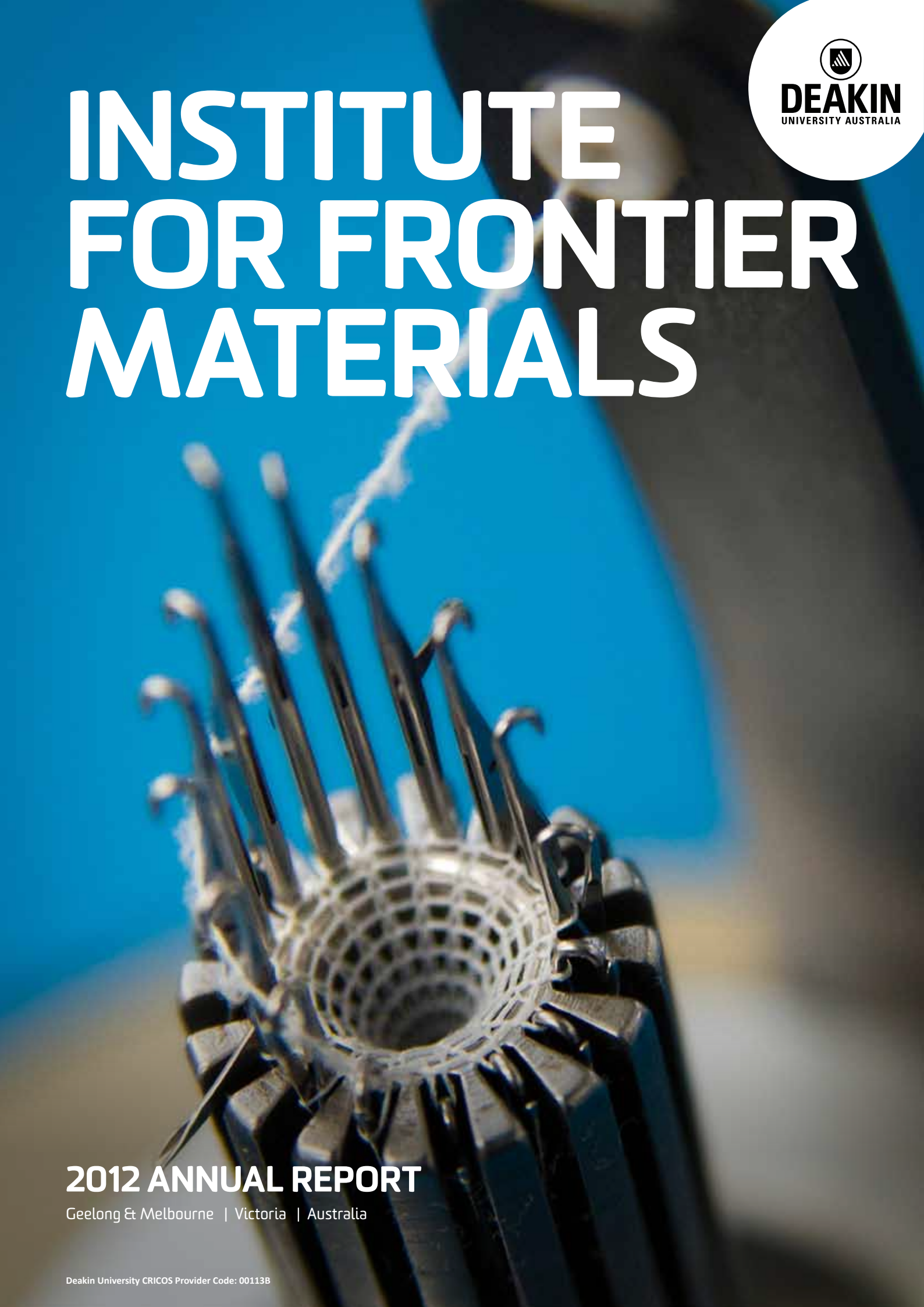
DEAKIN
UNIVERSITY AUSTRALIA

INSTITUTE FOR FRONTIER MATERIALS



2012 ANNUAL REPORT

Geelong & Melbourne | Victoria | Australia

Deakin University CRICOS Provider Code: 00113B

ABOUT US

The Institute for Frontier Materials (IFM) was founded in 2012 in recognition of Deakin's research strength in materials science.

Our mission is to foster innovation and excellence in materials science and engineering research with the aim of addressing the following critical societal objectives:

- Innovative manufacturing technologies
- Energy efficiency, resource and infrastructure sustainability.

IFM is led by Laureate Fellow Professor Peter Hodgson supported by Deputy Director Professor Xungai Wang, Professor Maria Forsyth and Professor Matthew Barnett.

IFM EXECUTIVE TEAM

PROFESSOR PETER D HODGSON

Director of the Institute for Frontier Materials

PROFESSOR XUNGAI WANG

Alfred Deakin Professor, Institute for Frontier Materials

PROFESSOR MARIA FORSYTH

Australian Laureate Fellow, Institute for Frontier Materials

PROFESSOR MATTHEW BARNETT

ARC Future Fellow and Chair in Metallurgy, Institute for Frontier Materials

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IFM IN 2012

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

CHAIRPERSON'S REPORT

The Institute for Frontier Materials has had another very productive and successful year. IFM was again recognised as one of the leading materials research institutes in Australia through the 2012 ERA, achieving the highest ranking possible (5) in the categories of 'Materials Engineering' and 'Macromolecular and Materials Chemistry'.

Deakin University was one of only four other universities achieving this score, primarily as a result of IFM research excellence. The research areas of Nanotechnology, Manufacturing Engineering and Mechanical Engineering scored a ranking of 4, classed as above world standard in ERA. I congratulate everyone in IFM for these superb results, as they arise as a result of high commitment and performance at all levels.

Collaboration with international institutions, including industry, academia and government departments was enhanced and broadened in 2012. IFM has secured two new ARC Linkage Project Grants to develop advanced materials processes for steel and wool in collaboration with Wuhan Iron and Steel (Group) Corporation (WISCO) and Shandong Ruyi Woollen Textile Co.

The annual Deakin – WISCO forum on advanced high strength steels was successfully held in Geelong, attracting more than 60 leading national and international research scientists. IFM welcomed high level delegations from WISCO, Wuhan Textile University, Wuhan University of Science and Technology and China Iron and Steel Research Institute Group (CISRI). A number of new collaborations have been initiated with these organisations.

I was pleased to formally take part in launching a joint research centre with CISRI. This centre, the Australian-China Energy Nanomaterials Research Centre, focusing on Professor Ying Chen's work, has been made a 'Beijing Key Laboratory in Energy Materials' by the Beijing Government. We also successfully established a collaboration, led by Professor Lingxue Kong, with a group of leading Chinese scientists in environmental science under the Australian Awards program – the Australia Leadership Awards Fellowships.

IFM Director Peter Hodgson was recognised by the Confederation of Australian Industry for his outstanding contribution to academia and industry. Professor Hodgson's extensive work with industry and academic research partners in India over the past seven years has been instrumental in introducing the concept of industry-academia partnership there. Through the Deakin India Research Initiative (DIRI), one of Professor Hodgson's brainchilds, university researchers have developed 15 active industry-academia partnerships supporting HDR students.

Deakin and The Energy Research Institute (TERI) established the joint Nano-Biotechnology Centre in New Delhi in 2012, with total projected joint investment of more than $8 million and with the goal of producing more than 50 PhD students over five years. The centre has been extremely productive in the past year, attracting significant Indian government grants and industry contracts.

IFM's Professor Tong Lin was awarded an ARC Future Fellowship. Professor Lin's research focuses on the preparation of ultra-fine fibres, functionalisation of fibrous materials and discovering new ways of using fibrous materials in both the textile and non-textile areas.

Associate Professor Tiffany Walsh became the first VESKI Innovation Fellow awarded to a university outside the Melbourne CBD when she joined IFM this year after a successful research career in the UK. She is using computer modelling and simulation to study how nature manufactures strong and durable materials such as shells, teeth and bones using non-toxic ingredients.

Carbon Nexus and the CSIRO Fibre Processing Building were well underway in 2012 along with the refurbishment of other GTP buildings as part of the $104 million EIF funded Australian Future Fibres and Innovation Centre (AFFRIC). Completion of the AFFRIC suite of projects is due by September 2013.

I look forward to the opening of AFFRIC and Carbon Nexus as well as the many possibilities and new opportunities that will arise as a result of these new facilities.

PROFESSOR PETER HODGSON
Director of IFM

DIRECTOR'S REPORT

The year 2012 was full of change, construction and a lack of caffeine. The Australian Future Fibres Research and Innovation Centre kicked off with the refurbishment of 50% of the building, including a new Electron Microscopy suite, new offices and laboratories for the fibre and textiles group and a new cafeteria.

Amidst this construction a number of new projects commenced and some key academics joined the team. Tiffany Walsh took up the position of Associate Professor in NanoBiotechnology, a key focus area for IFM in the future. Her skills in computer modelling and simulation of bio/nano interfaces is proving invaluable to the team by providing insight into how new materials may behave in biological environments.

We also consolidated our research focus through a name change and the separation of our intelligent systems and biotechnology groups. The Institute for Frontier Materials is focused on developing new materials to address key challenges in society with postgraduate and postdoctoral education at the forefront of our core business.

New projects that commenced in 2012 for IFM included Stage 2 of the Advanced Manufacturing CRC project "Development of an in vitro cell culture device" with Cytomatrix. Stage 1 of this project showed promising results and it is hoped that this continued collaboration will provide the foundations for commercial adaptation of the technology.

The composites team embarked on a collaboration with Qenos, a leading supplier of world class polyethylene and polymers. Their project investigated ways of using nanotechnology to improve product performance. Qenos has shown interest in expanding the partnership into 2013 and beyond.

Professor Tong Lin's Future Fellowship award is a clear indication of the outstanding research undertaken by the Fibres and Textiles team, and demonstrates the timeliness of the establishment of AFFRIC.

In July, Deakin University joined the Energy Pipeline CRC (EPCRC) and by November had four projects approved. As well, EPCRC funding has been secured for the National Facility for Pipeline Coating Assessment, which will open in 2013. Associate Professor Mike Yongjun Tan leads the EPCRC's Research Program on Coatings and Corrosion.

The successful creation of the Centre for Advanced Design in Engineering Training (CADET) will play an important role in producing researchers for the future. CADET is a $55 million state-of-the-art engineering facility that Deakin has initiated in partnership with the Gordon Institute of TAFE. CADET will emphasise product design and development through virtual and physical modeling, simulation and prototyping and will offer programs for young people from Year 8 through to PhD level.

Internationally, 2012 was a busy year for IFM researchers. A new Australia-China Centre for Light Metals was established leveraging off the existing ARC Centre of Excellence for Design in Light Metals.

Professor Ying Chen leads our involvement in the China Iron and Steel Research Institute (CISRI) – Deakin joint research laboratory. The Beijing Government recognised this initiative by awarding it the title of Beijing Key Laboratory in Energy Materials in 2012.

I would like to thank all IFM staff and students for their hard work. I would also like to extend our gratitude to our research and industry partners, whom we rely on for our continued success.

IFM Director Professor Peter Hodgson and Deputy Director, Professor Xungai Wang outside the newly refurbished building at Geelong.

INSTITUTE FOR FRONTIER MATERIALS BOARD MEMBERS

PROFESSOR JANE DEN HOLLANDER
Vice-Chancellor

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

PROFESSOR PETER D HODGSON
Director of the Institute for Frontier Materials

PROFESSOR GUY LITTLEFAIR
Head of School, Faculty of Science, Engineering & Built Environment

PROFESSOR BRENDAN CROTTY
Pro Vice-Chancellor, Faculty of Health

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

DR ANITA HILL
Independent Director (Chief, CSIRO Process Science and Engineering) appointed by the Vice-Chancellor

DR NEVILLE ROACH
Independent Director (Chairman, Advisory Board, Tata Consultancy Services) appointed by the Vice-Chancellor

PROFESSOR GEOFF STEVENS
Independent Director (Associate Dean (Engagement), Department of Chemical and Biomolecular Engineering, University of Melbourne) appointed by the Vice-Chancellor

MS VIRGINIE HOAREAU
Ex Officio member

MS KIM DURRANT
Secretariat

INTERNATIONAL COLLABORATIONS

CHINA

Collaboration with Chinese institutions, including industry, academia and government departments, was enhanced and broadened in 2012 with strong support from both the Australian and Chinese governments as well as industry.

