstep Technologies encompasses nine sub-projects. Aging studies of the key components of the Quickstep processes, including the heat transfer fluid, tray materials and silicone bladder, are almost finalized. Aerospace certified testing of a number of Quickstep cured composite systems is being conducted at the National Composites Certification and Evaluation Facility at the University of Manchester. The effect of exposure to simulated environmental aging conditions of these systems will also be studied. A parametric study of Quickstep cured honeycomb composite structures is also underway, of which core material, ramp angle, core thickness and core adhesion are of primary focus.

RUBBER WASTE RECYCLING

After two years of research, the waste rubber recycling project headed by VR TEK Global will come to a successful close in July 2012. The work at Deakin University has resulted in an entirely new way of processing car and truck waste rubber into high-quality rubber powder. The developments represent a significant breakthrough in tyre recycling that is superior to current practices of shredding and dumping tyres in landfill, burning, or recycling them into low-quality materials of limited use.

This new rubber powder is superior to existing rubber crumb products on the market in a number of ways; it has a very fine particle size distribution, high surface area, low fibre contamination and improved rubber chemistry using novel activation and de-vulcanisation methods. Further, the process uses no chemicals and is very energy efficient.

VR TEK is currently in discussions with several companies, local and international, and is expected to find markets in a variety of applications ranging from conveyor belts, road asphalt additive, rubber automobile components and new tyres. VR TEK will be opening its first commercial facility at the VCAMM Innovation Centre in Knoxfield Victoria.

Waste tyres will be turned into high-quality rubber powder for high value added applications.

ADVANCED MANUFACTURING CRC
Propelling Australian innovators into global manufacturing

SHEEP CRC

The Sheep CRC is a national program aimed at improving productivity gain, wool and meat quality and genetic improvement.

ITRI staff are leading the CRC work in evaluating a simple, cost-effective way to measure and guarantee next-to-skin comfort for knitted wool garments using the new Wool Comfort Meter.

ITRI staff have conducted analyses to quantify the relationship between next-to-skin comfort ratings determined by wearers with the fabric design attributes and wool fibre properties. An evaluation of the effect of fabric finishing treatment on the comfort properties of wool fabrics determined by the Wool Comfort Meter has been completed.

ITRI staff have designed and are currently undertaking a national laboratory round trial to determine the precision limits for the instrument.

ITRI staff were also involved in a national collaboration to develop a faster and cheaper test method to determine wearer responses to wool fabric properties. The developmental work to date has identified preferred wool fabric, yarn and fibre properties associated with high levels of wearer comfort.

An ITRI staff member, Dr Bruce McGregor, was a keynote presenter at the National Wool Industry Research and Development workshop in Sydney, held in November 2011. The workshop identified key future research priorities for the wool industry.

A new Sheep CRC Postgraduate Student, Mr James Preston, is now investigating wool handle attributes used by farmers to identify sheep that have preferred soft handling wool.

SHEEP CRC

FINANCIAL DATA

FINANCIAL SUMMARY - For Period Ended 31 December 2011	2011 ACTUAL
INCOME	$
External Research Income	12,769,652
Strategic Initiatives	-
Operational Initiatives	2,381,873
University Operating Funds	5,863,180
Research Allocation	6,574,876
Total Income	27,589,581
EMPLOYMENT COSTS	
Academic Salaries	11,086,124
General Salaries	3,704,093
Other Employment Costs	49,313
Contractors	16,447
Total Employment Costs	14,855,977
NON SALARY EXPENSES	
Buildings & Grounds Infrastructure Costs	121,559
Communication/Advertising, Marketing & Promotions	49,555
Consumables	1,352,752
Depreciation & Amortisation	4,666,927
Equipment - Repairs, Maintenance & Other Costs	1,343,518
Financial, Borrowing, Debtors & Currency Costs/Legal Costs & Consultants	8
Inter Budget Centre/Internal Charges/Recoveries	360,352
Contributions to other Universities	693,718
Other Costs	348,757
Professional, Legal and Consultants	263,592
Staff Recruiting, Training & Other/Library Information Resource Expenses	340,752
Student Expenses	2,026,397
Travel, Catering & Entertainment	836,632
Total Non Salary Expenses	12,404,519
Surplus/(Deficit)	329,085

