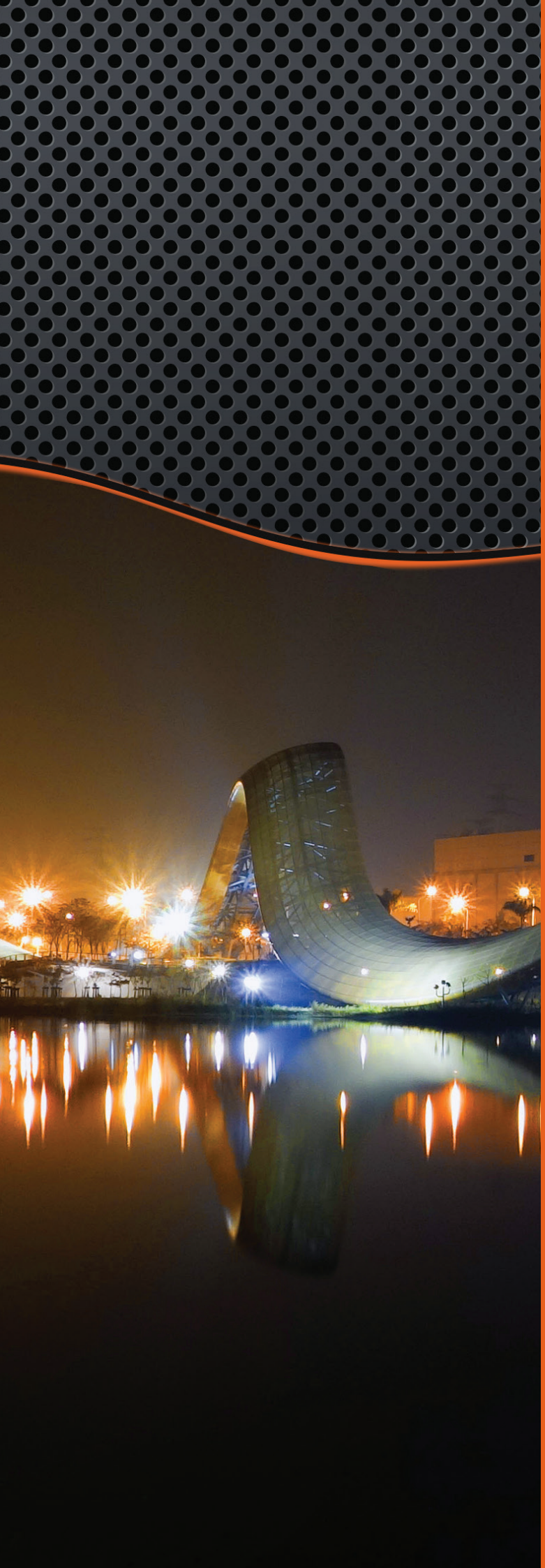
UNSW AUSTRALIA

School of Materials Science and Engineering

Annual Report 2013

Never Stand Still | Faculty of Science | School of Materials Science and Engineering



WHO WE ARE

From its foundation over 60 years ago, the School of Materials Science and Engineering at UNSW Australia has developed an international reputation for research and teaching excellence.

The School is consistently ranked number 1 in Australia and is currently 17th in the world for materials science (2014 QS World Rankings 2014).

This year our research income totalled more than $10.1m - a remarkable achievement for a small school with around twenty academic staff.

We continue to maintain close partnerships with industy to develop innovative advancements in materials and solve real-world problems, helping industries to stay at the cutting edge.

In early 2015 the School wil be moving into a brand new, purpose-built facility. This new building will provide staff and students in the School with exceptional, state-of-the-art research laboratories and versatile collaborative learning spaces. This is a clear indication of the University's faith in the future of materials science and engineering as an area of innovation and exponential growth.

Contents

PART ONE:

OVERVIEW

OUR ASPIRATION

To be recognised as a leading research and teaching school, among the World's best schools for Materials Science and Engineering

To provide a first class education, equipping graduates with technical and generic skills at a level which will lead them into attractive and productive employment

To provide first class research training in an intellectually stimulating and creative environment

To maintain and develop international prominence in research and teaching in materials science and engineering

OVERVIEW

Academic Staff	23
Research Staff	29
Professional and Technical Staff	20
Research Fellows	15
Undergraduate Students	224
Undergraduate Completions	25
Masters Completions	13
Doctoral Students	129
Doctoral Completions	25
Refereed Research Publications	296
Grant Funding	$10.1m
Strategic UNSW Income	$1.9m +

Foreward from Head of School

As Head of School I am immensely proud to present to you the 2013 Annual Report for the School of Materials Science and Engineering. The School is performing at a very high level not only through the generation of excellent research, but also through outstanding teaching and leadership and engagement at a national and international level.

In the QS World University Rankings announced earlier this year, the School did exceptionally well, being ranked 17th in the world for the Materials Sciences, up from 25 in 2013. The School is the highest ranked materials school in Australia and the only School at UNSW to be ranked number one in Australia for its discipline. The ranking reflects the extraordinary research achievements of the School's academic staff.

The School continues to attract significant amounts of research funding, mostly through various Australian Research Council schemes. In the most recent rounds announced the School was successful in winning six Discovery Project grants and 4 Linkage Project grants. Moreover, it was recently announced that the School will act as the lead for the ARC Industrial Transformation Research Hub for "Transforming waste directly in cost-effective green manufacturing". This centre, led by Professor Veena Sahajwalla, comprises a number of university and industry partners and will receive funding of ~ $6M over the next five years. The centre will do much to strengthen links between the School and industry in the coming years.

There have been a number of important staff changes over the past 12 months. Professor Aibing Yu recently left UNSW to take up a senior executive position at Monash University where he will lead a joint venture between Monash and Southeast University in China. Aibing has been one of UNSW's most successful academics in recent years. His appointment to this prestigious position is well deserved and we wish him well in this venture. The School has also been fortunate to appoint Dr Judy Hart to a lectureship as part of a University-wide scheme to appoint young, outstanding academics into newly created positions. Judy has a research interest in novel semiconducting materials specifically for use in renewable energy applications.

It should also be noted that Leo Selleck, the chair of the School's Visiting Committee, retired from his position at Arrium Mining & Minerals in July 2014. As a consequence, he has stepped away from his position on the Visiting Committee. Leo has served on this Committee for the past 10 years

and been its Chair for the past 5. He has been a staunch supporter of the School's activities and has been outstanding in providing leadership and strategic advice to the School. We sincerely thank Leo for his contribution and wish him the best as he commences the next stage of his life.

As described in detail later in this report, the School's new building is on track for completion in early 2015. The building is currently on time and on budget and will provide the School with badly needed contemporary laboratory and office space. The facilities provided through this building will do much to strengthen staff and student recruitment and enhance ties with industry.

The School is active in engaging with the global materials community on many different fronts. This year we were fortunate to be able to send a cohort of our senior year undergraduates to Taiwan to perform their industrial training. This not only provided the students with excellent industrial exposure, but also provided an outstanding cultural opportunity for our students.

The School's progress and achievements over the past year are described in this report and I am pleased to present this report as a snapshot of the School's current position.

Professor Paul Munroe
Head of School

STRATEGIC PLAN 2014 – 2018

The School's most recent business plan expired in 2013 so in June 2014 academic staff, general staff, students from the school and a representation of industry partners met to discuss the creation of a new School road map for the period 2014-18. After detailed consultation, the following Strategic Plan was generated.

Our Aspiration

- To inform and drive changes in Materials Science; to train the next generation of leaders in Materials Science and prosecute new developments in the field.
- The role of Materials Science in a changing world:
- Our changing world involves an aging population, greater resources allocated to improving health, issues with food and energy security
- Materials Science is a rapidly evolving discipline
- What are the implications for the School and the University?

Our Strategic Goals

We will seek to position research clusters to perform high profile research and so achieve high level outcomes and international recognition, supported by external funding

Two key research areas – functional materials and sustainable materials processing - will be supported by enabling activities in a broader range of materials areas including biomaterials, computational materials science, advanced ceramics and others.

Sustainable Materials Processing

This research area includes increasing efficiencies in materials production and effective methods for recycling and increasing materials sustainability.

Functional Materials

This research area would include materials with electronic, energy or transformational applications.

Supporting Research Areas

These research areas will be supported by our current strengths in:

- Advanced ceramic materials
- Heat resistant alloys and metallic glasses
- Extractive metallurgy and materials processing

Together with increased activity in emerging areas such as:

- Smart Polymers
- Biomaterials
- Computational materials

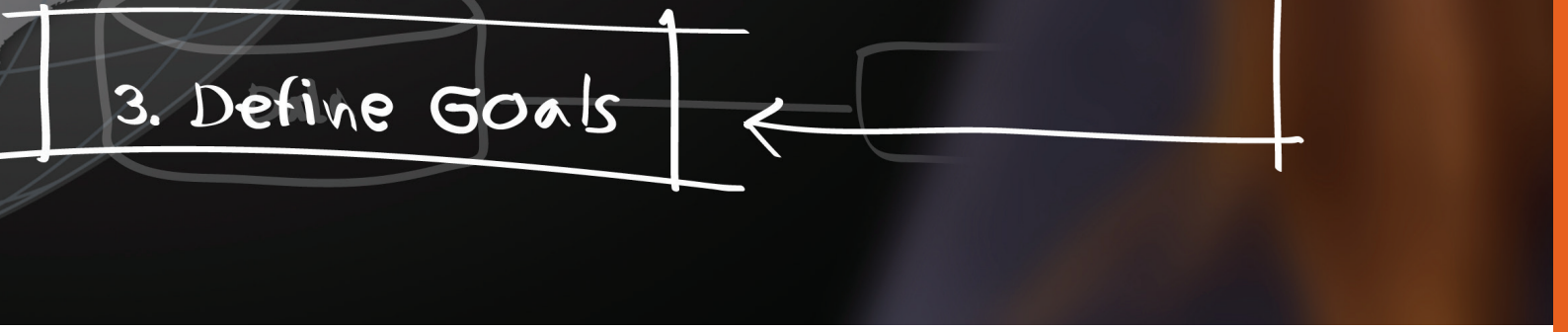
Our 5-Year Plan

To achieve these goals, there are four key objectives :

- Recruiting and retaining high performing and effective staff
- Delivering excellent learning and teaching
- Maximizing the effective use of infrastructure
- Engaging and collaborating with external stakeholders

Recruitment and Retention

- Actively recruit high profile SPF01 appointments aligned to areas of research strength
- Actively recruit high performing entry level or SPF03 appointments aligned to areas of research strength
- Engage and develop new academic staff to establish effective career paths so they can rapidly reach their potential
- Recruit and develop high quality professional staff
- Build a structured plan for induction and development, including effective mentoring support from senior staff, shadowing, coaching, ensuring clear goal setting and clarity of expectations
- Focus on retention of high performing staff and succession management
- Value and reward high quality teaching
- Explicitly recognize significant contributions in leadership, engagement and and innovation.
- Provide opportunities for staff to network through committees external to the School.



Learning and teaching

- Increase and enhance expertise, effort and delivery of a range of blended learning methodologies, strategies and tools.
- Encourage and exploit the use of IT in teaching
- Focus on the teaching of concepts/principles rather than factual detail; place emphasis on the application of concepts
- Constantly review and reflect on programs, course structures and delivery of teaching
- Seek greater alignment between learning and teaching and research strengths
- Consider the use of cross-year or cross-disciplinary teaching groups.
- Develop participatory laboratory classes

Infrastructure

- Materials Science and Engineering will relocate to a new facility in 2015. This presents both challenges and opportunities.
- Develop a plan for utilization based on principles of flexible space, collaboration and responsiveness to emerging research areas
- Continually review space resources for existing and future requirements
- Exploit the new building as a means of recruiting high quality staff and students.
- Develop a structured, transparent and methodical strategy for the acquisition of new equipment and infrastructure, which will be complimentary to existing resources, focused on areas of emerging research strengths and will engage 'whole of life' ownership of the facility.

External engagement

Undergraduates

- Develop more effective communication with school leavers: build awareness through methods such as web pages, social networking, open day and brochures
- Attract a broader range of scholarships and prizes for undergraduate students.