IFM has secured two new ARC Linkage projects to develop advanced materials processes for steel and wool in collaboration with leading Chinese companies Wuhan Iron and Steel (Group) Corporation (WISCO) and Shandong Ruyi Woollen Textile Co.

The annual Deakin – WISCO forum on advanced high strength steels was successfully held in Geelong, attracting more than 60 leading national and international research scientists. We welcomed high level delegations from WISCO, Wuhan Textile University, Wuhan University of Science and Technology and China Iron and Steel Research Institute Group (CISRI). The forum focused on the application for advanced high strength steels in the automotive industry. A number of new collaborations have been initiated with these organisations. The joint research centre with CISRI – the Australian-China Energy Nanomaterials Research Centre – was made a 'Beijing Key Laboratory in Energy Materials' by the Chinese Government. We also successfully established collaboration with a group of leading Chinese scientists in environmental science under the Australian Awards program – the Australia Leadership Awards Fellowships.

IFM's research and researchers are highly regarded in China. In May 2012 Professor Peter Hodgson was admitted into the Hubei Province 100 Talents program at a special ceremony in Wuhan. He also received the Lee Hsun Lecture Award after being nominated by two of China's leading metal experts, Professors Yiyi Li and Dianzhong Li, in recognition of his contribution to materials science and technology. Professors Xungai Wang and Ying Chen have been awarded the most prestigious 1000 talents by the Chinese central government. They have all established joint Deakin laboratories in Chinese institutes that will significantly facilitate future collaboration. Deakin's joint research centres with the Chinese Academy of Tropical Agriculture Sciences (CATAS), WISCO and HFUT have progressed well.

Vice-Director of Beijing Science and Technology Commission Mr GH Zhang, Chief Scientist of China Iron and Steel Research Institute, Prof S. Zhou, Deakin DVCR, Prof Lee Astheimer,and Prof Y Chen launched the Beijing Key Laboratory and the Deakin-CISRI Joint Research Centre for Energy Materials in Beijing.

INDIA

IFM strengthened its engagement with India by entering into new strategic partnerships and also by deepening the ties with existing partners.

Several IFM staff, including Director Prof Peter Hodgson, A/Prof Bernard Rolfe, Dr Matthias Weiss, Dr Daniel Fabijanic, Dr Rupinder Kanwar, Dr Rangam Rajkhowa and Dr Yuncang Li visited India in 2012.

MoUs were signed with IIT Indore, University of Mumbai, Bharat Forge, DBT-IOCL, Indian Oil Corporation Pvt Ltd and the DBT-IOCL centre, IIT Madras (which also submitted a joint proposal for the Australia India Strategic Research Fund (AISRF) Grant).

The Confederation of Indian Industry (CII) recognised Professor Hodgson for his outstanding contribution to Indian academia and industry.

Annual DIRI Symposium

Deakin India in association with The Energy and Resources Institute (TERI) organised a three day symposium in November. The event brought together Deakin's research partners across India at a common platform to discuss ongoing research and strategies for future collaborations.

The symposium, which was held at the TERI-Deakin Nanobiotech Centre at Gual Pahari, Gurgaon, was inaugurated by Deakin's Deputy Vice Chancellor, Research, Prof Lee Astheimer. Forty research scholars from Deakin's Indian partners and 30 supervisors from India and Australia participated in the symposium which was titled 'Frontiers in Science' and had an underlying theme of nanosciences and biosciences.

The annual DIRI symposium brought together research partners from across India to discuss ongoing research and strategies for future collaborations.

IFM PERFORMANCE TARGETS – 2009-2012

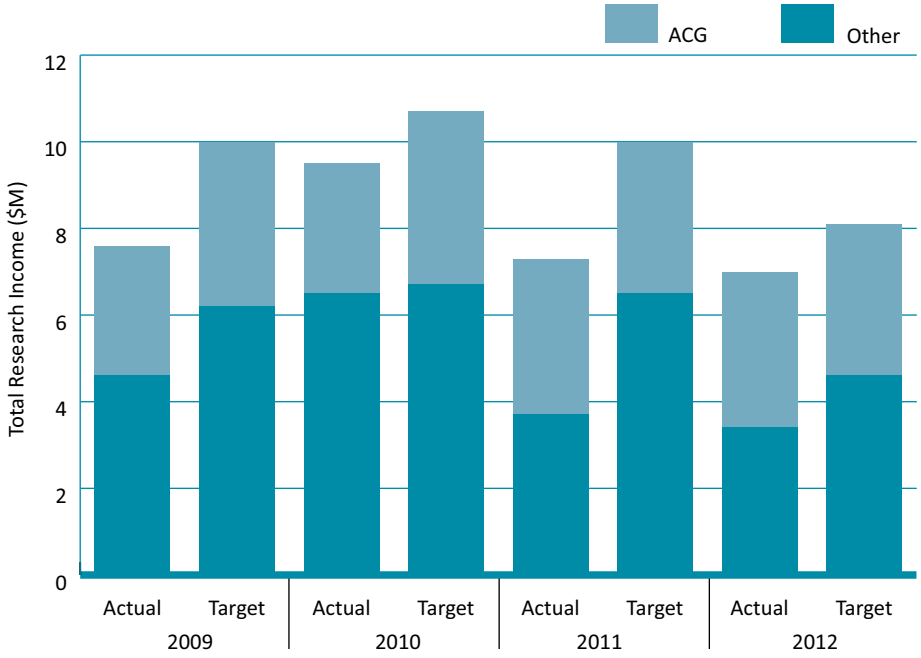
TOTAL RESEARCH INCOME BY CATEGORY ($M)

CATEGORY	2009		2010		2011		2012	
	ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET
ACG	3	3.8	3	4	3.6	3.5	3.5	3.5
Other	4.6	6.2	6.5	6.7	3.7	6.5	3.5	4.6
Total $M	**7.6**	**10**	**9.5**	**10.7**	**7.3**	**10**	**7**	**8.1**

2012 results do not include $1M infrastructure and excluded research income.

TOTAL RESEARCH INCOME BY CATEGORY – ACTUAL 2012 ($M)

CATEGORY	ACG	CRC	INDUSTRY	OTHER PUBLIC SECTOR
Total $M	**3.5**	**1.51**	**1.51**	**0.5**



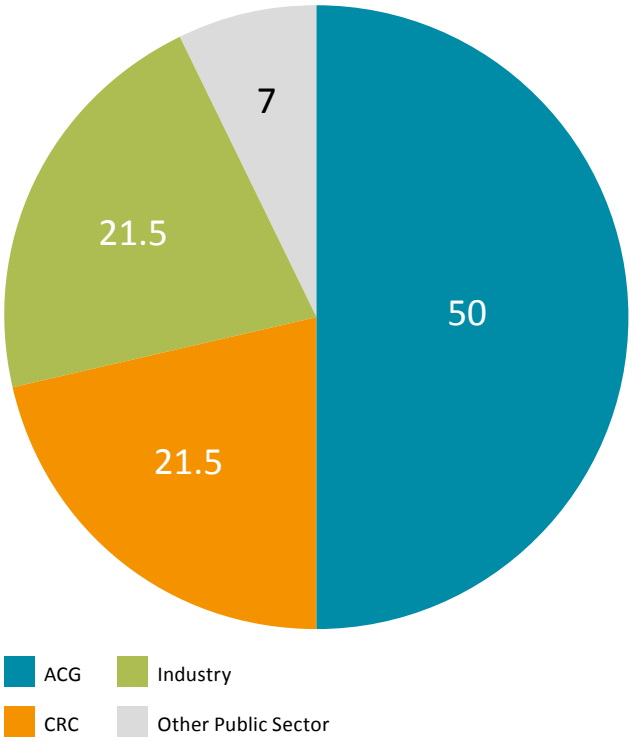
***ACG (Australian Competitive Research Grants – Category 1)** gives the income obtained in national competitive grants, the term used to describe a group of some 70 research grant schemes to which all universities can apply and where awards are based on merit of the application and the research team. 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.

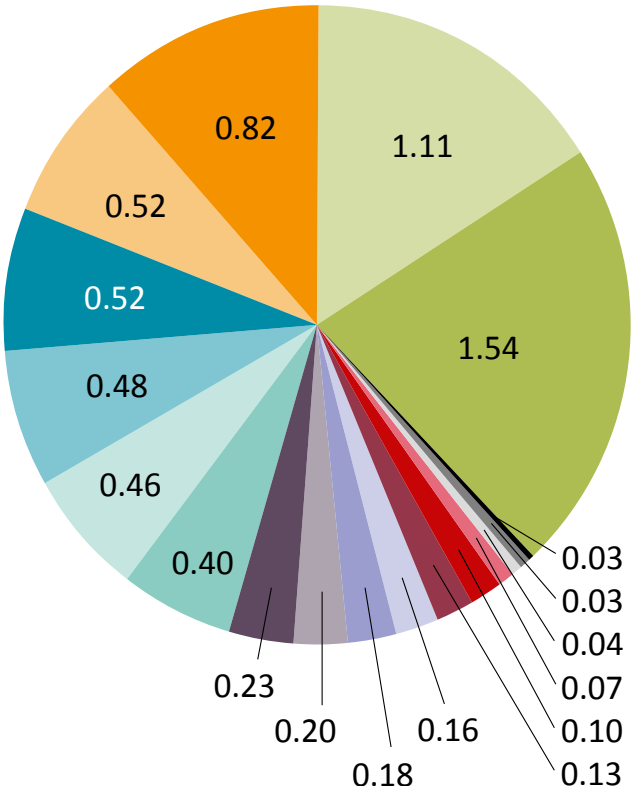
***Industry (Industry and Other Funding – Category 3)** includes all research funding from industry, international sources, donations, bequests and foundations, and Higher Degree by Research fee income for domestic and international students.

***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.

2012 RESEARCH INCOME BY CATEGORY %



2012 INCOME BY FIELD OF RESEARCH $M



2012 GRANT APPLICATIONS

GRANTS	APPLIED	SUCCESS	% SUCCESS	AMOUNT AWARDED*
Reportable - Category 1 Applications	37	11	30%	$3,707,749
Reportable - Category 2-4 Applications	26	20	77%	$2,730,874
Non-Reportable - Other	62	27	44%	$1,633,391

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

2009-2012 HDR STUDENT – EFTSL

2009		2010		2011		2012	
ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET
96	100	117	118	138	118	**153**	**154**

PUBLICATIONS 2009 - 2012*

2009		2010		2011		2012	
ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET	ACTUAL	TARGET
120	88	171	100	293	123	**132**	**139**

*Results are based on 2012 weighted HERDC publication points as currently recorded.

KEY RESEARCH AREAS

- Australian Future Fibres Research & Innovation Centre at Deakin
- Computer Modelling
- Corrosion Engineering
- Electromaterials
- Functional Nanomaterials
- Metals and Light Metals
- Micro and Nano Systems
- Plasma Research
- Polymers

AUSTRALIAN FUTURE FIBRES RESEARCH & INNOVATION CENTRE (AFFRIC)

The Australian Future Fibres Research & Innovation Centre (AFFRIC) is a $103 million initiative, supported by both Federal and State Governments.

It is a collaboration between Deakin University, CSIRO Materials Science and Engineering and the Victorian Centre for Advanced Materials Manufacturing (VCAMM).