GRANT HOLDERS AND THEIR PROJECTS

EXTERNAL GRANTS - Reportable

Category 1 - Australian Competitive Grants

Commonwealth Schemes

Australian Research Council Discovery	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
A Microstructure Based Approach to Steel Design for Improved Crash Performance	P D Hodgson, I Timokhina	-	2007	$145,000	-
		-	2008	$135,000	-
		-	2009	$135,000	-
		-	2010	$100,000	-
Titanium Alloy Scaffolds for Osseointegration Implant Materials	C Wen, W Yan, G C Nicholson	-	2007	$110,000	-
		-	2008	$110,000	-
		-	2009	$110,000	-
Development of New Steel Products by Thin Strip Casting and Direct Thermomechanical Processing	P D Hodgson, D J Phelan, J H Beynon, L Strezov, N Stanford, R J Dippenaar, J Sietsma, B J Thijsse	-	2008	$200,000	-
		-	2009	$225,000	-
		-	2010	$186,000	-
		-	2011	$214,000	-
Nanostructure Design and Toughening Mechanisms of Novel Thermosets (University of Sydney Administering Org)	Y W Mai, Q Guo	-	2008	$89,532	-
		-	2009	$75,284	-
		-	2010	$75,060	-
		-	2011	$51,512	-
Field Enhanced Electrospinning for Fine and Uniform Nanofibres	Tong Lin, Xungai Wang	-	2009	$119,000	-
		-	2010	$119,000	-
		-	2011	$113,000	-
Protein Fibre Powders: Production, Characterisation and Applications	Xungai Wang, Takuya Tsuzuki	-	2010	$140,000	-
		-	2011	$150,000	-
		-	2012	$160,000	-
Polymerization of amyloid fibrils and electroactive hybrid nanowires using ionic liquids	Nolene Byrne	-	2010	$105,000	-
		-	2011	$105,000	-
		-	2012	$105,000	-
A new angle on the coalescence of drops	Roger Horn	-	2010	$90,000	-
		-	2011	$82,946	-
		-	2012	$100,000	-
Interphase engineering of reactive metal surfaces using ionic liquids	Maria Forsyth	-	2010	$85,856	-
		-	2011	$211,565	-
Magnetic Manipulation of Liquid Droplets for Novel Channel-free Microfluidics and Microreactors	Yan Zhao	-	2011	$86,340	-
		-	2012	$85,000	-
		-	2013	$85,000	-
Superhydrophobic Fabrics for Solar Desalination of Seawater	Hong Xia Wang	-	2011	$87,355	-
		-	2012	$83,000	-
		-	2013	$83,000	-
Directional Fluid-transfer in Thin Porous Materials with Imbalanced Wettability	Tong Lin; Xin Lui	-	2011	$70,000	-
		-	2012	$70,000	-
		-	2013	$70,000	-
Ultra-fine Boron Nitride nanotubes	Ying Chen	-	2011	$60,000	-
		-	2012	$120,000	-
		-	2013	$120,000	-
		-	2014	$60,000	-

GRANT HOLDERS AND THEIR PROJECTS

Australian Research Council Linkage	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
The Properties and Processing Performance of Ultrasonically Cleaned Wool Fibres	Xungai Wang, Tong Lin, H Yu	Shangdong Ruyi Woollen Textile Co Lot	2009	$100,000	$35,000
			2010	$100,000	$33,000
			2011	$100,000	-
Enabling Ambient Intelligence for Manufacturing Processes through Distributed Camera Networks	Saeid Nahavandi	ARC, Boeing Defence Australia, Holden, VESTAS Technology R&D	2011	$43,169	$84,000
			2012	$89,660	$28,000
			2013	$85,000	$28,000
			2014	-	$28,000
Engineering a silk fibroin based ear drum with optimum acoustic properties	Xungai Wang	ARC, Ear Science Institute Incorporated	2011	$51,803	-
			2012	$108,120	$66,858
			2013	$109,900	$33,392
			2014	$101,000	$12,500
			2015	-	$12,250
Design strategy for cold rolled formed products	Peter D Hodgson, Bernie Rolfe, Chunhui Yang	ARC, Aust Rollforming Manufacturers (ARM), DataM Software GmbH, Applied Research and Development (ARD)	2008	$37,500	-
			2009	$75,000	$30,000
			2010	$75,000	$30,000
			2011	$37,500	$30,000
Value adding to Australian Cashmere Fleece	Xungai Wang, Tong Lin, Takuya Tsuzuki	ARC, Cashmere Connections P/L	2008	$46,750	$15,000
			2009	$93,441	$30,000
			2010	$95,572	$30,000
			2011	$48,881	$15,000
Distributed Real-time Multiobjective Scheduling for Joinery Manufacturing Processes using Discrete Event Simulation	Saeid Nahavandi, Doug Creighton	Informatic Technologies Pty Ltd	2009	$42,500	$34,500
			2010	$82,500	$34,500
			2011	$75,000	$34,500
			2012	$35,000	-
Enhanced Mechanical Properties of Steel Sheet through Novel Approach in Asymmetric Rolling	Rimma Lapovok, Ilana Timokhina, Peter D Hodgson, Laszlo Toth, Debashish Bhattacharjee	Laboratoire De Physique Et Mecanique Des Materiaux, Tata Steel Pty Ltd	2009	$26,140	$6,000
			2010	$26,140	$6,000
			2011	$26,140	$6,000
Haptic Realisation of Visual Art for the Blind and Visually Impaired	Saeid Nahavandi, Ben Patrick Horan	Australian Council for the Arts	2010	$55,000	$22,000
			2011	$46,657	$22,000
			2012	$50,000	$22,000
Formation and characterisation of continuous electrospun nanofibre yarns	Lingxue Kong, Xungai Wang, Tong Lin	Guangzhou Textile Union Group	2010	$100,000	$32,000
			2011	$101,609	$32,000
			2012	$100,000	$32,000
Advanced 3D Fibrous Structures for Vascular Graft Applications	Xungai Wang	Brookland Greens Medical Centre	2011	$55,000	$20,000
			2012	$58,016	$20,000
			2013	$55,000	$20,000