Postgraduates

- Recruit high quality postgraduates through competitive scholarship programs
- Develop a robust selection process for the provision of scholarships
- Increase the conversion of undergraduates to postgraduate study

International

- Academics should foster research collaborations with international peers of good standing
- Attract high achieving international exchange students
- Establish and/or develop joint teaching or research programs with overseas universities

Industry

- Enhance the role of the Visiting Committee as a vehicle to engage with industry
- Increase the level of engagement with industry through collaborative research grants, short term academic research partnerships, sponsorships, industrial training, scholarships.
- Exploit the new building as a means to attract industry partnerships
- Become regarded by industry as a partner of choice for development and research projects
- Build an alumni engagement strategy to create a thriving network leading to improved industry relations and opportunities for recruitment.

Financial Report 2013

INCOME

The School receives its income from three primary sources:

Operating income is allocated by the University, via the Faculty, to fund the day to day running of the School. Income, as it is earned by the University, is linked to a series of drivers around the level of undergraduate teaching load and research training, grants and outputs. It is then allocated based upon undergraduate and postgraduate teaching load. Research income is from research grants obtained from bodies outside the university. Strategic allocations are made by the University to the School for specific purposes. The graph in Figure 1 shows trends in the School's operating and research income.

Operating Income

Operating income is primarily used for salaries for teaching and research academics and technical and professional staff. Even though a number of the School's academic staff hold externally-funded research fellowships there is invariably a shortfall in these fellowships which the School pays from its operating budget allocation, following a specific, though capped, allocation from the University for this purpose. It is also used to pay for casual teaching, administrative and laboratory staff. Other major expenditure items are support of teaching laboratories, administration, marketing and undergraduate recruitment scholarships, allocations to staff based upon research supervision and publications.

Table 1 shows the breakdown of School operating income in 2013. Total operating income was $5.73M. This represented a modest increase on the previous year. A larger increase in operating income occurred in 2012 which is attributable to strongly growing undergraduate student numbers.

The primary driver for operating income at the School level is undergraduate and postgraduate teaching load. The graph in Figure 2 shows the strong growth which the School has enjoyed in these areas in recent years which is currently funding expansion of the School's staff. Over 2009-2013, the School's EFTSL has grown at a rate of 8% p.a.

Strategic UNSW Funding

The University provides central funding for a range of strategic research purposes including infrastructure, support of national initiatives and projects for early career researchers.

Figure 1: Trends in School's Operating & Research Income

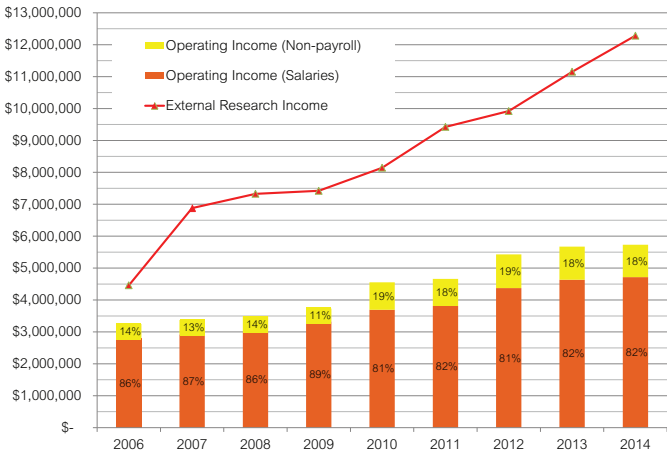
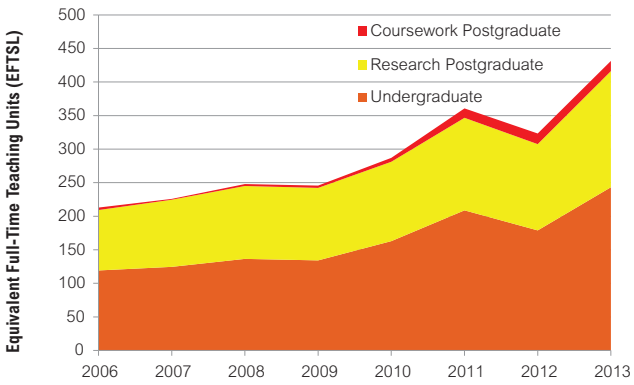


Table 1: Breakdown of School's Operating Income

INCOME		
University:		
Teaching	$9,324,878	
Other	$5,626	$9,330,504
Allocation to School:		
Teaching and Research	$5,353,390	
Fellowship salary shortfalls	$286,379	
Capital equipment funding	$120,000	$5,759,769
EXPENDITURE		
Salaries	$4,200,699	
Non-salary	$1,021,100	
Capital expenses	$228,340	$5,450,139
Variance		$189,630

Figure 2: Undergraduate and Postgraduate Teaching Load



EXPENDITURE

The main component of School expenditure is staff salaries which comprised about 80% of total non-capital operating expenditure. Despite the strong rise in salary costs, School income has grown at a faster rate, providing greater flexibility in strategic directions. Table 3 shows the School's main expenditure items in 2013.

Faculty Research Grants are funds for small research projects which are allocated from the School's operating budget. The School preferences junior staff who have not had the opportunity to build up significant external research funding when allocating these grants. The 2013 recipients are listed in Table 4.

External Research Income

The School's external research income comprises the largest fraction of the overall income of the School. It is the funding provided by external bodies to the School's staff to undertake specific research projects. The School is a very high performing research unit within the University. Figure 1 above shows trends in internal research income. Despite the School's growth in teaching-load driven operating income, research income continues to grow at a greater rate.

Research income increased by 10% from 2012 to 2013. This reflects, in part, the growth in industry supported research.

Overall the School is in a very strong financial position. Its operating income has grown from a large deficit situation in 2007 and 2008 to a strong position which has enabled a growth in academic staff. This has occurred primarily due to the growth in undergraduate and postgraduate research students.

Table 2: Strategic Allocations

Project Name	Project Manager	Amount
CoE DESIGN IN LIGHT METALS	Ferry, Michael	125,000
FF0883231 _ A Yu	Yu, Ai Bing	259,706
CRC ADVANCED MAN - FERRY	Ferry, Michael	33,333
AINSE Postdoctoral _Daniels,J	Daniels, John Elliott	33,165
2010 VC PostDoc_Ao, Z_Support	Ao, Zhimin	2,000
2011 VC PostDoc_Tian_Support	Tian, Zean	10,000
2012 VC Support_Xing, G	Xing, Guozhong	10,000
Research Support: Hoffman	Hoffman, Mark John	125,000
ECR-Development of a novel ci	Chu, KaiWei	9,312
ECR-Interface engineering of c	Chu, Dewei	8,200
Safety Net - Aibing Yu	Munroe, Paul Richard	125,000
2013 Goldstar_Yang,R	Yang, Runyu	40,008
2013 Goldstar_Ao,Z	Ao, Zhimin	40,000
2013 Goldstar_Quadir, M	Quadir, Md. Zakaria	35,050
2013 Goldstar_Li,S	Li, Sean	40,000
2013 Goldstar_Yu,Ai Bing	Yu, Ai Bing	38,552
2013 Goldstar_Yi ,J	Yi, Jiabao	40,000
Total:		974,327

Table 3: The School's non-salary expenditure items

Item	Amount [$]
Faculty Research Grants	71,800
Student Research Allocations	150,000
Undergraduate scholarships	90,000
Computer technical support	40,000
Publications allocation	100,000
Teaching laboratories	86,178
Safety	12,000
School Office	35,000
Staff Start Up	105,000
Marketing	35,000
Repair, Maintenance & building utilities	87,470

Table 4: Faculty Research Grants Recipients

Chief Investigator	Project Title	Grant
Seidel, Jan	High speed data acquisition system	$15,000
Chu, Kawei	Development of a novel circulating fluidized bed to improve solids-fluids contacting	
Dong, Kejun	Numerical modelling of the in-line pressure jig unit in ore preparation	$5,000
Chu, Dewei	Interface engineering of ceria nanocubes for resistive switching memory applications	$3,800
Shen, Yansong	Model of ironmaking blast furnace: effects of geometry setting	$5,000
Xing, Guozhong	Tailoring magnetocaloric chracteristics of FeRh thin films: Mechanism towards room temperature magnetic refrigerator applications	$10,000
Yi, Jiabao	Development of high quality magnetic semiconductor materials by rare earth doping	$10,000
Kuang, Shibo	Multiscale study of flow instability within pneumatic/hydraulic conveying systems	$5,000
Zhang, Tianshu	Tailoring thermal conduction of manganates via both nano and co-doping techniques	$7,000
Vodenitcharova, Tania	Novel effects on fracture strength of silicon wafers for the photovoltaic industry	$7,000
Zhou, Zongyan	Microscopic analysis of particle size segregation of granular free-surface flows	$4,000

New Research Funding for 2013

Grant Organisation	Research Topic	Researchers	Total Grant Value
Australian Research Council/ Discovery Project	Electro-mechanics of natural load-bearing materials: Understanding mechanisms of toughening, remodelling, and self-healing	Glaum, J., Daniels, J.E.	$360,000.00
Australian Research Council/ Discovery Project	Heat-resisting iron-nickel base alloys in challenging new applications - oxygen permeabilities and resistance to internal oxidation	Hibbert, B., Zhang, J.Q., Young, D.J.	$460,000.00
Department of Industry/Australia-China Science and Research Fund (ACSRF)	Australia-China Joint Research Centre for Minerals, Metallurgy and Materials (3M Centre)	Amal, R., Green, M., Sahajwalla, V., Wainwright, M.S., Young, .J., ~Zhang, L., Zou, R., Zulli, P., Yu, A.B.	$833,000.00
Australian Research Council/ Discovery Early Career Researcher Award (DECRA)	Design of alloys over multiple grain scales for improving fatigue performance	Gu, C.	$375,000.00
Australian Research Council/LIEF	Thermal and Mechanical Simulation Laboratory for Light Metals.	Barnett, M., Bettles, C., Cairney, J., Davies, C., Hoffman, M.J., Laws, K.J., Ma, Q., Munroe, P.R., Quadir, Md. Z., Ringer, S.P., Stanford, N., Zhang, M.X., Ferry, M.	$390,000.00
Australian Research Council/LIEF	Spin-Polarized Scanning Tunneling Microscope: A Critical Instrument for Expanding the Functionality of State-of-the-Art Oxide MBE System	Duty, T.L., Nowotny, M., Sahajwalla, V.H., Sheppard, L., Wang, D.Y., Yu, A.B., Li, S.	$340,000.00
Australian Research Council/LIEF	A multiscale electrochemical, magnetoelectric and electromechanical characterization facility for advanced materials and devices.	Amal, R., Cheng, Z.X., Hamilton, A.R., Munroe, P.R., Seidel, J., Valanoor, N., Wang, X., Zhang, C.,	$200,000.00
Australian Research Council/ Linkage Project	Micromechanical analysis of size segregation and its prediction in granular free-surface flows	Pinson, D.J., Zhou, Z.	$255,000.00
Australian Research Council/ Linkage Project	Coke integrity in blast furnace ironmaking: Understanding and technology development	Hockings, K., Zhang, G., Zulli, P., Ostrovski, O.	$365,000.00
Science & Industry Endowment Fund (SIEF)/John Stocker Postgraduate Scholarship	Domain wall nanoelectronics through combinatorial synthesis and scanning probe approaches - scholarship for Vidya Ramesh	Kalinin, S., Klose, F., Ramesh, V., Takeuchi, I., Valanoor, N.	$52,615.00
Australian Research Council/ Linkage Project	Decrease of environmental impact of steelmaking: development of fluorine-free mould flux for steel continuous casting	Maric, M., Zhang, C., Zhang, J.-Q., Ostrovski, O.	$250,000.00
Australian Research Council/ Linkage Project	Fundamental studies of multiphase flow and separation performance of natural medium cyclones for recovering waste coal	Lenagh, M., Williams, R., Zou, R., Yu, A.B.	$455,000.00
University of Queensland/ Baosteel-Australia Joint Research & Development Centre Contract	Fluoride-free mould flux for steel continuous casting	Zhang, J.-Q., Ostrovski, O.	$100,000.00
University of Queensland/ Baosteel-Australia Joint Research & Development Centre Contract	Advanced Fe-based nanocrystalline alloys with low coercive force and high saturation magnetic flux density for high performance electric motors	Chu, D.	$300,000.00
Haynes International Inc/ International Contract	Metal Dusting Resistance of developmental alloys	Zhang, J.-Q., Young, D.J.	$44,454.00
Monash University/DIICCSRTE Australia-China Science and Research Fund Shared Grant	Australia-China research centre for light metals	Ferry, M.	$98,000.00
BlueScope Steel (AIS)/ARC Linkage Project Industry Partner Contribution	Coke integrity in blast furnace ironmaking: Understanding and technology development	Hockings, K., Zhang, G., Zulli, P., Ostrovski, O.	$150,000.00
Korea Advanced Institute of Science & Technology/Global Research Network Research Grant shared grant	Exploration of exotic electronic conduction of carrier-doped multiferroics	Seidel, J.	$31,754.00
Fujian Longking Co., Ltd/ARC Linkage Project Industry Partner Contribution	Fundamental studies of multiphase flow and separation performance of natural medium cyclones for recovering waste coal	Lenagh, M., Williams, R., Zou, R., Yu, A.B.	$300,000.00
BlueScope Steel/ARC Linkage Project Industry Partner Contribution	LP130100365 - Modelling and optimisation of pulverised coal conveying and injection in blast furnace ironmaking – Yu, Ai Bing	Lenagh, M., Williams, R., Zhang, Zou, R., Yu, A.B.	$150,000.00

Work Health And Safety (WHS)

The School of Materials Science and Engineering is committed to providing a safe work environment for all staff, students, and visitors in compliance with the Work Health and Safety Act 2011 and as implemented through the UNSW Work Health and Safety Policy.