AFFRIC has about 100 staff and research students at Deakin working in four major program areas:

- Carbon fibres and composites
- Functional fibrous materials
- Green natural fibres
- Nanofibres

CARBON FIBRES & COMPOSITES

GROUP MEMBERS (STAFF)

Associate Professor Bronwyn Fox, Dr Mandy de Souza, Dr Abdullah Kafi, Dr Kevin Magniez, Dr Minoo Naebe, Dr Steven Agius, Dr Luke Henderson, Dr Claudia Creighton, Dr Jane Dai, Christelle De Lavigne, Alex Leblais, Katrina Robertson, Madhu Suryanarayana

GROUP MEMBERS (STUDENTS)

Matthew Jennings, Robert Nunn, Thomas Chaffraix, Sahar Naghashian, Peter Bruchmuller, Quanxiang Li, Linden Servinis, Ehsan Bafekrpour

The use of composite materials in structural applications has increased significantly over the past decade, particularly in civil, aerospace and automotive applications.

For example, 50 per cent of the primary structure of the new Boeing 787 Dreamliner, including the fuselage and wings, is made of composite materials.

This use of composites makes the aircraft 20 per cent more fuel efficient than other aircraft of its size. As a result of new applications like this, recent studies predict that the global demand for carbon will triple over the next decade.

The AFFRIC carbon fibre and composites research theme is focused on the manufacture and use of carbon fibres and composite materials. The understanding of the science of carbonisation, surface treatment and sizing of polyacrylonitrile (PAN) fibres to manufacture carbon fibre is limited due to commercial secrecy.

A new AFFRIC research facility, Carbon Nexus (www.carbonnexus.com.au), to be completed in 2013, will house multiscale, facilities to conduct industry relevant research to demystify carbon fibre manufacturing technology, thus enabling the development of new generation carbon fibres. In 2012, much progress has been made towards the realisation of Carbon Nexus, including laboratory design, strategic planning and the commencement of preliminary research projects.

The following major research themes relating to carbon fibre have been identified after years of consultation with global industry experts:

- low cost carbon fibre
- high performance fibres
- surface treatments and sizing for carbon fibre

These themes are underpinned by an increased understanding of the fundamental science of the manufacture of carbon fibres.

Composite related research projects include:

- bio-composites
- self-healing composites
- nanocomposites
- surface finish
- resin formulation and chemistry
- out-of-autoclave cured composites
- functionally graded materials

CARBON FIBRES & COMPOSITES (CONTINUED)

Research highlights

In 2012, the research work conducted by Dr Kevin Magniez's group showed that it is possible to control the surface properties of fibrous substrate by self-assembly and disassembly of the amphiphiles for functional materials.

A strong collaboration between Deakin and CSIRO has led to the first surface functionalisation of carbon fibre using in situ generated nitrenes. This work has provided a way of interrogating the graphitic surface of carbon fibre.

New projects

The group was awarded an Auto-CRC scholarship to research lightweight bio-composites material for automotive application. This work will commence in mid-2013.

Two highly competitive International Postgraduate Research Scholarships (IPRS) were awarded to two international students who will join the group in 2013 to work on graphene based nano-composites, jointly supervised by Dr Naebe and Associate Professor Fox.

In 2012, key members of the team (De Lavigne, Naebe and Magniez) worked on a 12 months industrial collaboration with Qenos, a leading supplier of world class polyethylene and polymers. The work used nanotechnologies to enhance the performance of the company's products. This project will probably be expanded into a PhD program.

A new defence project in collaboration with DMTC, ADA, VCAMM, BMT and Pacific ESI commenced in 2012, focusing on ongoing development of a suite of next generation manufacturing, materials and process technologies to deliver improved personnel armour to Australian forces.

Victoria Fellowship first for Deakin

In April 2012, Dr Mandy de Souza travelled to the United Kingdom, Sweden and the United States as part of the Victoria Fellowship she was awarded in 2011 to further her expertise in the field of carbon fibre composites for automotive surface finish applications. The Victorian Government awards the fellowship to six emerging leaders in science, technology and engineering, providing a travel grant of $18,000 to fund a short-term overseas study mission.

Dr de Souza was the first Deakin University recipient of the award. She attended the Global Automotive Lightweight Materials Conference in London, a three-day profilometry training course at Taylor-Hobson, as well as visiting Aston Martin Lagonda Advanced Composites Group, Oxeon, General Motors Global Research and Development, Ford Research and Innovation Centre and the Lamborghini Advanced Composite Structures Laboratory at the University of Washington.

A direct outcome of the fellowship is a new collaborative project with the University of Washington and Lamborghini.

In March 2012, Associate Professor Bronwyn Fox and Dr Claudia Creighton undertook industry visits in Germany (BMW, VW, SGL, and Composite Valley Stade) representing Carbon Nexus in order to establish new collaborations. The new carbon fibre research facility and its capabilities were also represented at the Composites Australia stand at the world's largest composites exhibition (JEC Europe) in Paris, attracting the attention of many international visitors. These meetings were supported by the Victorian Government office in Germany.

Steve Agius successfully completed his doctorate and graduated in April 2012.

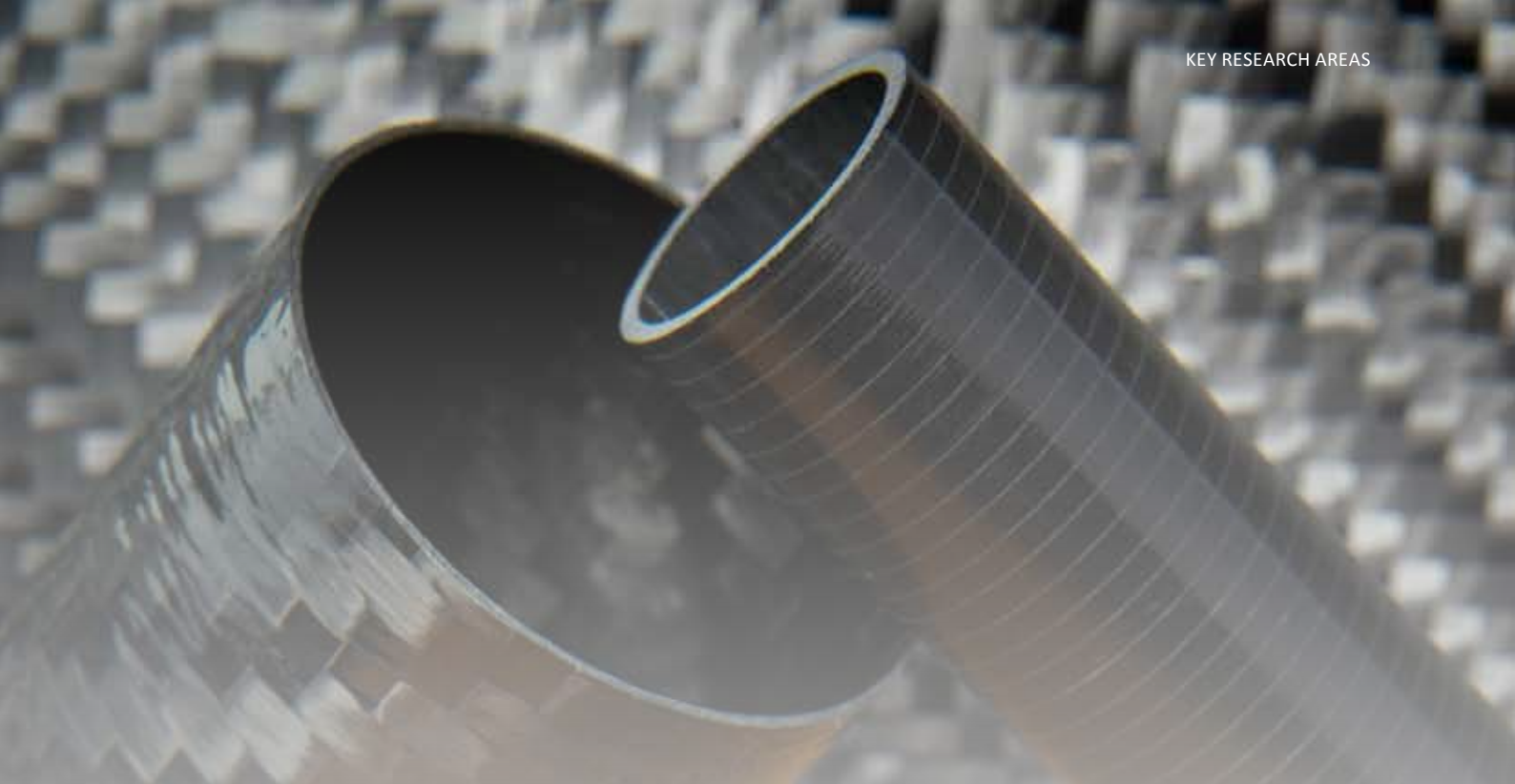
New generation inverse gas chromatography

Deakin University has recently commissioned new generation inverse gas chromatography (SEA-IGC) in collaboration with Surface Measurement System (SMS) Ltd UK. It is Australia's second advanced surface energy characterisation facility and is dedicated to promote industry focused R&D within IFM and Carbon Nexus. Dr. Abdullah Kafi, an Alfred Deakin Postdoctoral Research Fellow has been working closely with SMS to train staff and best utilise the equipment. The facility will be fully operational in April 2013.

The group was successful in internal research equipment applications and contributed to a successful Research Equipment Support Scheme (RESS) bid. These key pieces of equipment, such as a weatherometer, pycnometer and rheometer, are critical to the group's research on carbon fibre and composites.

Researchers using the Favimat single fibre tester.

The carbon fibre processing line.



CASE STUDY:

QUICKSTEP TAKES COMPOSITES A STEP CLOSER TO INDUSTRY

A new process being tested by IFM's composite research group is leading to the development and production of low-cost, high performance composite components.

Composites are widely used in the aerospace and defence industries and increasingly in the production of high-performance and electric powered vehicles for their lightweight, high strength properties. But, the high costs associated with their manufacture have limited the uptake of these new materials.

IFM research is helping to validate and test composite materials for industry.

Quickstep is Australia's largest independent manufacturer of aerospace-grade carbon fibre composites and a leader in providing advanced industrial technologies for the global market. Associate Professor Bronwyn Fox and her team have been working with Quickstep in providing validation for the company's cutting edge manufacturing processes for the production of aerospace-grade composites.

'If our products are to be utilized in the automotive and aerospace industries the technology needs to be validated and tested to exacting standards,' explains Quickstep's Research and Development Project Manager, Adriano Di Pietro. The work carried out by Professor Fox and her team has been a vital part of qualifying our technology,' he says. 'We recognise the benefits of collaboration between industry and universities and the opportunities for leveraging the expertise available in the university sector to achieve great results for our customers.'

AMCRC has facilitated and project managed the three-year partnership between Deakin and Quickstep.

FUNCTIONAL FIBROUS MATERIALS

GROUP MEMBERS (STAFF)

Professor Tong Lin, Dr Hongxia Wang, Dr Yan Zhao, Dr Cynthia Wong, Dr Alessandra Sutti, Dr Jing Wang, Dr Chris Hurren, Dr Jane Dai, Dr Jingliang Li, Professor Xungai Wang

GROUP MEMBERS (STUDENTS)

Hua Zhou, Amir Abbas, Chao Zeng, Zengxiao Cai, Charanpreet Singh, Esfandiar Pakdel, Rongliang He

The group's research has been focused on the development of new technologies, advanced materials and in-depth knowledge concerned with leading edge materials science, especially in the fibrous materials area.