GRANT HOLDERS AND THEIR PROJECTS

Australian Research Council Australian Laureate Fellowship	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
Metal Processes and Products for a Sustainable Future	Peter D Hodgson	-	2009	$212,731	-
		-	2010	$425,462	-
		-	2011	$450,066	-
		-	2012	$425,462	-
		-	2013	$353,182	-
		-	2014	$176,591	-
New Materials for a Sustainable Energy Future	Maria Forsyth	-	2011	$210,000	-
		-	2012	$456,218	-
		-	2013	$487,500	-
		-	2014	$487,500	-
		-	2015	$432,500	-
		-	2016	$210,000	-

Australian Research Council Australian Future Fellowship	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
Growing a multi-scale internal structure: new wrought metals for energy conservation	Matthew Barnett	-	2011	$206,400	-
		-	2012	$214,024	-
		-	2013	$202,373	-
		-	2014	$101,074	-

Australian Research Council Centre of Excellence	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
Centre for Design in Light Metals	Peter D Hodgson, Matthew Barnett, Barry Muddle	Monash University, University of Sydney, The University of New South Wales, University of South Australia, The University of Melbourne, University of Queensland, Department of Innovation, Industry and Regional Development	2005	$0	-
			2006	$400,000	-
			2007	$400,000	-
			2008	$400,000	-
			2009	$400,000	-
			2010	$400,000	-
			2011	$400,000	-
			2012	$400,000	-
			2013	$400,000	-
Centre for Electromaterials Science	Maria Forsyth	-	2010	$135,005	-
		-	2011	$259,399	-
		-	2012	$259,399	-
		-	2013	$259,399	-

Cotton Research & Development Corporation	Investigator	Industry Partner / Funding Body	Years	NHMRC Funding	Industry Funding
Development of low twist fine count yarns and fabrics from Australian Long Staple Upland cotton	Xungai Wang	CRDC	2010	$60,000	-
			2011	$120,000	-
			2012	$120,000	-
			2013	$60,000	-

Australia-India Strategic Research Grants	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
Anti-tumour and anti-microbial activities of orally administered Fe-saturated lactoferrin: a potential alternative medicine	Jagat Kanwar	Department of Innovation, Industry, Science and Research - Australia-India Strategic Research Fund	2009	$126,000	-
			2010	$126,000	-
			2011	$28,000	-
Developing Biodegradable Magnesium Alloys for Implant Materials	Cui'e Wen, Peter D Hodgson	Department of Innovation, Industry, Science and Research - Australia-India Strategic Research Fund	2009	$120,000	-
			2010	$85,000	-
			2011	$20,000	-

GRANT HOLDERS AND THEIR PROJECTS

Rural Industries R&D Corporation	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
Improving production efficiency, quality and value adding of rare natural fibres	Xungai Wang	RIRDC	2008	$66,700	-
			2009	$88,819	-
			2010	$88,819	-
			2011	$22,500	-
Improving knowledge, fibre and textile quality and communication	Xungai Wang	RIRDC	2011	$56,000	-
			2012	$20,000	-

Non-Commonwealth Schemes

Australian Institute of Nuclear Science and Engineering (AINSE)	Investigator	Industry Partner / Funding Body	Years	AINSE Funding	Industry Funding
Nanostructure Design and Toughening Mechanisms in Thermosets using Reactive Block Copolymers	Qipeng Guo	AINSE	2010	$7,500	-
			2011	$7,500	-
Self-Assembled Complex Micelles and Vesicles for Biomedical Applications	Nishar Hameed	AINSE	2011	$7,268	-
An investigation ofmetal ion binding properties of protein fibre powders (PFP) using nuclear techniques.	Tong Lin	AINSE	2011	$4,375	-

National Centre of Excellence in Desalination	Investigator	Industry Partner / Funding Body	Years	AINSE Funding	Industry Funding
Smart Materials for Corrosion Management	Maria Forsyth	DEWHA	2011	$48,000	-
			2012	$122,000	-
			2013	$150,000	-
			2014	$130,000	-