In 2013, the School WHS Committee consisted of Owen Standard (chairperson and academic representative), Anthony Zhang (School Safety Officer), Rahmat Kartono (administrative and technical staff representative), and Ruiping Zou (research-only staff representative). Paul Munroe joined the Committee in the latter half of 2013 replacing Mark Hoffman as management representative. Mark Hoffman departed from the Committee at the end of 2012 and is thanked for his significant contribution to the Committee over the last ~5 years and, more generally, for his demonstrated strong support and commitment to WHS in the School.

WHS activities in the School during 2013 included:

- continued update of WHS documentation to comply with the updated documentation introduced by the UNSW HS Unit;
- implementation of new policy for after-hours working in laboratories;
- extensive input by laboratory supervisors and laboratory managers into laboratory design and associated health and safety systems for the School's new building;
- electrical tagging and testing of equipment and appliances; mandatory School WHS information session (held in both semesters) for all new research staff, new postgraduate students, and Honours students;
- gas training session provided by the company Air Liquide;
- various laboratory training courses over the year; evacuation drill for the School in each session;
- laboratory safety audits conducted bimonthly;
- inspection and audit check of all offices and laboratories by the School WHS Committee.

All staff and students in the School are thanked for their ongoing cooperation and compliance with WHS requirements and procedures.

Dr Owen Standard
WHS Chairperson

Marketing and Outreach Activities

The School's marketing strategy aims to attract and retain high-quality undergraduate and postgraduate students as well as fostering a strong relationship with Alumni and Industry. The School implemented a range of strategies including events, digital marketing campaigns and other initiatives during 2013 to meet these goals. Highlights included:

Open Day 2013, the most important recruitment event of the year, was once again a huge success for the School, thanks in large part to an enthusiastic group of 50 students and 25 staff volunteers, clad in Orange t-shirts, spruiking about Materials Science and Engineering. With entertaining experiments, interesting displays, handouts and free gifts, we had a constant stream of curious prospective students of whom the majority were year 12 and 11 students.

The School's Facebook page continued to be an efficient channel to reach current and prospective students as well as alumni and friends. Thanks to interesting and relevant weekly posts there was a significant increase of followers during 2013 from 219 to 524. A quarter of the new likes can be attributed to page suggestions from existing followers and people talking about the various posts.

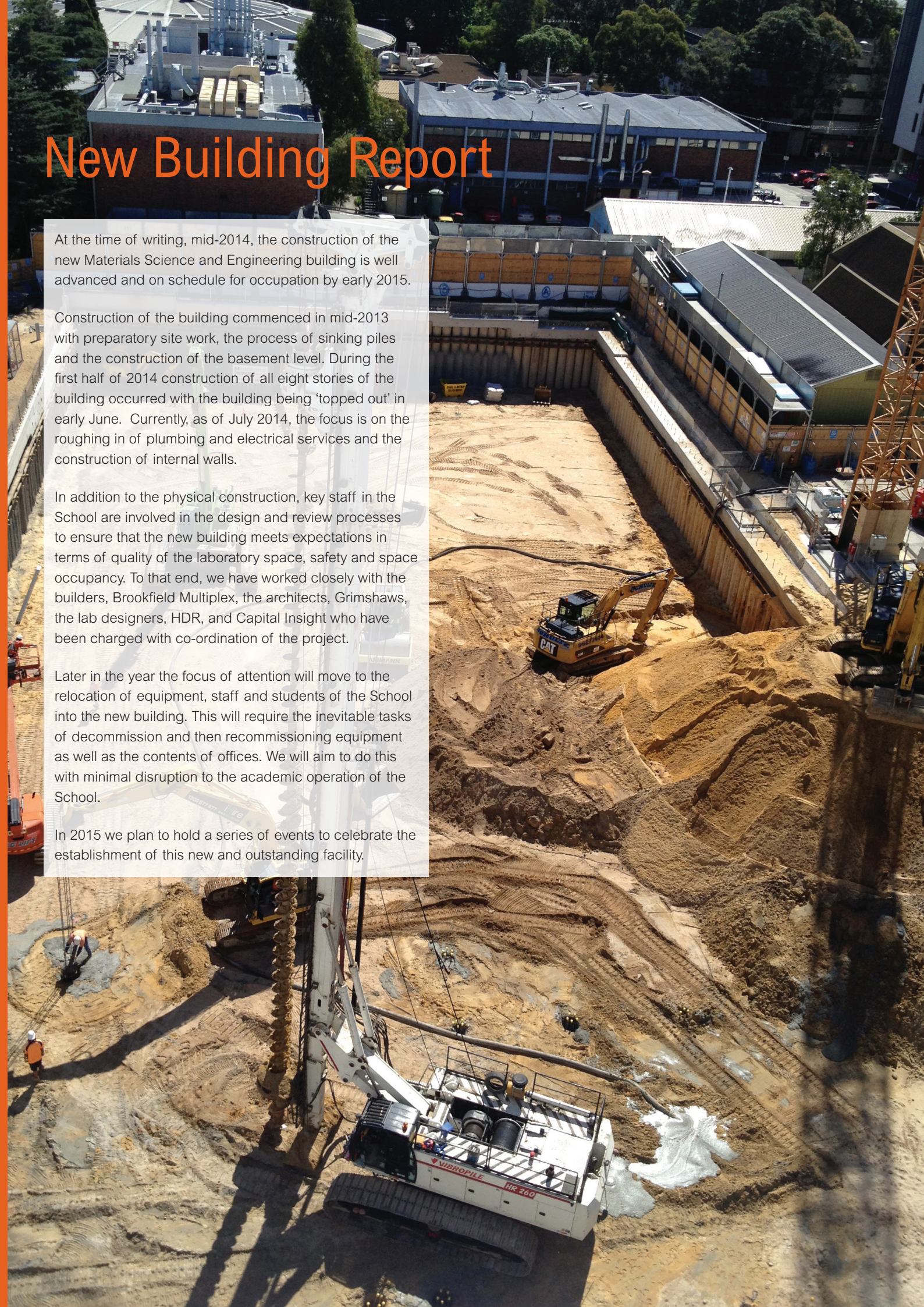
A paid Facebook ad campaign was launched in December to coincide with the release of the ATAR results. It targeted 18-24 year olds in Australia with an interest in Science. 70% of whom where males and the remaining 29% women, within Australia. A total of 40,280 people were reached with the Carbon fibre ad and 16,407 people were reached with the materials sustainability and recycling ad. (see over)

The School's Alumni LinkedIn page was launched to coincide with the 2013 Alumni and Friends Dinner, a Halloween inspired reunion that attracted 130 guests (See page 23 for more). The MSE Alumni group is open to graduates and provides networking opportunities and aims at maintaining connection between the graduands and the School. It broadcasts information about events and activities of interest to the alumni community.

The 2013 Scholarship program attracted a record response. Over 100 applications were received, which was a substantial increased from the previous year. A full report about the Scholarship initiatives can be found in page 33.

Materials Sustainability and Recycling advertisement campaign

New Building Report



At the time of writing, mid-2014, the construction of the new Materials Science and Engineering building is well advanced and on schedule for occupation by early 2015.

Construction of the building commenced in mid-2013 with preparatory site work, the process of sinking piles and the construction of the basement level. During the first half of 2014 construction of all eight stories of the building occurred with the building being 'topped out' in early June. Currently, as of July 2014, the focus is on the roughing in of plumbing and electrical services and the construction of internal walls.

In addition to the physical construction, key staff in the School are involved in the design and review processes to ensure that the new building meets expectations in terms of quality of the laboratory space, safety and space occupancy. To that end, we have worked closely with the builders, Brookfield Multiplex, the architects, Grimshaws, the lab designers, HDR, and Capital Insight who have been charged with co-ordination of the project.

Later in the year the focus of attention will move to the relocation of equipment, staff and students of the School into the new building. This will require the inevitable tasks of decommission and then recommissioning equipment as well as the contents of offices. We will aim to do this with minimal disruption to the academic operation of the School.

In 2015 we plan to hold a series of events to celebrate the establishment of this new and outstanding facility.


University of New South Wales
Materials Science and Engineering Building

PART TWO:

PEOPLE

SCHOOL ADMINISTRATION

Head of School
Paul Munroe

School Manager
Lucy Zhang

Executive Assistant to HoS
Joanne Hallis

Outreach and Student Liaison Officer
Juanita Vargas

Student Services Officer
Laura McNally

Administrative Officer
Alan Chow
Qing Xia

Industry Relations & Communications Manager
Uttra Benton

Committees

School

School Advisory Committee
Paul Munroe (Chair)
Owen Standard
Jan Seidel
Zongyan Zhou
Bill Joe
Lucy Zhang

Research Committee
Nagy Valanoor (Chair)
Paul Munroe
Aibing Yu
Veena Sahajwalla
Sean Li

Teaching and Learning Committee
Alan Crosky (Chair)
Owen Standard
Danyang Wang
Judy Hart
Paul Munroe

OHS Committee
Owen Standard (Chair)
Anthony Zhang
Paul Munroe
Ruiping Zou
Rahmat Kartono

Marketing and Recruitment Committee (Operational)
Paul Munroe (Chair)
Juanita Vargas
Lucy Zhang
Joanne Hallis

Marketing and Recruitment Committee (Strategic)
Chris Sorrell (Chair)
John Daniels
Zongyan Zhou
Alan Crosky

Space Committee
Michael Ferry (Chair)
Lucy Zhang
Rahmat Kartono

New Building Committee
Michael Ferry (Chair)
Paul Munroe
Lucy Zhang
Owen Standard

Masters Coursework Review Committee
Chris Sorrell (Chair)
Runyu Yang
Nagarajan Valanoor

School Scholarship Committee
Veena Sahajwalla (Chair)
Owen Standard
Sri Bandyopadhyay

Postgrad Coordinator
John Daniels

Honours Project Coordinator
Jianqiang Zhang

Undergraduate Program Coordinator
Owen Standard

Masters Coursework Coordinator
Runyu Yang

Misconduct and Grievance Officer
Owen Standard

PGSOC Staff Representative
Jan Seidel

MATSOC Staff Representative
Jiabao Yi

Faculty Undergraduate Assessment
Sri Bandyopadhyay

Nanotechnology Degree Coordinator
Danyang Wang

Overseas Degree Programs / Asia Engagement
Sammy Lap Ip Chan

Women in MS&E
Judy Hart

Faculty Standing Committee (Alt)
Sri Bandyopadhyay

School Co-op Scholarship Representative
Owen Standard

Visiting

Leo Selleck (Chair)
ARRIUM MINING AND MINERALS

Cathy Inglis
BRICKWORKS

Catherine Foley
CSIRO

Robert Every AO
BORAL and WESFARMERS

Adam Berkovich
PACIFIC ALUMINIUM

Chris Mouatt
BORAL Clay and Concrete

Paul Zulli
BLUESCOPE STEEL RESEARCH

Lyndon Edwards
ANSTO

Roger Leigh
COCHLEAR LIMITED

Fred Bradner
WEIR MINERALS

Michael Freislich
HATCH

Shane Griffin
UNSW

Merlin Crossley
UNSW

Owen Standard
UNSW

Lucy Zhang
UNSW

Paul Munroe
UNSW

Our Academic Staff

Associate Professor Sri Bandyopadhyay

Sri's research specialises in nanotechnology, polymers, fly ash recycling, novel composites/ nanocomposites fabrication/ characterisation and structure-property correlation. Under his supervision polymer matrix nanocomposites have been developed with close to a billion times improvement in electronic conductivity.