It covers technology to prepare and functionalise fibrous materials, their novel properties and applications. Areas of active research include:

- superhydrophobic fabrics
- superoleophobic fabrics
- directional water transport fabrics
- electrically conductive fabrics
- thermally conductive/insulating fabrics
- photochromic fabrics
- fluorescent and UV-shielding fabrics
- novel fibrous materials for healthcare and biological applications
- protective materials

Improvements in liquid repellent coatings

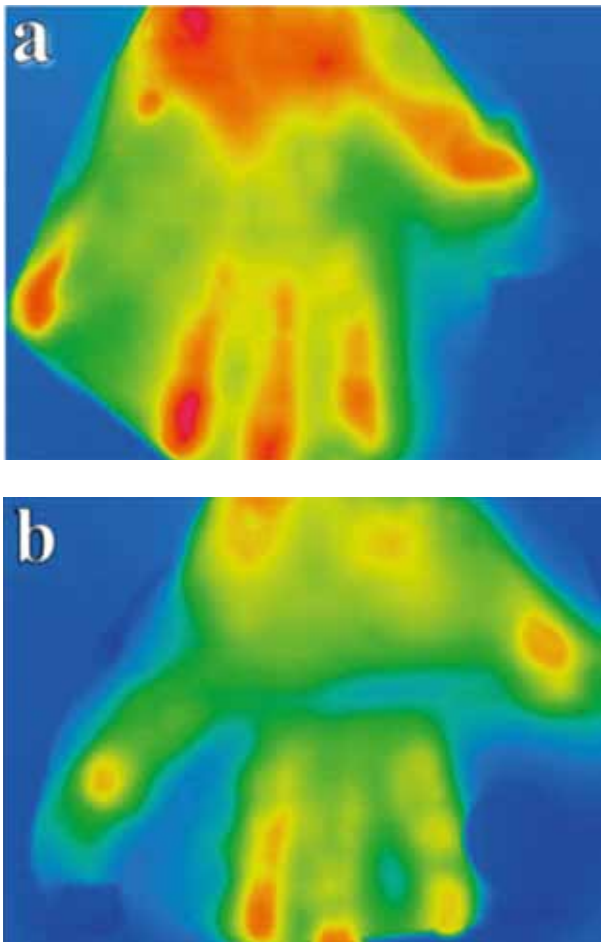
The key breakthrough for this year's research is in the superhydrophobic fabric area. Two new concepts have been developed to improve the durability of super liquid repellent coatings. One is the use of elastomeric nanocomposites to enhance the washing/abrasion durability of superhydrophobic fabrics and the other is the use of reactive self-assembly technology to form a durable functional coating on almost all organic substrates.

Coloured water drop on superhydrophobic fabric.

Graduations

Marzieh Parhizkar and Rongliang He completed their PhD studies and graduated in 2012. Marzieh is now working on an Advanced Manufacturing CRC project investigating the use of nanofibre tissue scaffolds for cell proliferation.

Rongliang He has been a key contributor to a project looking at the design of anti-needle-penetration gloves in collaboration with Hysport Pty Ltd.



IR images of a hand covered with a) a normal fabric, b) the fabric after the surface has been functionalised with a thermally-conductive coating.

GREEN NATURAL FIBRES

GROUP MEMBERS (STAFF)

Professor Xungai Wang, Dr Chris Hurren, Dr Xin Liu, Dr Rangam Rajkhowa, Dr Jin Zhang, Dr Nolene Byrne, Dr Bruce McGregor, Dr Maryam Naebe, Dr Bin Tang, Dr Qing Li, Dr Lu Sun, Jinfeng Wang, Dr Jing Wang, Dr Jingliang Li, Dr Ben Allardyce, Ray Wood, Dr Peter Lamb, Julie Zhang, Dr Takuya Tsuzuki

GROUP MEMBERS (STUDENTS)

Kiran Patil, Shan Du, Jasjeet Kaur, Xing Jin, Mehdi Kazemimostaghim, Rasike De Silva, Rene van der Sluijs, Yao Yu, Mingwen Zhang, Linda Hillbrick, James Preston, Chantal Denham, Sarmad Aslam, Liyuan Zhang, Tarannum Afrin, Alison Lee King

The green natural fibres program focuses on environmentally friendly ways of processing natural fibres and developing value-added applications for natural fibres, including silk, wool, cotton, hemp, bamboo, and rare natural fibres such as cashmere.

New discoveries in silk, wool and bamboo

A number of key breakthroughs in our research were achieved in 2012:

Through a new ARC Discovery project we have revealed the amazing structure and properties of wild silk cocoons. The thin and light-weight structure can protect silk pupae from extreme weather conditions and other environmental hazards.

Our understanding of the bast fibre degumming process has led to a novel technology for extracting bast fibres.

Using a green solvent, we have shown that the cuticles of protein fibres such as wool can be modified or removed to achieve shrink resistance. This work has major implications for the multi-billion dollar animal fibre industry in Australia, and is being further studied through a new ARC Discovery project. Australian Wool Innovation has supported initial work in this area.

Our work on bamboo has revealed that the UV absorption ability of the material originates from the lignin rather than the fibre itself.

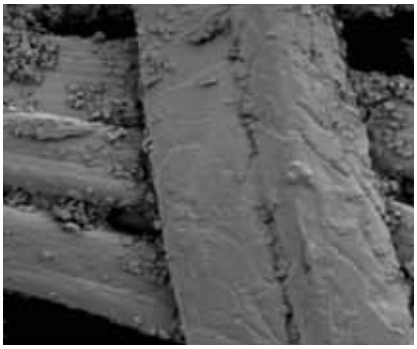
Researcher works with industry to improve hemp processing

Several new projects commenced in 2012, including a project funded by Logistik and the State Government's Researcher-in-Business (RiB) scheme to work on bast fibres. The Australian Defence Apparel (ADA) researcher in business project has worked on reducing the environmental footprint of a rapid hemp fibre separation process called 'catalytic degumming'. The process produces a hemp fibre with similar properties to cotton that can be spun on conventional cotton spinning equipment. The research has resulted in reductions in water, energy and chemicals used in the process and a system for reusing at least 50 per cent of effluent.

The ADA researcher worked closely with the Logistik Unicorp hemp fibre separation project, which has developed a rapid method for separating decorticated hemp fibre so that it can be spun on cotton spinning equipment. The four-step process uses conventional processing equipment to separate and clean the fibre ready for spinning. The project has developed one machine specific for one step of the process. Spinning and weaving trials were conducted on the fibre after the process to confirm success of the system. The process has low energy, chemical and water inputs compared to other available technologies.

Liyuan Zhang , Tarannum Afrin, and Alison Lee King successfully completed their PhD studies and graduated in 2012.

Wild silk cocoon.



Raw cocoon (silk fibre + serici glue + crystals).

Degummed silk fibre.

CASE STUDY:
SILK SOLUTION TO REPAIR EARDRUMS

A thin, transparent membrane produced from silk fibres could provide a novel but simple solution to a problem that affects millions of people.

Up to 330 million people worldwide suffer chronic eardrum perforation as a result of infection, leading to hearing loss. In Australia, one in six people suffer hearing impairment according to the Ear Science Institute Australia (ESIA).

The usual treatment for chronic eardrum perforations is a major procedure, requiring a full anaesthetic and surgery, taking a graft of muscle membrane or cartilage from the patient's body and transplanting it to their eardrum. While most of these grafts can seal the perforation after surgery and reduce the chance of infection, the procedure cannot restore hearing or assist optimum regeneration of ear drum.

An alternative being developed by researchers at the Institute of Frontier Materials and ESIA, as part of an ARC Linkage project, involves using fine silk membranes to replace damaged ear drums. Dr Rangam Rajkhowa and Dr Ben Allardyce are using the natural properties of silk fibres to produce an artificial eardrum which could be implanted in a simple outpatient procedure.

The material needs a number of properties to be successful as a potential eardrum replacement, explains Dr Rajkhowa. It needs to be thin and able to vibrate like the natural eardrum, biocompatible, strong enough to resist inner ear pressure, to biodegrade when ear drum is regenerated, and easy to shape and manipulate during surgery.

The researchers process silk fibres obtained from various silk species, dissolve it in solution after purification and cast the solution into a thin (30-90 micrometres) transparent membrane. They are assessing different silk fibres sourced from India and China and looking at different formats e.g. solid sheets, perforated sheets, fibre reinforced or a mat of silk to optimise the biomechanical properties and produce a range of ear drums to suit patients with different conditions.

When inserted into the ear, the membrane acts as a bio-scaffold, allowing cells to grow on and into it. Eventually the silk dissolves and leaves behind the new cells.

Researchers at ESIA have begun experiments to try and grow human eardrum cells on the membrane. In experiments where silk membranes have been implanted in the perforated ears of rats and guinea pigs, cells are starting to grow back much faster and more regularly on silk compared to other materials and there are no signs of any adverse effects after six months of study.

The team at IFM and ESIA has recently received a NHMRC development grant and ESIA hopes to start conducting clinical trials in humans in 2014.

Above: Dr Ben Allardyce and Dr Rangam Rajkhowa examine a solution of processed silk fibres.

NANOFIBRES

GROUP MEMBERS (STAFF)

Professor Tong Lin, Dr Jian Fang, Dr Haitao Niu, Dr Chuanxiang Qin, Dr Zhenyu Li, Dr Yong Du

GROUP MEMBERS (STUDENTS)

Xueyang Liu, Nadeem Shuakat, Amstrong Xie, Usman Ali, Hao Shao

The group is focused on leading edge science and engineering research in the field of nanofibre research.

Its research activities cover three main areas: novel, efficient, scalable electrospinning technology to produce nanofibres; novel nanofibres and nanofibrous structure; and unique nanofibre properties and applications.

Within these three areas, research includes:

- needleless electrospinning of nanofibres
- direct electrospinning of nanofibre yarns
- nanofibrous energy harvesters (e.g. piezoelectric power generator, solar cells)
- nanofibres for biomedical and healthcare applications
- nanofibres for composite reinforcement
- carbon nanofibres
- chemical sensors
- supercapacitors

Researchers spin nanofibre yarns

A significant breakthrough in yarn electrospinning saw two effective systems to prepare nanofibre yarns with well controlled twist and fibre/yarn dimension developed.

The development of needleless melt electrospinning technology to prepare polypropylene nanofibres will allow the large-scale production of nanofibres without using any solvent. This will lead to a green, environmentally friendly technology to produce robust nanofibres for various applications.

Future Fellowship success

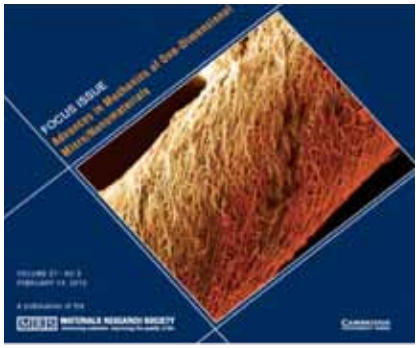
Professor Tong Lin was awarded an ARC Future Fellowship in July. His project will investigate how to efficiently convert small mechanical energy into directly useable electrical power using piezoelectric nanofibre membranes. The power generators developed will be useful for developing self-powered miniature electronics for diverse applications.

The ARC Future Fellowships are designed to promote research in areas of critical national importance by giving outstanding researchers incentives to conduct their research in Australia.

Jing Wang successfully completed his PhD studies and graduated in 2012.

Newly-developed Nanofibre Yarn Spinner.

Needleless Nanofibre Spinner.



A SEM image of nanofibre yarn was selected as the cover page of the Journal of Materials Research.

CORROSION ENGINEERING

GROUP MEMBERS (STAFF)

Associate Professor Mike Yongjun Tan, Professor Maria Forsyth, Dr Xiong Jianyu, Dr Nguyen Dang Nam, Abreu Davi, Dr Rajeev Gupta

GROUP MEMBERS (STUDENTS)

Facundo Varela, Huo Ying, Phillip Wyld, Tejas Bharnuke, Paul Erskine, Matthew Dogshun, James Bolton, Joel Norton, Samuel Morrow, Thomas Halifax-Ballhinger

Corrosion significantly affects the reliability, durability and sustainability of Australia's major industrial and civil infrastructure that is vital for the provision of the nation's essential services and the maintenance of its economic activities.