Category 2 - Other Public Sector Income

Commonwealth funding	Investigator	Industry Partner / Funding Body	Years	C'lth Funding	Industry Funding
Fabrication and characterisation of novel nanostructured lyotropic liquid crystalline membranes	Lingxue Kong	CSIRO	2009	$11,000	-
			2010	$11,000	-
			2011	$5,500	-
Strategies for developing self-repairing oxides to protect steel system	Maria Forsyth	CSIRO	2011	$16,000	-
			2012	$32,000	-
			2013	$32,000	-
			2013	$16,000	-
Controlled porosity biomaterials scaffolds based on self-assembled microemulsion templating	Qipeng Guo	CSIRO	2009	$20,000	-
			2010	$20,000	-
			2011	$20,000	-
Collaboration on environmental remediation in Australia and China	Lingxue Kong	DEEWR - Endeavour Research Fellowships	2011	$20,000	-
Improving production efficiency, quality and value adding of rare natural fibres	Xungai Wang	RIRDC	2008	$66,700	-
			2009	$88,819	-
			2010	$88,819	-
			2011	$22,500	-
Haptically Enabled Counter IED Robot	Saeid Nahavandi	Department of Defence	2009	$753,000	-
			2010	$1,019,000	-
			2011	$674,000	-

GRANT HOLDERS AND THEIR PROJECTS

Category 3 - Industry and Other Funding

Australian Grants	Investigator	Industry Partner / Funding Body	Years	C'lth Funding	Industry Funding
Powercor Australia Ltd - Tie Wire Assessment	Paul Collins	Powercor Australia Ltd	2011	-	$14,843
I-Beam Optimisation Design	Paul Collins	(ARM) Australian Rollforming Manufacturers	2010	-	$53,814
			2011	-	$4,000
Report into long term trends in automotive steels	Paul Collins	BHP Billiton	2011	-	$18,200
Non-destructive Evaluation of Carbon Fibre Wheels	Tim Hilditch	Cfusion	2011	-	$21,521
			2012	-	$64,563
VR TEK Wheels Initial Feasibility Study	Paul Collins	VR TEK Wheels Pty Ltd	2011	-	$5,000
			2012	-	$5,000
PE Pipe Material Upgrade Feasibility Study	Bronwyn Fox	Qenos	2011	-	$95,350
			2012	-	$190,700
Investigating the potential electrical current absorption of a carbon fibre composite spinal board after electrical discharge of a defibrillator	Kevin Magniez	DHS Emergency	2011	-	$2,138
Testing of Fibre Reinforces Composites using the losipescu method	Kevin Magniez	ZedCon Scientific Services	2011	-	$12,000
Materials for protective gloves	Xungai Wang, Christopher Hurren	Hysport International Pty Ltd	2010	-	$40,000
			2011	-	$140,000
			2012	-	$70,000
Researcher in Business - United Surface Technologies	Daniel Fabijanic	United Surface Technologies Pty Ltd	2011	-	$14,625
Researcher in Business - Zhik Pty Ltd	Christopher Hurren	Zhik Pty Ltd	2011	-	$73,775
Investigation into Aircraft Plastic's repair components	Bronwyn Fox	Aircraft Plastics Australia Pty Ltd	2011	-	$134,188
Research, Development, Design and Manufacture of a New Combat Helmet	Bronwyn Fox	VCAMM	2010	-	$56,000
			2011	-	$118,000

International Funding	Investigator	Industry Partner / Funding Body	Years	C'lth Funding	Int'l Funding
Stamping Technology for Automotive Processes	Peter D Hodgson	Ford Motor Co of Australia	2011	-	$104,530
			2012	-	$35,000
			2013	-	$35,000
			2014	-	$35,000
Research on Parallel Kinematics Robot	Saeid Nahavandi	Boeing Defence	2010	-	$42,000
Research of Mg-air primary cell with the corrosion control electrolyte	Maria Forsyth	Honda R&D Co., Ltd	2011	-	$60,000
Analysis of Scara-Tau Parallel Kinematic	Saeid Nahavandi	ABB Technology	2010	-	$50,000
			2011	-	$100,000
Hemp fibre separation	Christopher Hurren	Logistik Unicorp Inc	2011	-	$80,000
			2012	-	$283,880

GRANT HOLDERS AND THEIR PROJECTS

Category 4 - Cooperative Research Centres (CRC)

CAST CRC	Investigator	Industry Partner / Funding Body	Years	CRC Funding	Industry Funding
Wrought Magnesium Alloy Development	Matthew Barnett	CRC CAST	2005	$17,470	-
			2006	$207,295	-
			2007	$205,434	-
			2008	$276,835	-
			2009	$150,535	-
			2010	$301,236	-
			2011	$40,462	-
Melt Handling Systems & Dross Generation	Yakov Frayman, Saeid Nahavandi	CRC CAST	2006	$59,553	-
			2007	$102,176	-
			2008	$50,700	-
			2009	$114,349	-
			2010	$96,913	-
			2011	$6,699	-
Die Casting Productivity	Saeid Nahavandi	CRC CAST	2009	$65,477	-
			2010	$68,469	-
			2011	$65,640	-
Compact Alloy Processing in a Micro Mill Environment	Matt Barnett	CRC CAST	2010	$269,726	-
			2011	$41,395	-