Professor Sammy Lap Ip Chan

Sammy's research interests are in the areas of energy-materials, hydrogen storage and metal matrix composites (MMCs). Major contributions to the fields are the conclusive identification of hydrogen trapping ability of different microstructures in steel, development of hydrogen storage alloys particularly suitable for remote area power supply systems, and development of metal matrix composites with nano-reinforcements.

Professor Alan Crosky

Alan's research focuses on the effect of structure (both micro and macro) on mechanical behavior. Specific areas of research include directed fibre placement in fibre reinforced plastic composites, failure of composites, natural fibre composites, wood plastic composites and engineering failure analysis.

Senior Lecturer Dr John Daniels

John's research focuses on the understanding of the structural origin of physical properties of materials using advanced scattering methods. This research has, to date, been primarily directed in the field of electro-mechanical materials where a wide range of underlying structural processes at different length scales leads to the coupling of mechanical load and electrical charge.

Professor Michael Ferry

Michael's research interests are concerned mainly with the mechanisms of microstructure and texture evolution during solidification, solid-state phase transformation and deformation and annealing with recent emphasis on the mechanical and physical properties of crystalline and amorphous light metals.

Lecturer Dr Judy Hart

Judy's research interests are in developing new semiconducting materials, particularly solid solutions and doped materials, for use in renewable energy applications such as photocatalysis and solar cells. The focus of this work is understanding relationships between composition and properties and finding effective ways of using computational and experimental techniques in parallel.

Pro-Vice Chancellor (Research) Professor Mark Hoffman

Mark's research expertise is in the area of structural integrity of materials, specifically the design of materials for high reliability in complex environments through a combination of computational modelling and investigation using extensive mechanical property. His research covers fracture mechanics, fatigue and wear and tribology from the macro- to nano-scale.

Associate Professor Xuchuan Jiang

Xuchuan's research is focused on synthesis of nanoparticles, self-assembly of nanoparticles for ordered structures/patterns, exploration of functional properties in energy, environment and biomedicine, and fundamental understanding using theoretical methods.

Professor Sean Li

Sean currently leads a research group consisting of 8 full-time research fellows, 13 PhD students and 4 M.Sc students, working in the areas of advanced electronic, photonic and multifunctional materials.

Head of School Professor Paul Munroe

Paul's research is focused on the characterization of materials using electron microscopy and related methods. This includes publication of a significant body of work focused on ion beam technology. He is also active in a range of areas in characterization of materials such as functional thin films, intermetallic alloys and biochars.

Emeritus Professor Oleg Ostrovski

Oleg's major contributions are in the field of pyrometallurgical technologies for minerals processing, iron-, steel- and ferroalloy-making. Areas of research include thermodynamics, kinetics and mechanisms of metallurgical reactions, properties of molten metals and slags, reduction, smelting and refining processes, and environmental issues in pyrometallurgy.

SMaRT Centre Director, Associate Dean, Science. Scientia Professor, Veena Sahajwalla

Veena's research interests include sustainability of materials and processes with emphasis on environmental benefits. She has a deep knowledge of industrial processes. Veena invented an environmentally friendly process for recycling plastics and rubber into electric arc furnace steelmaking. As Director of SMaRT she provides leadership in research programs on sustainable materials.

Senior Lecturer Dr Jan Seidel

Jan's research interests are in the area of advanced electronic, photonic and spintronic materials, including scanning probe microscopy, nanotechnology enhanced photovoltaics, electrochromism, nanoscale phase separation, nano-optics, spectroscopy, plasmonics, x-ray based synchrotron techniques and high-resolution transmission electron microscopy.

Professor Chris Sorrell

The main focus of Chris' research has been the processing of ceramics, including fabricaiton, forming and densification of bulk materials, thick films and thin films. Main research areas include phase equilibria, crystal growth, high-temperature superconductivity, bioceramics, microwave heating of ceramics, gas sensors and fuel cells and photocatalytic titania.

Deputy Head of School, Senior Lecturer, Dr Owen Standard

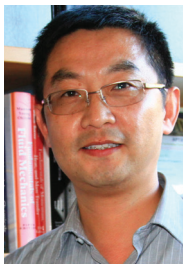
Owen's research is in the processing/ microstructure/property relationship of advanced ceramics for functional applications including colloidal processing of electroceramics, compositional and microstructural modification of bioactive and bionert ceramics, sol-gel deposition of functional ceramic coatings, development of sol-gel coatings on textile fibres and ceramic coatings on biomedical alloys.

Professor Nagarajan Valanoor

Nagy's most significant contribution is in the field of thin film epitaxy functional property relationships for ferroelectrics, dielectrics and multiferroic nano-materials. Research includes thin-film oxide epitaxy, scanned probe microscopy of functional materials and Landau-Ginzberg modelling of phase transitions

Lecturer Dr Danyang Wang

Danyang's most significant contribution is in the field of growth and characterization of functional oxide thin films for ferroelectric, piezoelectric, electro-optic and dielectric applications. Areas of research include thin film technology and physics, functional materials and devices, micro/ nanofabrication techniques, structural analysis and x-ray physics.



Associate Professor Runyu Yang

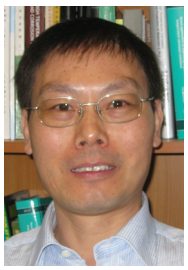
Runyu is focussed in the field of particle/powder science and technology. His primary research interests lie in particle technology, aiming to understand the behavior of particles through rigorous modelling and simulation at microscopic and macroscopic levels. This knowledge is then applied to solving problems in various industrial applications.

Emeritus Professor
David Young

David's most significant contributions are in the field of high temperature alloy-gas interactions. Particular emphasis is placed on the diffusion and phase transformation processes which support these reactions. Current work includes fundamental studies of corrosion by carbon dioxide, metal dusting reactions and water vapour effects on oxidation.

Senior Lecturer
Dr Jiabao Yi

Jiabao's most significant contributions are in the field of diluted magnetic semiconductors, based on oxide semiconductors, matnetic materials, nonstructural, oxide electronics and spintronics materials.



Senior Lecturer
Dr Jianqiang Zhang

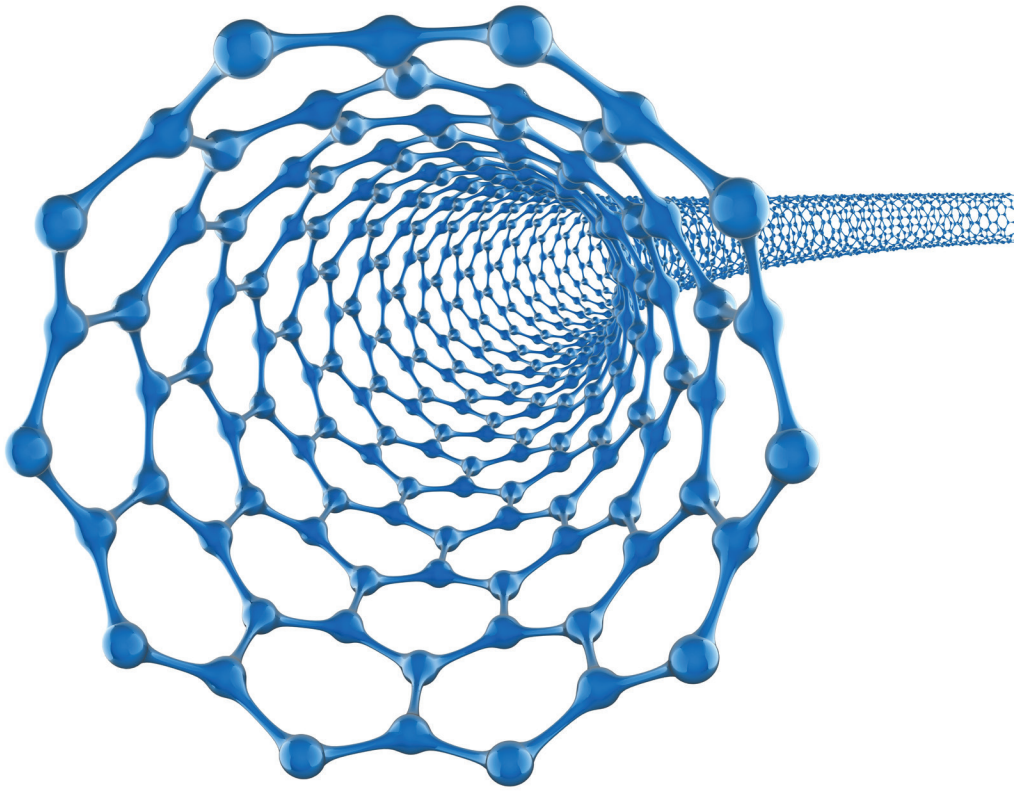
Jianqiang's research is focussed in the field of gas-solid reactions at high temperature, including high temperature corrosion and processing metallurgy. Research emphasis is on the reaction thermodynamics and kinetics, phase transformation and characterisation, reaction mechanism understanding, sustainable materials processing and new materials development.

Lecturer
Dr Zongyan Zhou

Zongyan's research work is in particle/powder science and technology. He has developed an extensive expertise in the numerical modelling of multiphase flow, heat transfer and granular dynamics, and their applications to different processes.

More detailed information about our Academic Staff can be found on the School website:

materials.unsw.edu.au



Our Research & Technical Staff

Research

Joseph Arsecularatne
Postdoctoral Fellow

Dewei Chu
Associate Lecturer

KaiWei (Kevin) Chu
Postdoctoral Fellow

Muhammad Ikram-Ul-Haq
Research Associate

Maryam Ghodrat
SMaRT Research Assistant

Julia Glaum
DECRA Fellow

Baoyu Guo
Lecturer

Sushil Kumar Gupta
Senior Lecturer

Manuel Hinterstein
Postdoctoral Fellow

Qinfu (Quentin) Hou
Postdoctoral Fellow

Rita Khanna
Associate Professor

Pramod Koshy
Postdoctoral Fellow

Shibo Kuang
Postdoctoral Fellow

Kevin Laws
Senior Lecturer

Reza Mahjoub
Research Associate

Thuan Dinh Nguyen
Postdoctoral Fellow

Ravindra Rajarao
Research Associate

Thiam Tack (TT) Tan
Postdoctoral Fellow

Ruoming Tian
Postdoctoral Fellow

Tania Vodenitcharova
Postdoctoral Fellow

Zhiyang Wang
Postdoctoral Fellow

Guozhong Xing
Associate Lecturer

Xing Xing
Postdoctoral Fellow

Wanqiang (Martin) Xu
Lecturer

Tianshu Zhang
Senior Lecturer

Qijun Zheng
Postdoctoral Fellow

Ruiping Zou
Senior Lecturer

Technical

Rohana Ganga Chandratilleke
Professional Officer

Soo Woon Chong
Technical officer

Jane Gao
ITC Support Manager

Bulent Gun
Technical officer

Thwin Htoo
Technical Officer

William (Bill) Joe
Research Support Engineer

Rahmat Kartono
Technical Officer

Danny Kim
ITC Support Officer

NM Saha-Chaudhury
SMaRT Centre Manager / Senior Research Engineer

John Sharp
Research Assistant

George Yang
Technical Officer

Anthony Zhang
Safety Officer

International Collaboration

The School is committed to active engagement with our colleagues in the materials science and engineering community overseas. We do this through activities on a number of fronts.