New electrochemical test to investigate corrosion behaviour of welding zones

The group has developed a new electrochemical test to investigate the localised corrosion behaviours of welding zones in simulated desalination environments (Reported to National Centre of Excellence for Desalination Australia and accepted for publication in NACE 2013). This test will enable rapid assessment of the localised corrosion behaviour of stainless steel pipeline weldments and the understanding of critical factors affecting the quality of welding. It has enabled critical electrochemical data from non-uniform stainless steel weldments to be measured for the first time.

Group gets desal grant

During 2012 the group was awarded a grant from the National Centre of Excellence in Desalination: Smart Materials for Corrosion Management.

This project, which involves a number of key academics from Deakin and other universities, will investigate:

- corrosion performance of existing materials, components and structures within desalination plants
- development of dedicated, lower cost, maintenance materials, and life-cycle extension to maximise output and efficiency in the desalination industry.

The first year of the grant focused on:

- electrochemical tests to investigate the corrosion behaviour of different metals in simulated desalination environments
- electrochemical polarisation measurements to investigate the corrosion behaviour of stainless steel welding zones – a key area of desalination pipeline failure
- Autoclave investigations on crevice corrosion of selected stainless steels and duplex stainless steels in natural and concentrated seawater at 50°C.

Research at the National Centre of Excellence in Desalination is investigating the corrosion behaviour of different metals in simulated desalination environments.

Energy Pipeline CRC industry advisors visiting National Facility for Pipeline Coating Assessment.

Deakin joins Energy Pipeline CRC

In July, Deakin University became a member of the Energy Pipeline CRC (EPCRC).

The EPCRC aims to provide the Australian energy pipeline industry with the technology necessary to:

- extend the safe operating life of Australia's ageing natural gas transmission network, thus avoiding the need for replacement
- build the new pipeline networks needed to support increased demand for natural gas
- build the new pipeline networks that will enable the transmission of new energy cycle fluids such as hydrogen and carbon dioxide
- prevent pipeline failures that could lead to consequential costs and harm to public health and safety and other infrastructure.

In November, Deakin hosted an EPCRC forum which saw 14 industry advisors and executives attend a one day seminar and facilities visit. This program was designed to create an opportunity for EPCRC advisors and Deakin researchers to exchange ideas, and to discuss current issues and research questions in the industry. Deakin has four projects with the EPCRC.

Corrosion laboratory open for business

Major efforts have been made, together with Professor Maria Forsyth, to develop a new corrosion laboratory at Deakin's Waurn Ponds campus. This new laboratory is based on our capabilities in electromaterials, metallurgy, materials and engineering research.

The laboratory will:

- support teaching programs in corrosion, reliability and maintenance engineering
- conduct world class research programs in partnership with local and international industries.

Strategically the group at Deakin targets:

- desalination and water infrastructure
- oil and gas production and refining, such as energy pipelines
- mining, defence and power industries

Additionally, EPCRC funding has been secured for the National Facility for Pipeline Coating Assessment. These facilities will secure Deakin's place at the forefront of corrosion research.

ARC CENTRE OF EXCELLENCE FOR ELECTROMATERIALS SCIENCE

GROUP MEMBERS (STAFF)

Professor Maria Forsyth, Dr Patrick Howlett, Sona Shekibi, Dr Angel Torriero, Dr Cristina Pozo-Gonzalo, Dr Jim Efthimiadis, Dr Fangfang Chen, Dr Jaka Sunarso, Dr Marianne Seter, Dr Peter Newman

HONORARY STAFF: Professor Bruce Hinton, Professor Tony Hollenkamp

GROUP MEMBERS (STUDENTS)

Nahid Iranipour, Julie-Anne Latham, Tim Khoo, Yajing Yan, Rainier Catubig, Yafei Zhang, Peipei Huang, Tristan Simons, Anthony Somers

The ARC Centre of Excellence for Electromaterials Science (ACES) at Burwood conducts fundamental and applied research focused on the discovery, development and use of new materials (primarily ionic materials) for a range of clean energy and resources sustainability areas.

Areas of research include:

- energy storage (batteries)
- energy conversion (DSSCs and thermoelectrochemical cells)
- novel electrolyte materials – ionic liquids and plastic crystals
- interfacial electrochemistry
- novel lubricants (tribology, friction and wear)
- novel catalysts for oxygen reduction for batteries and fuel cells
- advanced surface and interfacial characterisation techniques
- coatings and inhibitors for corrosion mitigation
- bacterial electrochemistry
- biomaterials and biolubrication
- simulation and complex modelling of new materials behaviour

Researchers using the Scanning Electrochemical Microscope to probe the electrochemical response of new corrosion inhibitors for magnesium alloys.

Plastic crystal electrolytes for lithium batteries

In 2012, key advances took place in our understanding and application of plastic crystal electrolytes. These ionic materials possess disorder modes within their crystal structure, which allows ionic transport (and molecular diffusion) to occur. In collaboration with Monash University and CSIRO, the group demonstrated:

- the use of advanced NMR and simulation techniques to elucidate the ion dynamics to describe a comprehensive transport model in a plastic crystal system
- the use of a plastic crystal electrolyte in an all solid-state lithium battery at elevated temperatures.

Improving the safety, durability and power of lithium batteries

In late 2012 the centre was awarded an ARC Linkage Project to develop new high performance electrolytes based on phosphonium ionic liquids. This will enable enhanced safety, longer shelf life, greater capacity and higher operating voltage in lithium battery technologies.

Our Linkage partner Cytec is the leading manufacturer of phosphonium ionic liquids in the world and we will be designing and developing new advanced forms of this family of ionic liquids specifically for lithium battery applications.

The lithium battery technologies are an important component of developing sustainable energy options, including various forms of electric and hybrid vehicles and stationary renewable energy storage.

Researchers in ACES electrochemical laboratory examining ionic liquids.

Deakin hosts 7th ACES Electromaterials Science Symposium

In February 2012, the group hosted the 7th ACES Electromaterials Science Symposium, at the Geelong Waterfront Campus. The three-day symposium, which covered a broad range of electromaterials science, attracted 135 local, national and international delegates. Later in the year, PhD student Mr Tristan Simons was a finalist in the national three minute thesis competition, ultimately winning the People's Choice Award.

Molecular dynamics simulation expert visits ACES

For six months, the ACES group at Burwood was fortunate to host Professor Simon de Leeuw as a Deakin 'Thinker in Residence'. Prof de Leeuw is a leading expert in the use of molecular dynamics simulation and his visit was instrumental in kick-starting a vibrant new activity within the group. His presence assisted the group to advance the use of this technique to improve understanding of the phase dependent ion transport behaviour in plastic crystal electrolytes. A number of staff and students worked closely with Prof de Leeuw over this period, benefiting enormously from his knowledge and experience.

ARC CENTRE OF EXCELLENCE FOR FUNCTIONAL NANOMATERIALS

GROUP MEMBERS (STAFF)

Professor Ying (Ian) Chen, Dr Alexey Glushenkov, Dr Md Mokhlesur Rahman, Dr Tao Tao, Dr Weiwei Lei, Dr Dan Li, Dr Mathieu Couvrat, Dr Luhua Li, Dr Jane Dai, Dr Peter Lamb

GROUP MEMBERS (STUDENTS)

Thrinathreddy Ramireddy, Olga Kartachova, Tan Xing, Md Mahedi Hasan Bhuian

The centre's research focuses on the synthesis of new nanostructured materials such as nanotubes, nanosheets, nanorods and nanocomposites and their applications in energy storage, advance composites, environmental protection and drug delivery.

The main research areas include:

- nanomaterials synthesis using ball milling, high-temperature process, CVD, sol-gel and chemical methods
- structure and property investigations of nanomaterials
- boron nitride nanotubes for reinforced metal composites, DUV light emission and desalination applications
- nanostructured materials for electrodes of Li-ion and Na-ion batteries
- electrochemical supercapacitors with nanoporous transition metal nitride electrodes
- biological and medical applications of nanomaterials

Prof. Barry Halliwell of the National University of Singapore, presents the best poster prize certificate to Dr Alexey Glushenkov at the IUMRS-ICYRAM 2012 conference.

IFM director, Professor Peter Hodgson, congratulates Olga Kartachova on winning the prize for the best poster and oral presentation at the IFM 2012 Conference.

Research shows new applications for boron nitride nanomaterials

The centre's ARC Discovery project has produced many important results in the synthesis and applications of boron nitride (BN) nanotubes:

- ultrafine nanotubes have been synthesised with the help of new catalysts of LiOx
- strong VUV light emission has been detected from the nanotubes using a new VUV photoluminescent spectroscope
- collaboration with researchers at BioDeakin has led to improved cell proliferation through use of functionalised BN nanotube films
- working with ANU researchers, boron nitride (BN) nanocells have been produced from BN nanotubes and have been successfully loaded with gold nanoparticles demonstrating BN's potential as a drug carrier for drug delivery application
- BN nanotube reinforced Al composites have been prepared successfully and the reactions between the BN nanotubes and Al matrix during high-temperature consolidation have been investigated in collaboration with a group at Florida International University.

These new breakthroughs maintain our world-leading status in BN nanomaterials research.

Porous nanorods with improved electrochemical properties

A new ARC Discovery grant was awarded for research on 'Nanoporous nanorods with improved electrochemical properties' to chief investigators Professor Chen, Dr Glushenkov and Professor Gogotsi.

The new project is the continuation of the centre's previous research on electrochemical supercapacitors. In 2012, the group synthesised mesoporous tungsten oxynitride by temperature-programmed reduction of tungsten oxide powder and used it as an electrode in supercapacitors.

The Functional Nanomaterials group - at the forefront of nanomaterials research.

International nanotube conference for Australia

The centre was heavily involved in the 13th International Conference in Science and Application of Nanotubes (NT12) held in Brisbane in June 2012, with Professor Ying Chen as the conference chair. The NT conference series are the largest conferences in nanotube research in the world and this was the first time it has been held in Australia.

The conference attracted 300 participants from 18 countries around the world including 30 international keynote and invited speakers and more than 100 students. Ms Helen Woodall and Dr Luhua Li worked with Professor Chen to ensure the success of this major international event.

Joint research centre opens in Beijing

The China Iron and Steel Research Institute (CISRI) and Deakin University have established a joint research centre in energy nanomaterials in Beijing under Prof Chen's 1000 talented professorship program from the Chinese central government.

The CISRI-Deakin centre is focused on fundamental and applied research of advanced nanomaterials for energy storage applications. CISRI has invested 30 million RMB (about $AU5 million) on the new research laboratory and a range of new research equipment. Deakin's researchers have started work at the new centre, benefiting from the fast development of energy storage research in China. Joint publications and research grants have been key outcomes of the collaboration so far.

The Chinese government has recognised the success of the joint research centre by awarding it the status of Beijing Key Laboratory in Energy Materials in 2012. Professor Lee Astheimer, Deakin's DVCR, launched the key laboratory on 28 June 2012.