AUTO CRC	Investigator	Industry Partner / Funding Body	Years	CRC Funding	Industry Funding
Development of a lightweight modular mixed material vehicle platform - C2-23	Matthew Edward Dingle, Timothy Brian Hilditch, Bernard Frank Rolfe, Frank Stefan Will	CRC CAST	2010	$250,000	-
			2011	$250,000	-
			2012	$250,000	-
Metal Core Foam Sandwich	Ciu'E Wen	AutoCRC	2008	$33,000	-
			2009	$33,000	-
			2010	$33,000	-
			2011	$16,500	-
Ultrastrong polymer nanocomposites for future automobiles	Lingxue Kong	AutoCRC	2009	$36,300	-
			2010	$36,300	-
			2011	$36,300	-
Tool Wear Prediction	Peter D Hodgson, Tim Hilditch	AutoCRC	2008	$127,414	-
			2009	$288,706	-
			2010		-
			2011	$65,218	-
Lightweight Interiors	Bronwyn Fox	AutoCRC	2010	$107,806	-
			2011	$191,694	-
			2011	$50,000	-
The Fatigue Behaviour of Cost Effective Magnesium and Titanium Alloys	Aiden Beer, Matthew Barnett, Rupinder Sian	AutoCRC	2010	$33,000	-
			2011	$33,000	-
			2012	$33,000	-
Lightweight Vehicle Structures	Bernard Rolfe, Lingxue Kong	AutoCRC	2010	$189,946	-
			2011	$121,123	-
			2012	$88,931	-
Virtual Simulated Work Environment	Saeid Nahavandi	AutoCRC	2010	$440,000	-
			2011	$282,130	-

GRANT HOLDERS AND THEIR PROJECTS

AMCRC	Investigator	Industry Partner / Funding Body	Years	CRC Funding	Industry Funding
Development of Macroporous Scaffolds for Biomedical Applications	Peter D Hodgson	AMCRC	2009	$107,945	-
			2010	$115,466	-
			2011	$93,255	-
Complex Composite for Load Bearing Applications	Bronwyn Fox, Russell Gallagher	AMCRC	2009	$166,030	-
			2010	$45,330	-
			2011	$417,992	-
			2012	$20,000	-
Nano-enhanced carbon fibre composites	Bronwyn Fox, Kevin Magniez	AMCRC	2009	$54,692	-
			2010	$47,676	-
			2011	$18,155	-
			2012	$3,000	-
Novel Fluidised Bed Reactor Surface Modification Technology for Ferrous and Light Metals	Dan Fabijanic, Peter D Hodgson, Ivica Cicak	AMCRC	2009	$314,991	-
			2010	$174,043	$6,705
			2011	$33,863	-
Quickstep & RST	Bronwyn Fox	AMCRC	2009	$178,875	-
			2010	$230,062	-
			2011	$78,060	-
			2012	$26,873	-
Rubber Waste recycling Product Ozone based Reclaiming and Activation of Rubber and Rubber Devulcanisation	Qipeng Guo	AMCRC, VR TEK Golobal Pty Ltd, VCAMM Ltd	2009	$40,000	-
			2010	$598,841	-
			2011	$305,732	-
			2012	$61,433	-
Armour Research	Bronwyn Fox, Minoo Naebe	VCAMM Ltd	2010	$56,000	-
			2011	$118,000	-
Novel self-healing fibre-reinforced composites	Kevin Magniez	AMCRC	2010	$18,750	-
			2011	$38,518	-
			2012	$34,288	-
			2013	$30,138	-
			2014	$4,586	-

Cooperative Research Centre (CRC) - SHEEP	Investigator	Industry Partner / Funding Body	Years	CRC Funding	Industry Funding
Sheep CRC Colour Program - Deakin 01-Wool Colour	Xungai Wang	Sheep CRC	2009	$25,000	-
			2010	$128,163	-
			2011	$193,164	-
Greasy Wool Handle	Bruce McGregor	Sheep CRC	2011	$15,000	-
			2012	$30,000	-
			2013	$15,000	-

GRANT HOLDERS AND THEIR PROJECTS

EXTERNAL GRANTS - Non-Reportable

Australian Research Council Linkage Infrastructure Equipment (LEIF) Grant	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
Field-emission gun transmission electron microscope for the research in nanomaterials, metal alloys and biological sciences	Ying Chen, Matthew Barnett, Peter D Hodgson, Xungai Wang, Takuya Tsuzuki, Cui'E Wen, Alexey Glushenkov, Lingxue Kong, Charles Sorrell, Yuebin Zhang, Vicki Chen, Dominic Phelan, Ken Walder, Germanas Peleckis, Simon Moulton, John Beynon, Xiaolin Wang, David Cahill, Pavel Cizek, Neil Barnett, Nicole Stanford, Qipeng Guo		2010	$1,000,000	-
			2011	$230,000	-
Facility for the development of new lightweight extruded alloys and structures	Aiden Beer		2011	$559,000	-
Facility for in-situ NMR of advanced materials and devices	Maria Forsyth		2011	$1,304,000	-
Advanced in-situ electron microscope facility for research in alloys, nanomaterials, functional materials, magnetic materials and minerals	Peter D Hodgson		2011	$1,000,000	-
A Comprehensive Magneto-Thermophysical Property Measurement System for the Development of Advanced Materials, Energy and Biomedical Technologies	Ying Chen		2011	$100,000	-