We continue to enroll a significant fraction of the undergraduate and postgraduate student cohorts from overseas. About a quarter of our undergraduate students come to us from outside of Australia. Although many will undertake their entire degree programs at UNSW, an increasingly large number of students come to UNSW through the 'Study Abroad' program. Here, students visit UNSW for 1 or 2 semesters and take a number of courses within the School as part of their degree programs at their home institution. Conversely, increasing numbers of our own students take the opportunity to study abroad for a session or two to experience learning environments overseas.

Last year, through the efforts of Associate Professor, Sammy Chan, the School was able to garner funding through the 'AsiaBound' program to send seven undergraduates to Taiwan to complete their industrial training programs. The students who travelled to Taiwan over the summer break enjoyed a vibrant and enriching program of study and adventure over their 10 week stay. During the 2014/15 summer break, we will send a further group of students to Taiwan and, in addition, send a group of 5 students to North Carolina State University. A further outcome from the visit of our students to Taiwan is that a contingent of students will come to UNSW next year to study.

The School plays host to many visiting academics. We were fortunate to host a visit by Professor Martin Castell from the Department of Materials at the University of Oxford. Martin's visit was facilitated through the Faculty of Science Visiting Fellowship scheme. This allows leading academics from outside Australia is make visits to UNSW to develop research collaborations with UNSW. Martin's research interest in ferroelectric materials aligned well with those of many staff in the School and his visit was a highly productive one.

Last year the School played host to a number of visitors from Shanghai Jiao Tong University (SJTU) to discuss research collaborations. As a result of those visits the School won two joint research grants with SJTU academics to develop collaborative research programs. These programs have fostered a number of exchanges between UNSW and SJTU and have already led to a number of research publications.

All academics in the School have strong links with leading researchers overseas. A high fraction of the research grants and publications generated by the School involve collaborations with overseas institutions.

Alumni & Friends Dinner

On Thursday 31 October 2013 our Alumni, Industry partners, Academics and Staff gathered to reconnect, celebrate past and recent achievements and share plans for the School's future. The Halloween inspired "Alumni and Friends" celebration began with a pre-dinner cocktail at the ASB Lounge where guests enjoyed drinks and nibbles and had the opportunity to appreciate the sweeping views of Royal Randwick through to the Sydney CBD and see the progress of the School's new building due to be completed in early 2015.

Following the pre-dinner cocktail, 130 guests made their way to the Tyree room in the John Niland Scientia building, where they came upon an eerie sight of flowering pumpkins centre pieces covered in spiders and webs, and haunted musical themes. The event's MC, final year Materials Science student Amanda Wang, began the proceedings and introduced our Head of School, Professor Paul Munroe, who officially welcomed all the guests and acknowledged the special guests, alumni and visitors from industry. The guests were later addressed by the Vice-Chancellor Professor Fred Hilmer who spoke candidly and spiritedly about the School's achievements and gave a unique insight into the planning and development of the new building.

The final guest speakers of the night were Professor Merlin Crossley, Dean of the Faculty of Science at UNSW and our very own Scientia Professor Veena Sahajwalla. Alumni from the 1970s to the present day were able to catch up with friends and colleagues and meet a selected group of undergraduate scholars, industry contacts and School staff.

Process Metallurgy @ UNSW Australia

An Alumni Profile

Chris Compton

Current Role
Graduate Process Engineer

Current Employer
BHP Billiton – Mt Arthur Coal

Graduating Year
2012

Highest Qualification
Bachelor of Engineering (Hons)

What did you study at UNSW?

I studied a Bachelor of Engineering in Process Metallurgy and graduated at the end of 2012.

Why did you choose to do a Process Metallurgy degree?

Although I grew up primarily in Sydney, I spent a lot of time working on my grandparent's farm in West Wyalong. From this I always loved working with my hands on machines and the land. Throughout high school I was always attracted to engineering and wanted to combine the two.

Originally, I intended to apply to do Aeronautical Engineering at UNSW, however, I discovered Materials at the UNSW Open Day and from there liked it more and more. After receiving an academic and subsequent industry based scholarship, I decided to change my preference to Metallurgy.

Something that I think is mirrored by a lot of people studying Materials is the satisfaction of understanding how things around us are made, what they are made of and the considerations that went into their creation and application.

The personality and quality of the staff and school itself, along with the future prospects of graduates were also a large part of why I chose Process Metallurgy.

What was your experience being a Process Metallurgy student?

My first year was more based around courses for general engineering principals and enjoying university. Making new friends at first year camp and across other engineering disciplines, getting involved in MATSOC and university events and spending too much time at the Round House made first year a lot of fun.

Throughout the latter years I really got to appreciate the quality and how tight-knit the school was. Developing a close materials group, the access to school labs, the open-door policy of staff and the balance between academic and social life made my experience both valuable and memorable.

Where are you working now and what is your role?

I am currently working in the Upper Hunter region of NSW at BHP Billiton Mt Arthur Coal. Mt Arthur Coal is one of the largest single site thermal coalmines in Australia, which produces up to 24 million tonnes of coal for domestic and export markets. I am a part of the Process Analysis and Improvement (PA&I) department in the Coal Handling and Preparation Plant (CHPP).

My role is centralised around understanding the processes in the plant that drive coal preparation and improving them for greater efficiency, throughput and reliability. This is achieved through plant performance and consumable monitoring, equipment testing and optimisation, process support for other departments, analyzing delay data, developing maintenance strategies and lots of troubleshooting. In my role there is a strong focus on planning and prioritizing tasks, intercommunication between departments, working with production technicians, safe work culture and professional development.

After graduating, how did your career path evolve?

Prior to graduating I was lucky enough to have completed three internships during each summer break. After my first year I worked with Stork Cooperheat a heat treatment and non-destructive testing company where I took x-rays of welds for a summer. After second year, I moved into the mining industry working in central QLD for Xstrata in a heavy medium processing and Lead-Zinc concentrator at Mt Isa Mines. After this vacation period I decided that this was what I wanted to do. In my penultimate vacation period I joined the PA&I team at BHP Billiton Mt Arthur Coal. After my tenure here I was offered a full time position upon graduation.

Do you have any advice for school leavers considering studying Process Metallurgy at UNSW Australia?

Do it.

Consider where you might like to end up and work from there. If you are not too sure, pick what you think is best, follow your interests and as you progress it will become clearer.

Following on from having an end goal in mind, in order to fully utilize your time at university, I would suggest seeking as many opportunities for industry experience as you can, as early as you can. Doing this provides you with the best job prospects but more importantly, will accurately prepare you for life in industry or broaden your knowledge base for higher research.

Finally, while you are at university, enjoy yourself!

My fondest memories mainly revolve around my group of friends that tackled an engineering degree together. Late morning coffees, living in the computer lab, cramming in G10, and sleeping many people on the couch was a terrific experience.

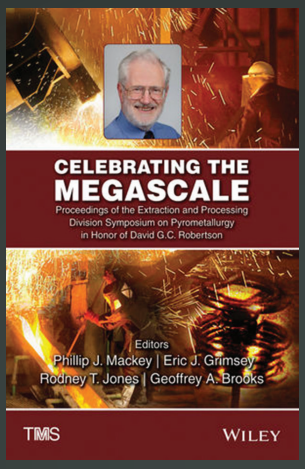
The openness and friendships developed with the lectures and staff was tremendous and I believe this sets Materials far above other schools.

Of special academic mention was pulling an all-nighter for Mark Hoffman's final computer modeling assignment and Runyu Yang's first Advanced Processing assessment, and struggling to understand which line meant what in Chris Sorrell's phase diagrams. Being lucky enough to work alongside Nagy Valanoor for my thesis project and winning the UNSW futsal competition were also terrific experiences.

Finally, most of my fond memories started with first year camp and I would encourage all new Materials Engineers to go.

TRIBUTE TO A FORMER GRADUATE AND REMINISCENCES ON THE 1960s SCHOOL OF METALLURGY

J Bruce See and Phillip J Mackey



A Symposium on pyrometallurgy, 'Celebrating the Megascale', was held in honour of Professor David G.C. Robertson, as part of the TMS Annual Meeting from 17-20 February 2014 in San Diego, California. David graduated with a PhD from the UNSW School of Metallurgy in 1968 and this Symposium was held as a tribute to him for his contributions to education and research in pyrometallurgy in a variety of roles over almost fifty years. The Symposium formed a part of the TMS Annual Meeting – a large event attended by about 4,300 people (the second highest total attendance for a TMS Annual Meeting in 15 years) from about 50 countries.

David obtained a BSc(Eng) degree in metallurgy from the Royal School of Mines, Imperial College, London, in 1963 before becoming a Teaching Fellow in Metallurgy at UNSW in 1964. He subsequently became a BHP postgraduate Research Scholar at UNSW and joined the faculty at Imperial College on completion of his PhD. He became a Reader at Imperial College in the John Percy Research Group and in 1985 accepted the position of Professor of Metallurgical Engineering and Director of the Center for Pyrometallurgy at the University of Missouri-Rolla (now Missouri University of Science and Technology –Missouri S&T). He is currently an Emeritus Professor at Missouri S&T.

He has devoted his career to the education of highly skilled metallurgical professionals and to research on the physical chemistry and process engineering of all types and sizes of metallurgical processes, particularly those involving molten metals. His research has involved major contributions in many areas, such as metal-slag-gas reactions, gas injection into melts, atomization of liquid metals by gas jets, ferroalloy production, continuous steelmaking and the modelling of metallurgical processes. During his research at Imperial College and at

Missouri S&T, he has supervised the work of 26 doctoral and 14 masters students and authored or co-authored over 100 publications. A more detailed overview of David Robertson's life and career is given in the Symposium proceedings.

The Robertson Symposium consisted of approximately 70 papers presented over four days and the selection of high-level speakers meant that the sessions were well attended by up to eighty pyrometallurgists from all around the world. The conference sessions included ferroalloys, non-ferrous smelting, iron and steel production, modelling, metallurgical education, and fundamentals. The symposium proceedings remain as a record of the event and contain a comprehensive list of references to David Robertson's publications. *(Mackey P J, Grimsey E J, Jones R T, & Brooks G A (Editors), Celebrating the Megascale, Proceedings of the Extraction and Processing Division Symposium on Pyrometallurgy in Honor of David G.C. Robertson, Wiley, 2014, 664 pp., ISBN: 978-1-118-88961-9).*

For us, an interesting personal feature of the Symposium was that this was the first time that all three of us (David and ourselves) had been together as friends and colleagues in the one place in over thirty years. It was also the first time that we had written a paper together *('Current and Suggested Focus on Sustainability in Pyrometallurgy' – refer Symposium Proceedings cited above)* even though we had all worked in related areas both during our doctoral programs and in our subsequent careers.

A Symposium Dinner Cruise was held in San Diego Bay on the evening of Monday 17 February. The ship we sailed in was the 'High Spirits' – a sister ship to Franklin D. Roosevelt's presidential yacht 'Sequoia'. This was a high point of the Symposium as a number of David Robertson's colleagues and former students reminisced about David's life and career with Cam Harris as MC. Art Morris, a long-term colleague of David at Missouri S&T, was notable amongst others in giving an excellent speech as a tribute to David.

This Symposium also presented an opportunity for David to catch up with old friends and colleagues as well as with two former Heads of the School of Materials Science and Engineering at UNSW, Emeritus Professor Oleg Ostrovski and Emeritus Professor David Young.