METALS AND LIGHT METALS

GROUP MEMBERS (STAFF)

Professor Peter Hodgson, Professor Matthew Barnett, Associate Professor Bernard Rolfe, Dr Matthias Weiss, Dr Michael Pereira, Dr Erik Pavlina, Dr Abbas Amini, Dr Zhijian Zhang (WISCO), Dr Libo Pan (WISCO), Dale Atwell, Alireza Asgari, Dr Hossein Beladi, Dr Aiden Beer, Dr Pavel Cizek, Dr Daniel Fabijanic, Dr Weimin Gao, Dr Tim Hilditch, Katrina Morgans, Mark Nave, Robert Pow, Dr Ananthi Sankaran, Mohan Setty, Dr Filip Siska, Dr Nicole Stanford, Dr Andrew Sullivan, Dr Ilana Timokhina, John Vella

GROUP MEMBERS (STUDENTS)

Amir Abdollahpoor, Buddhika Abeyrathna, Akbar Abvabi, Ossama Badr, Mohammadjafar Biria, Qi Chao, Satyaveer Dhinwal, Shiromani Gangoda, Pinar Genc, Alireza Ghaderi, Jason Jiao, Sitarama Raju Kada, Andreas Kupke, Jiangting Li, Ajay Kumar Mahato, Jascha Marnette, Matthew Moss, Subrata Mukherjee, Paul Okonkwo, Kushboo Rakha, Ravi Ranjan, Shahriar Reza, Nigel Ross, Prabhukumar Sellamuthu, Vadim Shterner, Rupinder Kaur Sian, Arwa Faraj Tawfeeq, Xing Wei, Irwan Yahaya, Shuo Zhu

Metals play an important role in the advance of technology. Each new technological development brings a new set of metal performance requirements and continual innovation is required to meet these demands.

The Metals group develops new light metal alloys and novel ways of producing them. The group also works on the next generation of automotive steels and producing new porous metallic implants. To complement this work, we are developing new surface technologies to optimise performance.

Research areas include:

- Sheet metal forming
- Advanced high strength steels
- Light metal alloys including magnesium and titanium
- Strip casting simulation
- Bio-metals
- Architectured materials
- Twinning
- Texture control
- Nano-bainite

Strip casting to produce advanced high-strength steels

In 2012, the metals group was awarded an ARC Discovery grant to investigate advanced high-strength steels produced by energy efficient direct strip casting. With more than one billion tonnes of steel produced every year, one method of reducing the environmental footprint of this production is through strip casting. This process reduces the energy required to process liquid steel into thin sheet product by an astounding 90 per cent.

This research aims to expand the application of this technology to new steel grades. Prof. Hodgson and Dr. Stanford were also part of an ARC Linkage grant led by the University of New South Wales and with Baoshan Iron and Steel Co Ltd as an industry partner, that aims to expand the application of strip casting to more steel grades and to assess possible new steel grades with improved properties.

Prof Hodgson was part of a successful Science and Industry Endowment Fund (SIEF) grant application, alongside Monash University, CSIRO and Microturbo, that aims to manufacture a small demonstrator aero-engine entirely through additive manufacturing. This project brings together Australia's leading materials, design and additive manufacturing R&D capabilities, alongside industries across the materials and aero-space supply chain to manufacture a small aero-engine using entirely additive manufacturing technologies.

Roll forming of ultra high-strength steels and lightweight sheet metals.

Tensile testing of a wrought magnesium alloy.

Researchers within the metals group were involved in a successful bid to establish the Australia-China Research Centre for Light Metals (ACCLiM). The ACCLiM, to be headed by Monash University in Australia and Central-South University in China, was one of six centres founded with support from the Australia-China Science and Research Fund. The ACCLiM is a collaboration between research and industry leaders that aims to transform the high-end manufacturing and aerospace industries of both countries, leading to both cost and carbon emissions savings. It will research revolutionary light-weight alloys and advanced manufacturing processes, making it easier to customise materials while producing almost no waste.

Two PhD students successfully completed their degrees and graduated: Subrata Mukherjee, whose thesis was titled 'Nanoscale Precipitation in Advanced High Strength Steels' and Nigel Ross, with the thesis entitled "Microstructural Development and Mechanical Properties in Wrought Mg-Zn-RE Alloys."

Roll forming and stamping research

Roll forming is an important metal forming technology in Australia. The demands for shorter lead times, more complex shapes, new high strength materials and more demanding markets such as the automotive industry, require an improved understanding of the forming process and the increased application of virtual engineering at the design stage.

The group's main focus areas are:

- roll forming and flexible roll forming of ultra high-strength steels and lightweight sheet materials for structural and crash applications in automotive and aerospace
- to understand key process and material parameters and to develop inline process control and shape compensation routines
- development of new testing routines and material models to improve model accuracy in the finite element analysis of the roll forming process.

Sheet metal stamping is the main manufacturing method used to produce chassis and body components in the automotive industry.

The group's stamping research focuses on:

- the understanding, prediction and alleviation of tool wear using advanced numerical tools and analytical methods to better explain the contact, sliding, deformation and temperature conditions that are critical to the wear process
- detailed experimental characterisation and analysis of tool wear mechanisms and tool life under laboratory and industrial conditions
- formability, springback and robustness stamping prediction for advanced High Strength Steels (AHSS).

The group discovered a transition between the dominant wear mechanism that is dependent on bulk temperature (published in Wear 2012). This transition may have a large effect on the wear of stamping dies when stamping high strength steels. This is significant because dies are expensive to manufacture and maintain.

Other activities in 2012 included the ongoing development of a bend tester to provide more accurate information on roll forming sheet material and the design of a new heat assisted mini roll former for forming magnesium.

Understanding steel behaviour

The group was awarded an ARC Linkage project on Flexible roll forming of advanced high strength steel sheet in partnership with Wuhan Iron and Steel Corporation (China), Australian Rollforming Manufacturers, dataM (Germany) and Bluescope Steel, with total project funding of $420,000. The project is investigating behaviour of advanced high strength steels in the new flexible roll forming process.

Another ARC Linkage project to develop an environmentally friendly, low cost solution to reduce wear and improve productivity in metal forming is being carried out with Ford Australia. This project, with total funding of $599,000, will develop new ways to track tooling condition and develop environmentally friendly lubricants to reduce manufacturing costs.

Spreading the word

The group was invited to speak about latest research in advanced high strength steels at the International Deep Drawing Research Group International Conference in Mumbai, India. A/Prof Rolfe also addressed the International conference on Materials, Processing and Characterization in Hyderabad, India on the latest research in tool wear.

MICRO AND NANO SYSTEMS

GROUP MEMBERS (STAFF)

Professor Lingxue Kong, Dr Mary She, Dr Weimin Gao, Dr Sugumar Dharmalingam, Dr Haitao Niu, Dr Zheng Peng, Dr Ludovic Dumée, Dr Leonora Velleman, Dr Li He

GROUP MEMBERS (STUDENTS)

Chengpeng Li, Weiwei Cong, Feng An, Zhifeng Yi, Xiaodong She, Chunfang Feng, Yongzheng Li, Lijue Chen, Ronghua Chen, Jin Wang, Xiangping Sun, Youhai Qiu, Yuanyuan Guo, Tahir Ghandoori, Xiaowei Dong, Yanan Lv

The development of micro and nano systems, such as molecular diagnostics, nanoencapsulation for targeted drug delivery and nanoporous membrane materials is important to address future biomedical and environmental challenges.

The group focuses on the following technologies:

- Membrane fabrication and characterisation by developing membranes with aligned nanostructure for improved performance
- The development of a point-of-care diagnostic device
- Micro and nano encapsulated drug delivery systems
- Molecular dynamic simulation

Membrane synthesis and characterisation

The fabrication, alignment, and retention of well organised nanostructures are important for the development of high-performance membrane materials.

A new class of polymeric membranes has been developed with nanopores of about 2nm templated from hexagonal lyotropic liquid crystals (LLC). These membranes will potentially match the performance of nanotube membranes – three orders of magnitude higher than conventional membranes in permeability – and could significantly improve the efficiency of wastewater treatment and desalination processes.

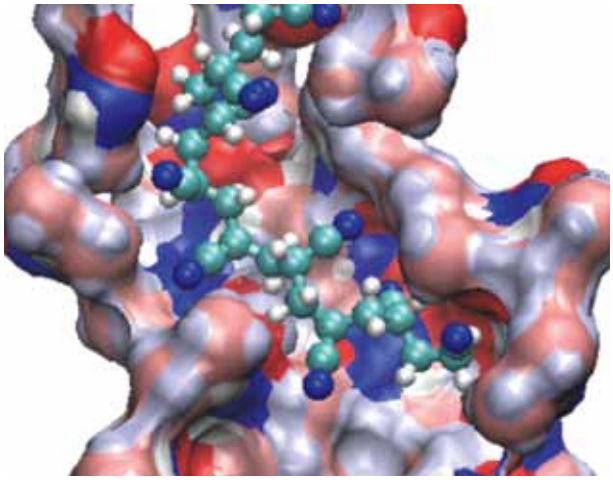
The research is being carried out in collaboration with ANSTO and the Australian Synchrotron including the support of an AINSE postgraduate scholarship. Synchrotron SAXS has clearly shown the alignment of the pores under tailor designed conditions. The breakthrough was highlighted on the cover of the leading materials journal Soft Matter.

Australian Leadership Awards

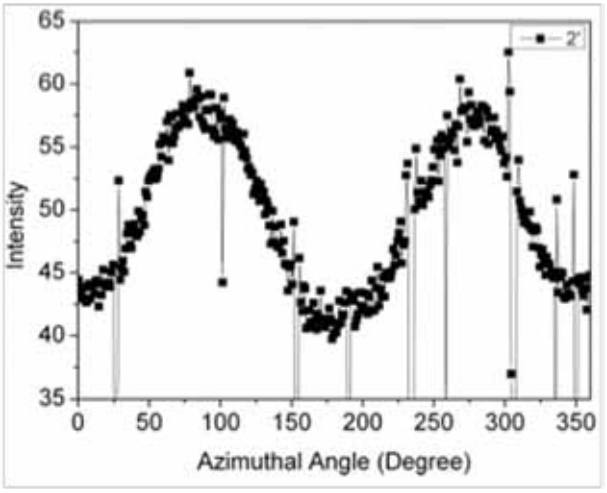
Chronic water shortages and increasing soil contamination represent enormous challenges which require the use of innovative approaches to water and land use and remediation.

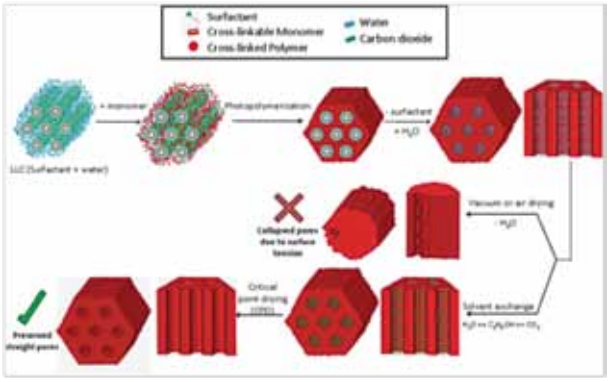
A group of leaders in environmental sciences from China and Taiwan has visited Australia to work with Deakin University scientists in formulating a multidisciplinary strategy to address these problems.

This Fellowships Program has improved our understanding of land and water conservation, allowing Australian and Chinese scientists to collaborate on the development of scientific, engineering and technological solutions as well as biological remediation. It also facilitated the formation of an Australia – China think-tank on environmental science and engineering.



Physical and electrical properties of polyacrylonitrile (PAN) in dimethylformamide (DMF) solution under electric fields are investigated with molecular dynamics simulation. The interaction of molecules in the solution controls the nanofibre formation.





The LLC templated nanopores are aligned under magnetic (left) and electric fields and retained if the surface tension is accurately controlled (right).