Australian National Data Service (ANDS) Grants	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Education Investment Fund (EIF)
DC20A Crystal Orientation Data Collection for Conversation to a General Data Type	Matthew Barnett	Australian National Data Service	2011	-	$100,000
DC20B Enhancing Filtration Membrane Fouling Data Collection for Water Treatment Research	Mary She	Australian National Data Service	2011	-	$100,000

Collaborative Research Network	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Industry Funding
Self-sustaining Regions Research and Innovation Initiative	Saeid Nahavandi	Ballarat University	2011	-	$189,998
			2012	-	$189,998
			2013	-	$189,998
			2014	-	$189,998

Education Investment Fund (EIF) Grant	Investigator	Industry Partner / Funding Body	Years	ARC/C'lth Funding	Education Investment Fund (EIF)
Australian National Fabrication Facility Ltd	Xungai Wang	Monash University	2011	-	$1,000,000

GRANT HOLDERS AND THEIR PROJECTS

INTERNAL GRANTS - Non-Reportable

Central Research Grants Scheme (CRGS)	Investigator	Industry Partner / Funding Body	Years	DVCR Funding	Industry Funding
New degradable bionanocomposites based on natural polymers and amyloid fibers	Nolene Byrne	Deakin University	2011	$20,000	-
Stable Nanostructured Micelles and Vesicles for Advanced Drug Delivery	Nishar Hameed	Deakin University	2011	$15,000	-
Eco-friendly carbon nanofibre production from green nanomaterials	Takuya Tsuzuki	Deakin University	2011	$20,000	-
UV-Protection of Fabrics Using Organic/ Inorganic-Hybrid Nanoplatelet Coatings	Yan Zhao	Deakin University	2011	$20,000	-
Organic Ionic Plastic Crystal Electrolytes Based on the Bisoxalatoborate Anion	Patrick Howlett	Deakin University	2011	$20,000	-
New approach to controllable nitrogen doping for improved nano-semiconductors	Jane Dai	Deakin University	2011	$20,000	-
Electrospinning of Anti-Infective Nanofibre Wound Dressings	Xin Liu	Deakin University	2011	$15,000	-
Graphene-Reinforced Polymer Composite Nanofibres	Minoo Naebe	Deakin University	2011	$12,000	-
Wild silkworm cocoon as a model for advanced protective clothing	Rangam Rajkhowa	Deakin University	2011	$17,000	-
Piezoelectric Electrospun Nanofibre Yarns for Energy Harvesting	Jian Fang	Deakin University	2011	$15,000	-
Desalination of Water using Superhydrophobic Fabrics	Hong Wang	Deakin University	2011	$15,000	-
Novel polyurethane scaffolds for vascular grafts: addition of basement membrane	Cynthia Wong, Xin Liu	Deakin University	2011	$15,000	-
A Study on the Dynamics of Ultrasonic Cavitation Bubble	Qing Li	Deakin University	2011	$20,000	-
Nanoporous Titania on Titanium-based biomaterials for Controlled Drug Delivery	Jianyu Xiong	Deakin University	2011	$15,000	-

Deakin University Near Miss Funding	Investigator	Industry Partner / Funding Body	Years	DVCR Funding	Industry Funding
Near Miss Funding 2011 Jianyu Xiong	Jianyu Xiong	Deakin University	2010	$5,000	-
			2011	$5,000	-

Research Equipment Scheme (RESS)	Investigator	Industry Partner / Funding Body	Years	Central Funding	Industry Funding
Surface Energy Analyser (SEA) for Characterisation of Fibres / Polymers / Composites / Powders	Bronwyn Fox	-	-	$90,000	-
Isothermal Titration Calorimetry: for accurately measuring the thermodynamics of molecular interactions	Nolene Byrne	-		$100,000	-
State of the art elemental analysis for Deakin's electron microscope laboratory	Andrew Sullivan	-	-	$125,000	-
Multiangle light scattering (MALS) system for advanced molecular weight determination and particle size analysis	Nishar Hameed	-		$55,000	-
EXAscan - High Resolution 3D Scanner to bring real life to the virtual world	Paul Collins	-	-	$95,000	-
Energy Dispersive X-Ray Spectroscopy (EDXS) facility for elemental analysis and imaging	Patrick Howlett	-		$75,000	-
Micro fabrication facility for biomedical, forensic and environmental applications	Sugumar Dharmalingam	-	-	$90,000	-