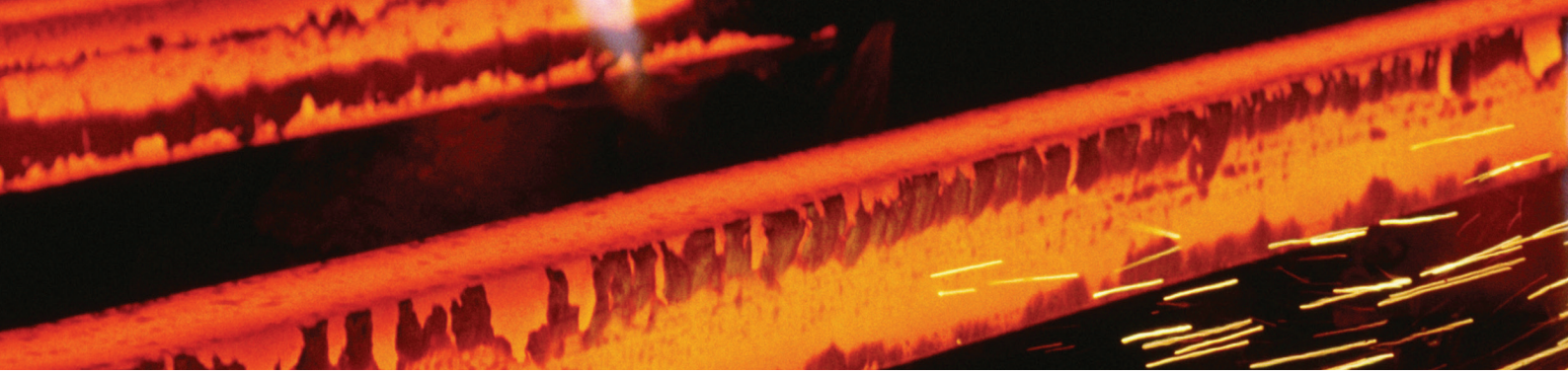
We decided to include some perspectives on our experiences as postgraduates in the School of Metallurgy, in part because we consider this period of about fifty years ago as our "Golden Age" in the School of Metallurgy. We also felt we could provide some insights into the School at that time as there has been much change and evolution both within the School of Metallurgy – now of course the School of Materials Science and Engineering – and UNSW as a whole.

We both began our undergraduate studies at the beginning of the 1960s. In 1961 one of us (JBS) can remember being addressed as a first year metallurgy student by the Foundation Professor and Head of School, Professor Rupert Myers, who was beginning his climb to become Sir Rupert and Vice-Chancellor of UNSW. UNSW itself was a comparatively young university having had its aegis in the Sydney Technical College at Ultimo and was led by a powerful and visionary Vice-Chancellor, the chemical engineer Sir Philip Baxter. We can both also recollect some of our earlier undergraduate subjects such as chemistry practicals and engineering being held at the old Sydney Technical College at Ultimo. One noteworthy feature of our student years that has changed dramatically in the past fifty years is the vast increase in the numbers of women students in MSE as we both remember the first female graduate of the School, Ilse Uhlenhut.

It is a tribute to the vision and leadership of people like Philip Baxter and Rupert Myers that the 1960s School of Metallurgy then, as now, possessed a strong and internationally recognised academic staff especially given its early struggles in the late 1940s and the 1950s to develop infrastructure and strong degree courses, to achieve recognition and to grow the professoriate . This period has been documented by a former Pro-Vice-Chancellor, Emeritus Professor A.H. Willis, in *The University of New South Wales. The Baxter Years* (UNSW Press 1983) and his book covers the period up to 1969 when the Foundation Professor of the School of Metallurgy – the now Emeritus Professor Myers – became Vice-Chancellor.

The metallurgy degree was then a general one incorporating both physical and chemical metallurgy. and the academics specialising in physical metallurgy and materials science included luminaries like Hugh Muir, John Bowles, Max Hatherly and Greig Wallwork. Chemical metallurgists like ourselves remember struggling to develop some understanding of topics such as martensitic transformations, textures, fracture mechanics and the like, although both of us subsequently found such exposure valuable.

Academics specialising in high temperature chemical metallurgy and pyrometallurgical processing included Alex Jenkins, Noel Warner, Bruce Harris, David R Young and Les Baker. All of these men made significant contributions in their own right with, for example, Jenkins and Harris pioneering the use of the levitation melting technique and Noel Warner applying classical chemical engineering concepts to the analysis of high temperature metallurgical processes. Noel



had used this approach in his 1958 UNSW PhD thesis on the absorption of zinc vapour into molten lead which to this day remains a brilliant experimental and theoretical study.

Dave Young helped develop our background in thermodynamics whilst the background provided by Noel Warner in chemical engineering concepts has proved invaluable for both of us. Just one example of the various tours de force by the UNSW pyrometallurgical academic staff was the 1966 Hunt Outstanding Paper Award from The American Institute of Mining Engineers (AIME) given to Les Baker, Noel Warner and Alex Jenkins for their landmark paper, "Kinetics of Decarburization of Liquid Iron in an Oxidizing Atmosphere Using the Levitation Technique" and which was published in the December 1964 issue of The Transactions of the Metallurgical Society of AIME.

Our recollection is that there was an average of about twenty or so postgraduate students in metallurgy at UNSW during the 1960s. There were many able physical metallurgists and materials scientists like Druce Dunne, Bob Every, John Croll, Peter Krauklis, Ron Blombery, Graham Thompson, Geoff Stevens, John Watson, Dick Jago, Bill Sheppherd, John Eady, Don Dautovich and Kevin Brown and the pyrometallurgists included Ian Clarke, David Robertson, ourselves, Steve Algie, Clive Roberts, Diony Regozo, John Wright and John Edwards. Steve and Clive were both university medallists, all the students had Honours degrees and many were fully and well supported as Commonwealth Postgraduate Scholars.

The pyrometallurgical group was very close knit as we both worked and frequently socialised together with this closeness being enhanced by our location within the School in what became known as 'The Postgrad Hole'. This was an enclosed space on the mezzanine floor in the process metallurgy building and, in today's parlance, was essentially an open plan office containing about eight desks. As it was then accessed by steep ladders, not well ventilated, out of the way and contained a number of young and frequently boisterous postgraduates it was frequently not an ideal environment for serious academic study. In addition, as we all lived off campus, a feature of social life was parties at our flats but some of the more interesting social events were in the Roundhouse or at Metallurgical Society functions.

There was one very unique feature of our postgraduate work that merits some comment as it played a particularly large role in shaping the career of one of us (PJM). Noel Warner is a very innovative chemical engineer and we worked with him and others on a large pilot plant that was housed in a corner of the process metallurgy building nearest to the main building of the School of Metallurgy. This pilot plant (named the 'GDZ') shown below had been designed by Noel and built under his direction to examine a concept for the gaseous dezincing (=GDZ) of lead as an alternative to vacuum dezincing. The GDZ was meant to operate by stripping zinc from molten lead by countercurrent contacting with nitrogen in a packed bed of Raschig rings.

The operation of such a large pilot plant in the School placed extraordinary demands upon the resources and finances of the School and its workshop facilities. Both of us at different stages assumed responsibility for the overall operation and servicing of this comparative behemoth in a university environment and our trials and tribulations are documented in our PhD theses.

The preparations for and execution of pilot plant runs were especially gruelling and required a large group of plant operators and long days – especially for an actual run. As one example of the time and effort needed it would take hours for the lead pipelines to heat up sufficiently to allow molten lead to flow through them and this preheating phase required constant monitoring and recording of a large number of thermocouples on the pipe itself – all this and many other measurements without online computerised data acquisition and analysis.

The pilot plant team was under Noel Warner's overall supervision but it included ourselves and Diony Regozo, Bill Hayes as electrician, Bill Jenner as rigger and Dave

From left: David Young, David Robertson, Phillip Mackey, Bruce See, and Oleg Ostrovski

Hall as technical assistant. It was an incredible team building exercise and helped us both greatly in learning how to work together with a range of people with different skills and abilities. Other postgraduate students became very accustomed to seeing us both wandering around or working in grimy overalls plus respirators and other safety gear performing interesting manoeuvres like unbolting large flanges and changing nitrogen cylinders.

There were many interesting characters in our team and in the School at that time such as Bill Jenner and Jim Monteith. Bill Jenner was a Welshman who had been in the British Merchant Navy in World War II and, in addition to often puffing bemusedly on a rather obnoxious pipe and acting as a form of mentor to tired and discouraged students, showed great skill in rigging in often difficult, hot and awkward situations. Jim Monteith was the fearsome guardian of the supply store and often intimidated those who dared to request some of the stores.

Little did any one of us fully appreciate it at the time, but this work – in addition to gaining our PhD degrees – was ideal training for new process development. It was during a visit to the School of Metallurgy in 1968 by Dr. N.J. Themelis, Director of Engineering Research at the famed Noranda Mines Limited of Canada, being quite impressed with this work at the School, offered one of us (PJM) a position with the Canadian Company. More details of our subsequent careers are given below in the biographical notes.

In common with our fellow postgraduates like David Robertson both of us owe a great deal to our 'Golden Age' in the School of Metallurgy at UNSW and to inspirational academics like Professors Noel Warner and Alex Jenkins. Noel Warner is now an Emeritus Professor in the University of Birmingham and has continued to publish numerous articles on alternative concepts for smelting processes whilst Professor Jenkins, as one of the first PhD graduates in metallurgy in Australia, has had an especially interesting life as he completed his PhD after his wartime service as a Pilot Officer in the RAF Bomber Command. Details of his career are available on the Internet and one of the most recent newspaper articles in 2014 describes his piloting of a bomber near Calais on D-Day.

Given this history we are pleased that the current School of Materials Science and Engineering has an outstanding and diverse academic staff including internationally recognised pyrometallurgists and chemical metallurgists like Professors Oleg Ostrovski, Veena Sahajwalla and David J Young and that the School will therefore continue to provide the type of education and training from which we have personally benefited.

School of Metallurgy

Biographical notes

Bruce See worked as an academic and government researcher overseas in the USA and South Africa for eleven years after completing his PhD at UNSW in 1970, in the positions of Assistant Professor of Metallurgy and Materials Science at MIT, Chief Scientist and Research Group Leader of the Pyrometallurgy Research Group of the National Institute for Metallurgy (now MINTEK) within the University of the Witwatersrand and Associate Professor of Chemical and Metallurgical Engineering at the University of Nevada – Reno. He subsequently worked for about 20 years in industrial research and research management for CRA (now Rio Tinto), Pasminco (now Nystar) and the University of Western Sydney before leaving the profession to pursue alternative interests and studies in economics, history, business management and tourism and hospitality. He has a Graduate Diploma in Economics from UNE and has authored or co-authored over forty publications and numerous published reports on iron and steelmaking, ferroalloy production, atomisation of liquid metals, non-ferrous pyrometallurgy, galvanizing and the properties of lead-acid battery alloys.

Phillip Mackey took up a position with Noranda Research Centre in Montreal, Canada in 1969 after completing his PhD at UNSW. His work included a stint as Supervisor of the new 100 t/day pilot plant for the continuous smelting and converting of copper concentrate, later called the Noranda Process. He was involved in all aspects of the project, including development of data for the full scale commercial plant which commenced operations in 1973. This process is now recognized as one of the significant developments in copper smelting of the last century. He later became Smelter Superintendent at the Noranda Horne smelter in Rouyn-Nornada, Quebec, Canada and was later involved in licensing the technology at plants round the world, including Canada, USA, China, Chile and Australia. Phillip is a Past-President of The Metallurgical Society of The Canadian Institute of Mining and Metallurgy; was instrumental in establishing the Copper-Cobre world conferences and has received a number of professional awards for his work. He now runs his own company and consults for mining companies worldwide.

PART THREE:

STUDENTS

...The main **objective** of our **undergraduate program** is to produce graduates who will be **recognised** as the best **suited** and most appropriately **trained** to **contribute** to the institutions and industries of Australia...

Undergraduate Studies

The main objective of our undergraduate program is to produce graduates who will be recognised as the best suited and most appropriately trained to contribute to the institutions and industries of Australia. For many years, the demand for graduates has well and truly exceeded the number the School produces. However, a significant recruitment effort is ensuring that there is a pipeline of high quality students who will graduate in the years to come.

Teaching Programs:

The major undergraduate programs taught by the School are:

BE Bachelor of Engineering (Materials Eng., Ceramic Eng., Physical Metallurgy or Process Metallurgy) – Program 3135

BE/MBiomedE Bachelor of Engineering (Materials Eng., Ceramic Eng., Physical Metallurgy or Process Metallurgy) and Master of Biomedical Engineering combined program (Program 3138)

BE/BCom Bachelor of Engineering (Materials Eng., Ceramic Eng., Physical Metallurgy or Process Metallurgy) and Bachelor of Commerce combined program (Program 3136)

BE/BE Bachelor of Engineering (Materials Eng., Ceramic Eng., Physical Metallurgy or Process Metallurgy) and Bachelor of Engineering (Chemical Eng.) combined program (Program 3137)

Student enrolment numbers in these programs are summarised in the table below. The School offers a major in Materials Science in the University's general Bachelor of Science (BSc) degree (Program 3970) and is also a major contributor to the Bachelor of Science – Nanotechnology degree (Program 3617).