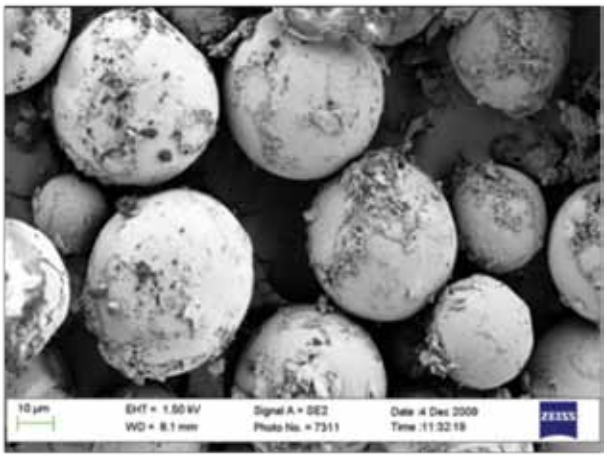
Oral delivery of colon cancer drug

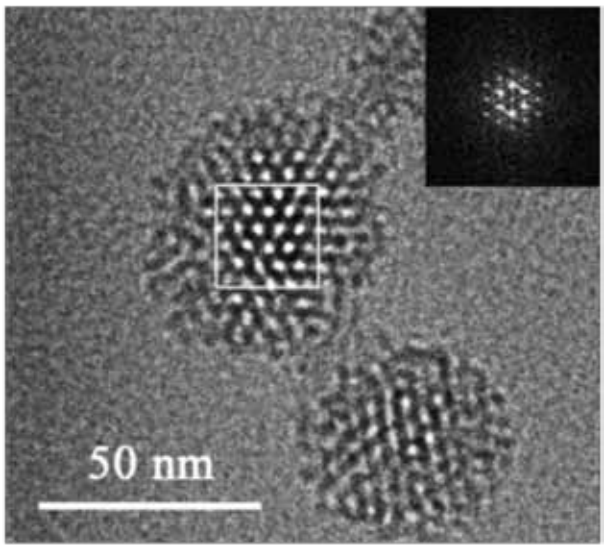
The encapsulation of drugs into micro- and nano-particles will lead to sustained, targeted and controlled drug release which should significantly improve the efficiency and efficacy of drugs for diseases such as cancer.

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 nano-particles, the drugs can survive the harsh pH conditions of the human gastrointestinal tract.

In vitro drug dissolution tests show an initial burst release followed by an extended slow release of up to 120 hours. The system clearly shows promise for treatment of colorectal cancer because it overcomes the often seen problems of both early drug release from nanoparticles and poor functionality of microspheres.

Membrane research at IFM has been enhanced with the commencement of the Collaborative Research Networks (CRN) program and through collaboration with Victoria University. We have started research into other new membranes including metallic, inorganic, and composite membranes with a number of strategic appointments.





1. *Micro and nano-encapsulated particles can deliver drugs to the colon.*

2. *Mesoporous silica nanoparticles with ordered porous structures for drug loading.*

PLASMA RESEARCH

GROUP MEMBERS (STAFF)

Dr Jane Dai, Dr Abu Sadek, Robert Lovett, Marion Wright, Dr Peter Lamb

GROUP MEMBERS (STUDENTS)

Gayathri Devi Rajmohan, David Rubin de Celis Leal, Sri Balaji Ponraj, Zhiqiang Chen, Tariq Mehmood, Yang Choon Lim, Md Saiful Islam, Ailan Wan, Haiying Chen

Plasma is present in lighting, auroras, fluorescent lamps and TVs. It is also an exciting new way of shaping materials for scientific and industrial applications.

The group's objectives are to:

- develop novel plasma technologies and methodologies
- improve understanding of the underlying mechanisms
- apply these developments and understanding to diverse applications

The two major research themes are tailoring of surfaces/interfaces with new functionality and fabrication/doping of nanomaterials.

We provide a platform technology for research at IFM and Deakin as well as with external collaborators, bringing different experts together in a harmonious environment.

These research areas include:

- Energy, including dye sensitized solar cells (DSSCs) and batteries
- Nanomaterials/composites, including element doping, functional nanomaterials, nanocomposites, and carbon fibre sizing
- Biomedicine, including biocompatible surfaces/interfaces, biosensors, and nanotuboids for drug delivery
- Textile industry applications, including anti-pilling of wool knitwear, electronic textiles, and wastewater treatment.

Opening of plasma laboratory

The plasma laboratory was officially opened at a symposium on 4 December 2012 where students presented their research. Students and staff demonstrated the equipment in the laboratory to the invited guests, collaborators, and IFM/university staff and students. Some new collaborative projects have already been proposed.

IFM Director, Peter Hodgson officially opens the new laboratory.

Dr Jane Dai and Mr Robert Lovett explain the capabilities of some of the new facility.

The custom designed advanced plasma facility combines physical vapour deposition with plasma enhanced chemical vapour deposition in a dual-chamber system.

Scientific breakthrough

We have achieved higher levels of required surface functional groups with strong bonding to the surface of nanotubes, while avoiding damage to the tube surface and keeping the integrity of the materials. The levels of the surface functional groups are higher than previously reported for any nitrogen-containing gas plasma treatment.

The functionalised surface improves the dispersion of the multi-walled carbon nanotubes and their interfacial bonding with epoxy. By adding just 0.1 wt% of these functionalised nanotubes to epoxy resin, the mechanical properties of the nanocomposites, from nano to macro, were significantly improved. Nanoindentation tests showed that hardness and elasticity increased by 40% and 19%, respectively.

Macro-mechanical properties from thermo-mechanical and flexural analysis were also enhanced, with a nearly 40% improvement in toughness.

Unique facility brings new possibilities

The advanced plasma facility will enable production of new and higher quality materials without surface contamination and provide multi-functional capabilities. The custom-designed facility combines physical vapour deposition with plasma enhanced chemical vapour deposition in a dual chamber system. Its multi-functional capabilities enable the dry fabrication of nanostructures (both top-down and bottom-up), their surface treatment, and multi-layer thin films and nanostructuring of materials in one go. We believe the facility is the only one of its kind in the world.

We have also developed a unique Plasma + Thermal technology, which combines plasma and thermal energy to fabricate nanosemiconductors. Nitrogen-doping has been successfully achieved for improvement of the efficiency of dye sensitized solar cells and batteries.

A systematic study to understand how the conductivity of a conducting polymer coated on textiles can be improved has significantly contributed to the field of electric textiles research.

POLYMERS

GROUP MEMBERS (STAFF)
Professor Qipeng Guo, Chris Skourtis, Dr Nishar Hameed, Dr Zhiguang Xu, Marion Wright

GROUP MEMBERS (STUDENTS)
Andreea Voda, Gigi George, Shuhua Peng, Nisa Salim, Shuying Wu, Renyan Xiong, Anbazhagan Palanisamy, Tao Zhang, Masihullah Jabarulla Khan

Polymers are an essential element of modern life and have many applications, including adhesives, coatings, paints, foams, composites, textiles, electronic and optical devices, and biomaterials.

The polymers research group in IFM studies fundamental principles in polymer science both theoretically and experimentally, developing new polymeric materials and conducting commercial research with industry partners.

Research areas include:

- block co-polymer 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

Developing new improved PDMS membranes

The group has 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, mechanical properties and transparency through relatively subtle manipulations of the precursor microemulsion phase represents a facile approach to developing new 'fit for function' siloxane based materials.

Six HDR students graduate

The group had an extraordinary number of HDR completions in 2012 with a total of six PhD graduates. One of these, Shuhua Peng, secured a three-year postdoctoral position at the University of Melbourne before completing her studies.

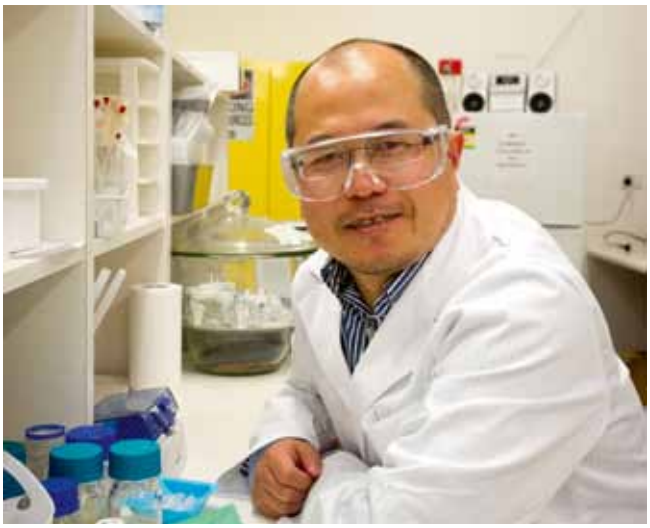
Needleless drug delivery for the eye

In collaboration with CSIRO and Seagull Technologies Pty Ltd, the polymers group were awarded an ARC linkage project to investigate tailored polymers for use in a novel non-invasive ocular drug delivery device which treats vision threatening conditions such as age-related macular degeneration (AMD). The outcomes of this project will enable an entirely new ocular drug delivery technology, thereby delivering significant benefits to ophthalmic healthcare.

Fire-fighting expert joins the team

Alfred Deakin Postdoctoral Research Fellow, Dr Pingan Song joined the group to investigate the development of flame-retardant polymer nanocomposites. These materials are more environmentally friendly than existing products and can actually improve the mechanical properties of the polymers.

Dr Song brings with him a wealth of knowledge in polymer composite and nanocomposite fabrication, properties and structure-property relationships.



Professor Qipeng Guo and his group have successfully developed a simple approach to the fabrication of novel porous polysiloxane membranes.

COMPUTER MODELLING

GROUP MEMBERS (STAFF)

Associate Professor Bernard Rolfe, Dr. Alireza Asgari (School of Engineering), Dr. Weimin Gao, Dr. Michael Pereira, Dr. Tim de Souza, Dr Zhijian Zhang (WISCO), Dr Libo Pan (WISCO)

GROUP MEMBERS (STUDENTS)

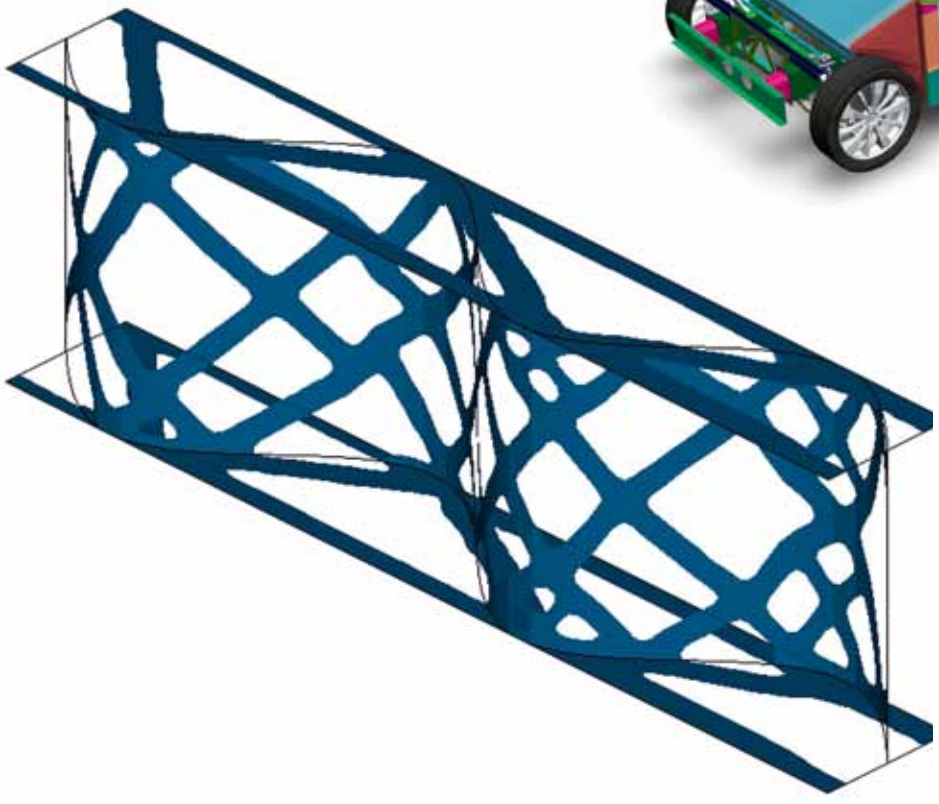
Akbar Abvabi (School of Engineering), Amir Abdollahpoor (School of Engineering), Jingsi Jiao, Klaus Fiedler, Ossama Badr, Paul Okonkwo, Pushpakumar Sugirtharaj (School of Engineering), Yanan Lv, Jiangting Wang, Xing Wei (WISCO)

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

The group's two main themes are material modelling under deformation 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.