GRANT HOLDERS AND THEIR PROJECTS

Alfred Deakin Fellowships	Investigator	Industry Partner / Funding Body	Years	DVCR Funding	Industry Funding
Sugumar Dharmalingam	Lingxue Kong	-	2010	$51,552	-
			2011	$85,598	-
			2012	$44,938	-
Xiao Kai Hu	Ciu'E Wen	-	2010	$51,552	-
			2011	$85,598	-
			2012	$44,938	-
Weiwei Lei	Ying Chen	-	2010	$51,552	-
			2011	$85,598	-
			2012	$44,938	-
Ming Wen	Ciu'E Wen	-	2010	$51,552	-
			2011	$85,598	-
			2012	$44,938	-
Jianyu Xiong	Peter D Hodgson	-	2010	$51,552	-
			2011	$85,598	-
			2012	$44,938	-
Daoyong Cong	Matthew Barnett	-	2011	$82,345	-
			2012	$82,345	-
Nishar Hameed	Qipeng Guo	-	2011	$82,345	-
			2012	$82,345	-
Daniel Liu	Ying Chen	-	2011	$82,345	-
			2012	$82,345	-
Zheng Peng	Lingxue Kong	-	2011	$82,345	-
			2012	$82,345	-
Jaka Barry Sunarso	Maria Forsyth	-	2011	$82,345	-
			2012	$82,345	-
Bin Tang	Xungai Wang	-	2011	$82,345	-
			2012	$82,345	-
Dengke Yang	Peter D Hodgson	-	2011	$82,345	-
			2012	$82,345	-
Abbas Khosravi	Saeid Nahavandi	-	2011	$52,345	-
			2012	$52,345	-
Chuanxiang Qin	Tong Lin	-	2011	$52,345	-
			2012	$52,345	-
Chintha Handapangoda	Saeid Nahavandi	-	2011	$46,675	-
			2012	$56,224	-

INDUSTRY PARTNERS

FIBRES AND TEXTILES

Barwon Health
Brookland Greens Medical Centre
Cashmere Connections Pty Ltd
Cotton Research and Development Corporation
Cytomatrix Pty Ltd
Ear Science Institute Incorporated
Geofabrics Australasia Pty Ltd
Guangzhou Textile Union Group Co.
Hysport International Pty Ltd
Hysport International Pty Ltd
International Fibre Centre (IFC)
Shangdong Ruyi Technology Group

METALS AND COMPOSITES

Aircraft Plastics Australia Pty Ltd
Applied Research and Development
Australian RollForming Manufacturers Pty Ltd
BHP Billiton
CFusion Pty Ltd
DataM Software GMBH
DHS Emergency
Ford Motor Company
FTS Australasia Pty Ltd
GM Holden
Hard Technologies Pty Ltd
Honda R&D Co., Ltd
JE Hoffmann Engineering Pty Ltd
Laboratoire De Physique Et Mecanique Des Materiaux
Logistik Unicorp Inc.
Powercor Australia Ltd
Quenos
QuickStep Technologies Pty Ltd
Shinil Chemical Company
Tata Steel Pty Ltd
United Surface Technologies Pty Ltd
VR TEK Global Pty Ltd
VR TEK Wheels Pty Ltd
VRTek Global Pty Ltd
ZedCon Scientific Services
Zhik Pty Ltd

INTELLIGENT SYSTEMS

3G Engineering
ABB Technology
Australian Council for the Arts
Boeing Defence Australia
Defence Science and Technology Organisation (DSTO)
GM Holden
GM US
Informatic Technologies Pty Ltd
VESTAS Technology R&D

BIOTECHNOLO GY

Dairy Australia
Interpath Services Pty Ltd
Kemin Nutrisurance
Ocean Nutrition Canada Ltd
Prime Nutrition
Warrnambool Cheese and Butter Co. Hold. Ltd

COOPERATIVE RESEARCH CENTRES

Advanced Manufacturing CRC
AutoCRC
CAST CRC
Sheep CRC

CENTRES OF EXCELLENCE

Design in Light Metals
Electromaterials Science
Functional Nanomaterials

PUBLICATIONS

BIODEAKIN PUBLICATIONS 2011

JOURNAL PAPERS

1 Kaur, Inderdeep*, Yadav, Santosh K.*, Hariprasad, Gururao*, Gupta, R. C.*, Srinivasan, Alagiri*, Batra, Janendra K.* and Puri, Munish (2011) Balsamin, a novel ribosome-inactivating protein from the seeds of Balsam apple Momordica balsamina, Amino acids, pp. 1-9, Springer Wien, Vienna, Austria

2 Attri, Pankaj*, Venkatesu, Pannuru*, Kumar, Anil* and Byrne, Nolene (2011) A protic ionic liquid attenuates the deleterious actions of urea on Î±-chymotrypsin, Physical chemistry chemical physics, vol. 13, no. 38, pp. 17023-17026, Royal Society of Chemistry, Cambridge, England

3 Baratchi, Sara, Kanwar, Rupinder K. and Kanwar, Jagat R. (2011) Novel survivin mutant protects differentiated SK-N-SH human neuroblastoma cells from activated T-cell neurotoxicity, Journal of neuroimmunology, vol. 233, no. 1-2, pp. 18-28, Elsevier BV, Amsterdam, Netherlands

4 Baratchi, Sara, Kanwar, Rupinder K. and Kanwar, Jagat R. (2011) Survivin mutant protects differentiated dopaminergic SK-N-SH cells against oxidative stress, PLoS ONE, vol. 6, no. 1, pp. 1-8, Public Library of Science, San Francisco, California