Table: Student enrolment numbers

Program	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Total
BE (3135)	41	23	30	32	-	126
BE/BCom (3136)	3	1	2	2	3	11
BE/BE (3137)	9	8	-	-	-	17
BE/MBiomed (3138)	18	16	21	12	3	70
Total	71	48	53	46	6	224

2013 Program Enrolments by Stages:

Entry into the BE programs is generic and students choose one of the following four study plans for the BE at the end of Stage 2: Materials Engineering, Ceramic Engineering, Physical Metallurgy and Process Metallurgy. These study plans give the students the opportunity to specialise in specific disciplines. The majority of students choose to do Materials Engineering as reflected in the 2013 final year enrolment distribution of 25 students in Materials Engineering, 11 students in Process Metallurgy, 3 students in Physical Metallurgy, 3 students in Ceramic Engineering.

New Enrolments

The intake of students over the past 14 years is shown in the graph below. The number of students enrolling in School programs, particularly the combined BE/MBiomedE and BE/BCom programs, has increased steadily. Also shown is enrolment in the coursework Masters MScTech program which has grown significantly in previous years.

High quality of new students was maintained in 2013 as reflected by ATAR entry scores of 84 for the BE program, 91 for the BE/MBiomedE program, 96 for the BE/BCom program, and 91 for the BE/BE program. This is driven in large part by a significant investment in scholarships, by both industry and the School, and strong marketing and recruitment activity in the School. The School continues to have the largest undergraduate program in the discipline nationwide by far. As in previous years, there was a steady and consistent increase in the number of international students, particularly into the BE(Materials) program.

Undergraduate teaching load includes both students studying towards a degree in Materials and students in other study programs who choose to take materials courses. Approximately 40% of the School's teaching load is external to its own programs. Data of the total undergraduate teaching load over the last 9 years is given in the table below. The data show a steady increase in the number of students the School teaches.

Undergraduate Teaching Load (EFTSU):

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Local	105.3	99.72	98.72	101.7	103.2	97.02	109.1	121.0	136.0
International	17.4	17.47	20.70	23.95	32.73	37.45	53.54	58.0	60.0
Total	122.7	117.3	119.4	125.6	135.9	134.5	162.6	179.0	196.0

Dr Owen Standard
Undergraduate Program Coordinator

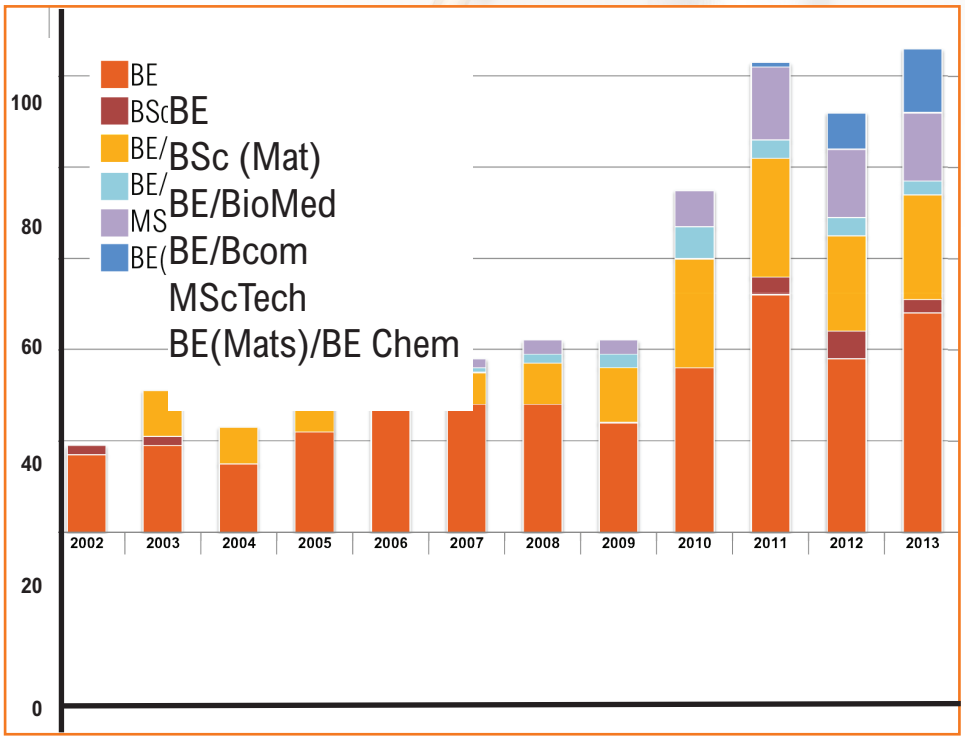


Figure: First Year Enrolment Data

Undergraduate Scholarship Programs

The School operates a comprehensive suite of scholarship programs for attracting and supporting high-achieving, motivated students in its materials science and engineering undergraduate degrees. In addition to providing financial support to students, the scholarship program gives students valuable opportunities to work in the Australian materials industry as well as the chance to apply and reinforce knowledge and skills learnt in undergraduate classes. The scholarship programs are:

School Scholarship Program:

The School has two perpetual scholarships established from benefactory funding from Sir Rupert Myers and the Thomson Family. The Sir Rupert Myers Scholarship commences once every 2 years at a stipend of $2,500 p.a. and is available to all students in the BE degree. The Thomson Family Scholarship commences once every 4 years at a stipend of $2,000 p.a. for students undertaking the Ceramic Engineering academic specialisation. The School also offers a number of School scholarships valued at $1000, $1,500, and $2,000 and these are awarded depending on academic ability.

For all scholarships, scholars are selected on the basis of written application and formal interview by panels consisting of Sponsor representatives and School academics. Scholarships are awarded on the basis of academic performance, relevant materials experience, and interest in the discipline. All Scholars are required to maintain satisfactory academic progress throughout their academic studies and Scholar performances are reviewed at the completion of every semester.

The scholarship programs provide an important contribution to education of the School's undergraduate students and comprise an important facet of the School's strong partnership with industry. The School takes this opportunity to thank its many current and past industrial sponsors for their generous and continued support of our undergraduate students and undergraduate programs.

Co-op Scholarship Program:

The Co-op Scholarship program provides students with a scholarship of ~$16,750 p.a. and 68 weeks industrial training throughout the BE degree. In 2013, there were 6 Co-op scholarships funded by the following 5 industrial industrial sponsors: Alcoa Australia, Bluescope Steel Research, Pacific Aluminium (Rio Tinto), Shinagawa Refractories Australasia P/L, and TEMCO. Please refer to the separate Co-op Program report.

Industry Partnership Scholarship Program:

The Industry Partnership Scholarship program provides students with $3000 p.a and an opportunity for industrial training with sponsors during summer vacation periods. In 2013, there were 14 industry partnership scholarships funded by the following 9 sponsors: Boral Bricks, Bureau Veritas, Cochlear, CSIRO, Gujarat Coal, Hitachi, OneSteel Ltd, Parex Davco, Weir Minerals.

Scholarship Committee

Owen Standard (Co-op Scholarships Coordinator)
Veena Sahajwalla (Industry Partner Scholarships Coordinator)
Alan Crosky
Juanita Vargas
Lucy Zhang

Co-op Scholarship Program

Table 1: Co-op Program in Materials Science and Engineering – Cohort Statistics (2009 to 2013)

Intake Year	2009	2010	2011	2012	2013	Total
Current Year of Degree	4	3 (IT)	3	2	1	
Number of Scholars						
Ceramic Eng.	1	–	–	–	–	1
Materials Eng.	1	–	2	–	–	3
Physical Met.	1	–	–	–	1	1
Process Met.	–	–	1	–	–	1
Total	3	–	3	–	1	6

Table 2: Co-op Program in Materials Science and Engineering – Current Sponsors (2009-2013)

Alcoa Australia	Shinagawa Refractories Australasia P/L
Bluescope Steel Research	TEMCO
Pacific Aluminium (Rio Tinto)	

The Co-op Program is a scholarship program run in cooperation between UNSW Australia and industry to provide scholarships and industrial training for undergraduate students in various degree programs. In the School of Materials Science and Engineering, scholarships are provided by sponsors in each of the 4 academic specialisations of Ceramic Engineering, Materials Engineering, Physical Metallurgy, and Process Metallurgy. The Co-op Program is a highly visible and very effective means to attract high-quality students into our discipline.

The first Co-op scholarships in Materials Science and Engineering commenced in 1989 and the success of the Co-op Program in delivering the above benefits to scholars and sponsors in Materials Science and Engineering is demonstrated by the strong and consistent support of the Program by industry: there has been a total of 126 scholarships from 30 different industrial sponsors since 1989. Co-op graduates are highly sought by industry and those students entering the materials industry usually rise to positions of leadership and management.

The Co-op Program attracts the academically strongest students (typically, ATARs are greater than 99.0) who, importantly, also have good leadership, teamwork, and communication skills. For students in Materials Science and Engineering, each scholarship provides $16,750 per annum for 5 years, 68 weeks of structured and highly relevant industrial training with up to 4 sponsor companies, the opportunity to experience typical graduate employment, and close access to potential employers. The Program provides industrial sponsors with highly motivated, capable students to complete important and valuable industrial work. It also provides sponsors the opportunity to have direct involvement in the education and development of our School's students and from whom they can potentially recruit their future managers and leaders.

A total of 6 scholarships (Table 1) were provided by 5 industrial sponsors in 2013 (Table 2). This represents an investment by industry of approximately $100,000 for the year. Although one new scholarship commenced in 2013, the attraction of new scholarships remains a challenge owing to the continued economic downturn in the Australian manufacturing industry.

Scholars completed the following industrial training (IT) placements during the year: IT1 (10 weeks) by students at the end of their first year; IT2 (10 weeks) by students at the end of their second year; and IT3 (24 weeks) and IT4 (24 weeks) by students midway through their third year of study. Each IT placement was reviewed by the Academic Coordinator in the form of an interview with the scholar and sponsor representative(s). The scholar and sponsor also provided written appraisals of the placement. Each scholar also gave a short presentation to industry sponsors and fellow Co-op students summarising their IT work and, importantly, the technical and professional benefit they obtained from the placement. Judging from the placement interviews, written appraisals, and presentations, all placements were completed successfully and fulfilled the philosophy and objectives of the Co-op Program – for both scholars and sponsors. Industry sponsors indicated the significant quality and value of work completed by the scholars during their placements. The commitment of scholars and sponsors to the IT placements is fundamental to the success of the Co-op Program. The School thanks all of its Co-op sponsors for the efforts they put into organising the placements as well as their training, guidance, and support of scholars during the placements, and for their continued generous support of the Co-op Program.

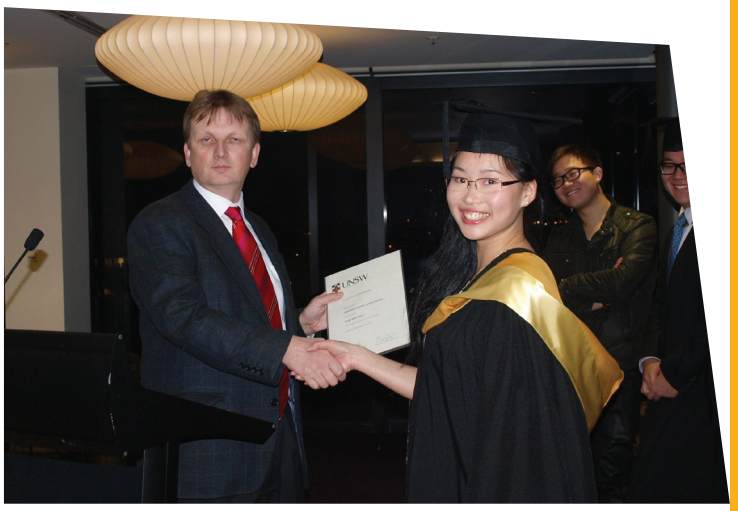
Owen Standard
Academic Coordinator
Co-op Program in Materials Science and Engineering

Undergraduate Prizes

Hugh Muir Prize

For the final year student who, in the opinion of the Head of School, has contributed most to the corporate life of the School.