Lightweighting automotive body structures

A major achievement was development of a new concept optimisation technique for lightweighting automotive body structures. This work was presented at the conference WIT Transactions on the Built Environment.

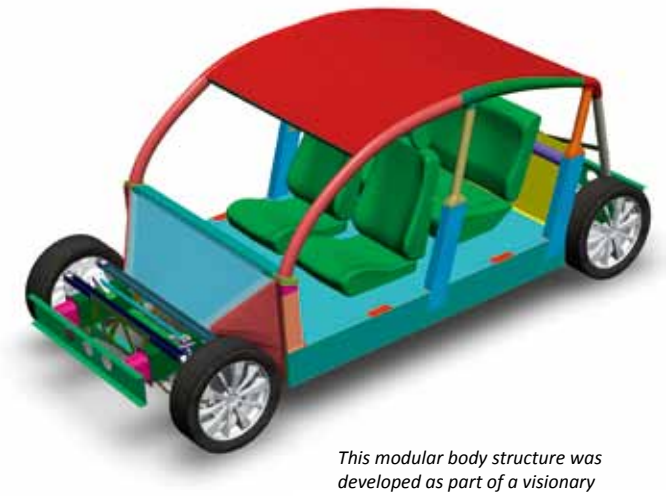


New lightweighting optimisation routine applied to an I-beam to minimise weight for a given compliance performance.

AutoCRC project

The group worked on a project as part of the re-funded AutoCRC 2020 to assist a Thai canopy manufacturer on lightweighting their product with partners the Victorian Partnership for Advanced Computing (VPAC), and SAMMITR (Thailand). The project has funding of $469,000.

Jiangting Wang successfully completed his PhD studies and graduated in 2012.



This modular body structure was developed as part of a visionary project for the AutoCRC.

COLLABORATIVE CENTRES

Advanced Manufacturing CRC (AMCRC)

Auto CRC

Sheep CRC

ADVANCED MANUFACTURING CRC (AMCRC)

Several AMCRC projects were completed, commenced or awarded in 2012 including a three-year project with Quickstep Technologies Pty Ltd to increase the robustness of a rapid composite curing process

A Strategic Fund Project 2010-2012 to develop functionally graded nanocomposites to optimise mechanical properties, while tailoring thermal and electrical properties for multi-functional applications was conducted by Ehsan Bafekrpour, who successfully completed his PhD studies in 2012.

Dr Dan Fabijanic was awarded a strategic project in 2012 to be completed in 2013. The title of the project is "Microstructure and properties of bulk high entropy alloys formed by direct laser sintering". This project will produce bulk specimens of a five-element high entropy alloy system (NiCrFeCoAlx) at the direct laser sintering facilities at the Centre of Excellence in the Design of Light Metals, Monash University.

Professor Qipeng Guo completed a project in partnership with VCAMM and VR TEK Global Pty Ltd to refine rubber de-vulcanisation and activation technologies which he developed in an earlier project. This research has led to a new, cost-effective and environmentally friendly solution for recycling tyres into high quality ingredients for the manufacture of new rubber products.

A pilot plant was established at the Geelong Waurn Ponds Campus and VR TEK Global is preparing to set up commercial facilities in Australia and overseas to produce high quality, high value rubber powders.

A collaborative two-year project involving IFM, Cytomatrix Pty. Ltd. and the Monash Institute of Medical Research (MIMR) was commenced to develop a novel three-dimensional cell culture platform. This platform uses a non-woven scaffold developed by Deakin University and Cytomatrix, together with proprietary and patented reagents and methods.

The primary goal of this project is to develop a clinical-grade device for the expansion of haematopoietic stem cells (the stem cells in bone marrow that give rise to blood cells).

Such a device would have widespread application in bone marrow transplantation, making the treatment safer and more available for patients. The project involves materials scientists and cell biologists at IFM, who will examine ways of functionalising the scaffold to enhance expansion, working with scientists at MIMR who will perform stem cell transplants in a mouse model. The project is expected to be completed by June 2014.

Dr Dan Fabijanic has continued Deakin University representation on the AMCRC Science Advisory Committee and also as guest reviewer at the AMCRC PhD Symposium.

IFM PhD student, Charanpreet Singh, was awarded the AMCRC Student Prize for the project "Hybrid unibody designs of vascular endografts for treatment of abdominal aorta aneurysms using biocompatible polymeric filaments".

The AMCRC Student Prize is a competition for the best overall proposal in the area of a medical/health technology that contains a strong element of manufacturing or the creation of intellectual property suitable for eventual manufacture.

IFM research as part of the AMCRC has led to a new cost-effective and environmentally friendly solution for recycling tyres.

AUTO CRC

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 AutoCRC has been refunded from 2012 to 2017 to implement the Auto 2020 roadmap for Australia. This will assist in the transformation of Australia from being an innovation follower to a technology provider for the Asian region in strategic areas of the automotive industry. IFM is the lead institution for the 'Lightweighting' theme, which is part of the CRC's sustainable manufacturing research.

In 2012, the IFM completed its development of a lightweight modular vehicle platform to support the next generation of sustainable and safe vehicles. This project, which involved collaboration between Deakin, Swinburne, ANU, RMIT, and VPAC, has produced two provisional patents and now needs an industry sponsor. Work will continue on the structure at a reduced level with a partnership of ANU and Deakin PhD students.

The IFM held the last of the joint Hefei University of Technology/ Deakin Automotive Technology forums in Hefei, China, under the original CRC. Deakin's Deputy Vice-Chancellor of Research, Prof Lee Astheimer opened proceedings and technologies developed by both universities were showcased to an audience representing Chinese automotive equipment manufacturers and local students.

Late 2012 saw the initiation of three new projects with the re-funded AutoCRC. Beginning in September 2012, Deakin and VPAC have been working with a Thai canopy manufacturer to assist with the lightweighting of their product. This has involved investigating the product design to assess where the weight is distributed, and using advanced design tools and computer aided engineering to analyse directions for potential new designs.

Deakin also began negotiating project agreements with the Malaysian Automotive Institute in the areas of tool wear and novel forming techniques for projects to start in 2013.

The AutoCRC will help Australia become a technology provider for Asia in strategic areas of the automotive industry.

SHEEP CRC

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

The comfort team of the fibre group 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. Staff in the comfort team completed experimental work to finalise the instrument's operational test method, operating conditions and to quantify its precision limits. A large number of knitted garments and fabrics have been added to a special fabric library now held at Deakin University.

The team has investigated aspects of the relationship between the assessed comfort of fabrics and yarns with the structural features and fundamental mechanical properties of the fabrics and yarns. The outcomes are a series of identified attributes, construction methods and textile processes associated with improved comfort properties that can be used by the textile industries.

Members of the team were also involved in a national collaboration to develop a faster and cheaper test method to determine wearer responses to wool fabric properties. A range of specific fabrics were designed and constructed for testing. The developmental work to date has identified preferred wool fabric, yarn and fibre properties associated with high levels of wearer comfort.

The CRC postgraduate student, who is co-supervised by staff of the comfort team, is advancing investigations of wool handle attributes to identify sheep with preferred soft handling wool.

Wool Comfort Meter

The group assessed Wool Comfort Meter responses to variations in operating conditions. The meter appeared stable at 20°C but, as expected, the values were heavily affected by variations in humidity at higher temperatures. The results are being used in the technology support package to help industry adopt the equipment.

National Wool Week

Two members of the comfort team were key presenters at the National Wool Week conference in Melbourne in September. Dr McGregor spoke on the outcomes of scientific investigations into identifying more comfortable fabrics and Dr Naebe conducted a series of demonstrations on the operation of the Wool Comfort Meter.

Alison Lee King completed her PhD under the CRC. Her thesis title is *Influence of Trace-metals on the Colour and Photostability of Wool*.

As an extension of the research and commercial success of the Wool Comfort Meter, a new instrument, the Wool Handle Meter, is going to be relocated to the IFM. The Wool Handle Meter will be used to evaluate the fabrics currently available in the fabric library. This will provide new technical information to assess the comfort attributes for next-to-skin knitwear.

Dr Maryam Naebe and Dr Bruce McGregor will use the Wool Handle Meter to evaluate fabrics in the fabric library.

IFM FINANCIAL SUMMARY - 2012

TOTAL RESEARCH INCOME BY CATEGORY – ACTUAL 2012 ($M)

FINANCIAL SUMMARY- FOR PERIOD ENDED 31 DECEMBER 2012	2012 Actual
INCOME	**$**
External Research Income	6,772,096
Strategic Initiatives	-
Operational Initiatives	2,306,537
University Operating Funds	6,219,964
Research Allocation	10,087,623
Total Income	**25,386,220**
EMPLOYMENT COSTS	
Academic Salaries	11,808,332
General Salaries	3,517,344
Other Employment Costs	34,897
Contractors	-
Total Employment costs	**15,360,573**
NON SALARY EXPENSES	
Buildings & Grounds Infrastructure Costs	154,867
Communication/Advertising, Marketing & Promotions	51,250
Consumables	1,333,183
Depreciation & Amortisation	2,794,456
Equipment - Repairs, Maintenance & Other Costs	994,069
Financial, Borrowing, Debtors & Currency Costs/Legal Costs & Consultants	-
Inter Budget Centre/Internal Charges/Recoveries	487,094
Contributions to other Universities	351,347
Other Costs	403,515
Professional, Legal and Consultants	129,227
Staff Recruiting, Training & Other/Library Information Resource Expenses	353,918
Student Expenses	1,768,423
Travel, Catering & Entertainment	950,940
Total Non Salary Expenses	**9,772,289**
Surplus/(Deficit)	**253,358**

INDUSTRY PARTNERS

FIBRES AND TEXTILES

Australian Wool Innovation
Australia Defence Apparel
Brookland Greens Medical Centre
Carpro Trading Ltd
Cashmere Connections Pty Ltd
Cotton Research and Development Corporation
Cytomatrix Pty Ltd
Ear Science Institute Australia Incorporated
Geofabrics Australasia Pty Ltd
Guangzhou Textile Union Group Co
Hysport International Pty Ltd
International Fibre Centre (IFC)
Rural Industries R&D Corporation
Shangdong Ruyi Technology Group
Ug Manufacturing Co Pty Ltd
Zhejiang Shenzhou Woollen Textile Co
Zhik Pty Ltd

METALS AND COMPOSITES

Aircraft Plastics Australia Pty Ltd
Backwell IXL
BHP Billiton
Bluescope Steel Ltd
Carbon Revolution Pty Ltd
DataM Software GMBH
DHS Emergency
Ford Motor Company
FTS Australasia Pty Ltd
GM Holden
Hard Technologies Pty Ltd
JE Hoffmann Engineering Pty Ltd
Laboratoire De Physique Et Mecanique Des
Logistik Unicorp Inc.
Materiaux
Powercor Australia Ltd
Qenos
QuickStep Technologies Pty Ltd
Shinil Chemical Company
Tata Steel Pty Ltd
United Surface Technologies Pty Ltd
VR TEK Wheels Pty Ltd
Wuhan Iron and Steel (Group) Corporation
ZedCon Scientific Services

ELECTROMATERIALS AND CORROSION

AECOM
Agricultural Organics Pty Ltd
AusComposites Manufacturing Facility
Australian Pipeline Industry Association
APA Group
Cytec Canada Inc
Defence Materials Technology Centre
Honda R&D Co Ltd
Horizon Fuel Cells Technologies
Hydrochem Pty Ltd
Jemena
National Centre for Excellence in Desalination
ROC Oil (WA) Ltd
Rockingham Desalination Research Facility
Santos Ltd
Seagas
Shell Refinery (Australia) Pty Ltd
Sussex Material Solutions

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