5 Bivalkar-Mehla, Shalmali*, Vakharia, Janaki*, Mehla, Rajeev*, Abreha, Measho*, Kanwar, Jagat Rakesh, Tikoo, Akshay* and Chauhan, Ashok* (2011) Viral RNA silencing suppressors (RSS) : novel strategy of viruses to ablate the host RNA interference (RNAi) defense system, Virus research, vol. 155, no. 1, pp. 1-9, Elsevier BV, Amsterdam, Netherlands

6 Burrow, H., Kanwar, R. K. and Kanwar, J. R. (2011) Antioxidant enzyme activities of iron-saturated bovine lactoferrin (Fe-bLf) in human gut epithelial cells under oxidative stress, Medicinal chemistry, vol. 7, no. 3, pp. 224-230, Bentham Science Publishers, Bussum, Netherlands

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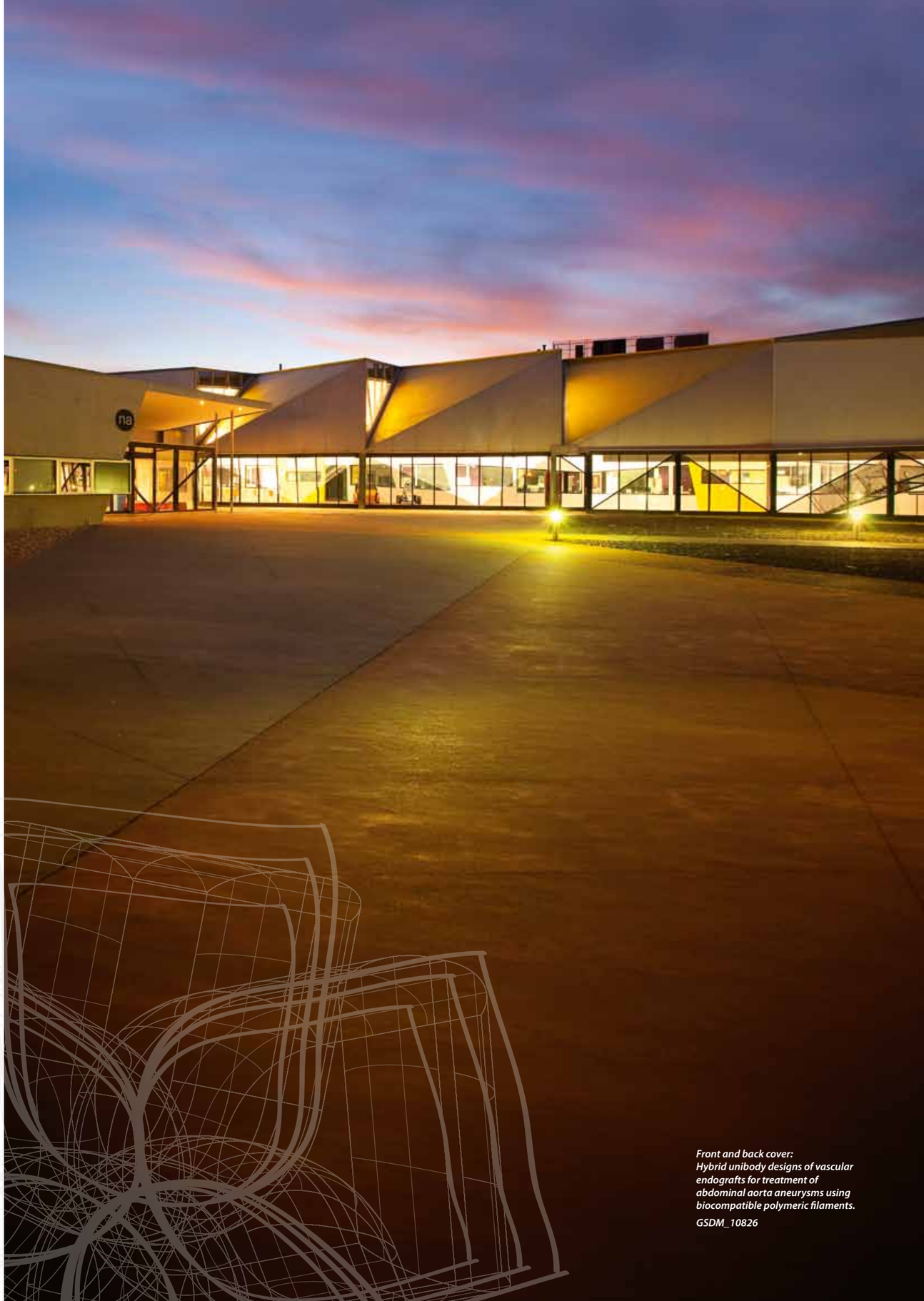

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Hybrid unibody designs of vascular endografts for treatment of abdominal aorta aneurysms using biocompatible polymeric filaments.

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