Recipient: Amanda Wang



ANSTO Prize

For the best performance in MATS3006 – Computational Modelling

Recipient: Kevin Tengarra

Max Hatherly Prize

For the best performance in Crystallography and x-ray diffraction components of MATS2003 - Materials Characterisation

Recipient: Yuan Yeo

Wallarah Minerals Prize

For the best honours thesis in the Bachelor of Engineering in Ceramic Engineering program

Recipient: Holstein Wong

Emily Vu Duon – OneSteel Newcastle

During my first semester of second year, I received a cadetship with OneSteel in Newcastle. Conditions of this cadetship require me to study for only one semester a year, then move up to and work in Newcastle for the remaining 8 or so months, essentially extending my degree by two years!

In the last five years, I have been involved with

- Quality control and product audits
- Steelmaking operation and shift work
- Spring manufacturing chain optimisation
- Customer and competitor investigations
- R&D trials
- Report writing
- People management

From a technical perspective, I have learned bucketloads, from the use of scientific equipment to analysis instruments and methods, how to run my own projects and trials, and how to interpret results and findings. I've also developed my presentation skills, and management of people and time. It was scary leaving the familiar and quite sad to see all my peers graduate and move on from uni without me, but if I had the chance to do it over, I wouldn't change a thing.

In return, I've gained invaluable industrial experience and contacts, fostered lifelong friendships and have a taste of what awaits in the real world. Also, OneSteel pay a decent salary and all my uni fees so I'll graduate debt free!

This cadetship is one of the best decisions I've ever made, and I would highly recommend that if the opportunity presented itself again, every student should apply.

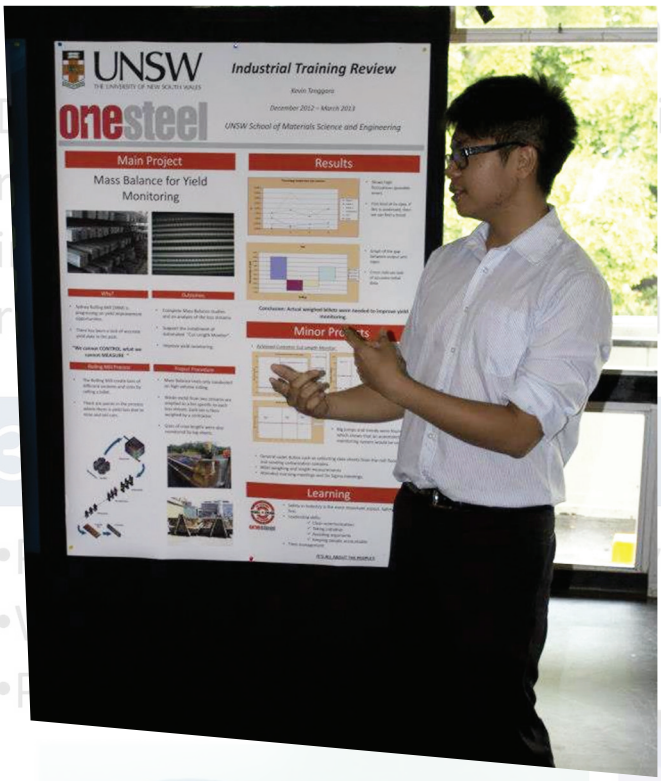
Undergraduate Industrial Training Poster Presentation

The annual undergraduate Industrial Training Poster Presentation is an opportunity to showcase our students' industrial training experiences.

Whilst it was a very close competition our judges Alan Crosky, Owen Standard and Ronald Maran awarded five prizes:

1st Kevin Tengarra
2nd Amanda Wang
3rd Tao Tan
4th Phatphinya Herlipaisarn
5th Brianna Ganley

The quality of the posters and the 1-minute presentations was very high and all students were commended for their efforts.



Forces of Colloidal Interactions on Antifouling Surfaces

BLUESCOPE STEEL

UNIVERSITY OF WOLLONGONG

ARC Centre of Excellence for Electromaterials Science

INTELLIGENT POLYMER RESEARCH INSTITUTE

Amanda Wang[1,2], Michael Higgins[1], Dean Cardillo[1], Paul Molino[1], Alex Keller[2], Elise Stewart[1], Shane MacLaughlin[2], Evan Evans[1], Gordon Wallace[1]

[1] Intelligent Polymer Research Institute, ARC Centre for Excellence in Electromaterials Science, University of Wollongong, Wollongong, NSW, 2522, Australia
[2] BlueScope Steel, Port Kembla Road, Port Kembla, NSW, 2505, Australia
[3] The University of New South Wales, UNSW Sydney, NSW, 2052, Australia

Introduction

- Biofouling occurs when undesirable micro-organisms adhere onto wetted surfaces.
- Traditional antifouling measures used paints with toxic chemicals such as TBT (tributyltin moiety).
- As this harms the environment, non-toxic alternatives are explored to understand the mechanisms in which these micro-organisms adhere and ways to prevent first contact (Magin, et al., 2010).
- In collaboration with BlueScope Steel, ACES aims to develop nanostructured polymeric surfaces which are both non-toxic and can prevent micro-organisms from adhering.
- This project utilizes Atomic Force Microscopy (AFM) to quantify nano scale forces of attraction and adhesion on three polymeric surfaces using colloidal probes at first contact.

Method

- BlueScope had provided ACES with three colloid dispersions and three surfactants—two of which were chosen for this project. A third was chosen to further investigate variations observed in 3B:

2B	Native silica colloid	17nm diameter
3B	Functionalized silica colloid	5nm diameter
3B w/o surfactant		

Figure 1 — Polymeric surfaces used in this project provided by BlueScope.

- 3B was chosen as this exhibited the best anti-fouling properties from BSA protein adsorption using the QCM.
- 2B was chosen as this shared a common surfactant with 3B.
- On a glass cover slip UV cleaned for 30 minutes, 20µL of the coating was spun coated at 7000rpm for 30 seconds and cured overnight at 110°C. Unbound surfactant was rinsed using Milli-Q water prior to any experimentation.
- Prepared surfaces where characterized using Goniometry, Profilometry and AFM imaging to gain an understanding of surface energy and morphology to be related to subsequent force measurements.
- 9µm colloidal silica beads were attached to cantilever tips using 2-part epoxy. Forces measured were taken after probes were chemically functionalized as hydrophilic (using UV radiation), and again when hydrophobic (using Fluorinated Silanol). Measurements were normalized with the radius of the colloidal bead for accurate results.

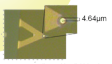


Figure 2 — Cantilever with colloidal probe.

Results — Characterization


Figure 3 — Goniometry on 3B.


Figure 4 — Profilometry on 3B after successive washing.


Figure 5 — AFM imaging on 3B prior to successive washing.


Figure 6 — AFM imaging on 3B after successive washing.

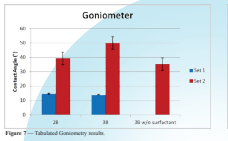


Figure 7 — Tabulated Goniometry results.

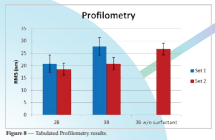


Figure 8 — Tabulated Profilometry results.

Results — AFM Force Measurements

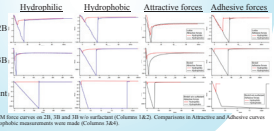
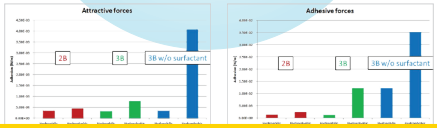


Figure 9 — Representative AFM force curves on 2B, 3B and 3B w/o surfactant (Columns 1&2). Comparisons in Attractive and Adhesive curves between Hydrophilic and Hydrophobic measurements were made (Columns 3&4).



Van der Waals attractive forces upon extension of the cantilever.

Point of contact.

Oscillation of cantilever upon retraction.

Base line.

Interpreting the Curves

Cantilever returns to its original position.

Adhesive forces upon retraction after contact between polymer surface and hydrophilic/hydrophobic colloid.

Conclusions

From analysing Characterization and AFM results:

- Attractive and Adhesive forces can be measured and then related to Characterization results.
- Hydrophobic measurements exhibit greater adhesion than hydrophilic measurements.
  - 2B: Consistent force measurements were obtained.
  - 3B: Addition of surfactant significantly increases its anti-fouling properties, apparent when comparing 3B with 3B w/o surfactant.

Further Studies

- Force measurements on other combinations with and without surfactant added.
- Force measurements in fluids of varying pH.
- Functionalization of colloidal probe or sample surfaces with protein and/or bacteria.

Industrial Training Benefits

- Gained insight into research and interactions with other companies.
- Attended a symposium with speakers from all across the globe.
- Used various larger machinery.

ETHYLENE CRACKING FURNACE COIL FAILURE

ptt GLOBAL CHEMICAL

Phatphinya Herlipaisarn Z3325863

PROJECT

Research on possible causes of coil failure and identify possible coil failures occurring in PTT PE Ethylene Cracking Furnace at PTT PE Ethane Cracker Plant.

Sample 1:

Sample 2:

RESEARCH: Causes of Coil Failure

Carburisation: The development of metal carbides, chromium carbide, layer on the surface of a material as a result of exposure to a carbon-containing atmosphere. Carbon content reacts with chromium content to produce chromium carbide precipitates. This phenomenon is often associated with high temperature service. Effects of carburisation include:

*Premature failure overtime

*Increases strength which produces brittle materials and causes loss of ductility, consequently, formation of cracks

*Increases volume which results in stresses and eventually bulging occurs

Creep: The tendency of a material to move slowly or deform permanently under the influence of stresses. It is a result of long term exposure to high levels of stress below yield strength of the material. Creep increases with temperature and becomes more severe when heated for long period. Three stages of creep are:

*Primary Creep: No significant damage is generated.

*Secondary Creep: Grain boundary yielding produces local work hardening and the nucleation of grain boundary voids.

*Tertiary Creep: The grain boundary voids link up and gross necking or thinning develops. Consequently, cracks are formed.

INSPECTION

MACROSTRUCTURE INSPECTION

Sample 1:

*A 100% columnar

*Clear indication of carbulisation on bulged areas


Bulged Area


Carburisation Etching

Sample 2:

*A 100% columnar structure

*Cracks formation on the macrostructure


Crack Area


Crack Area


Carburisation Etching

MICROSTRUCTURE INSPECTION

Sample 1:

Carburisation occurred on the entire wall thickness of the bulged area. Severe internal oxidation was also found. This indicated the material is unable to maintain protective oxide layer. Creep damage was also detected in this area as well as large cracks.

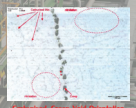

Severe Internal Oxidation


Large Cracks, Carburisation, Creep Damage

Sample 2:

Severe material deterioration was found on this sample, indicating high temperature exposure. Large oxidised cracks was also seen. Carburisation occurred mainly on areas close to internal diameter. Severe creep damage and creep voids were also noticed, suggesting this failure was enhanced by carburisation.


Internal Oxidation, Oxidised Cracks


Carburised, Creep Void Orientation

KEY TASKS

*Understanding ethane cracker process

*Researching on causes of ethylene cracking furnace coil failure

*Identifying the causes of coil failure happening in PTT PE Ethylene

SKILLS LEARNT

*Communicational Skills

*Teamwork Skills

*Problem-Solving Skills

Predictive Modelling of Crosslinked Polymer Networks

Industrial Training Project

Tao Tan, Vacation Student

MATERIALS SCIENCE AND ENGINEERING
www.csiro.au

CSIRO

With the increased acceptance and usage of Carbon Fibre Reinforced Plastics in the aviation industry, there is a growing need for cheaper and quicker validation methods for composite materials. Molecular dynamics simulations offers a potential method to significantly reduce the time and costs in finding as well as testing new resin systems.

Background

Due to its highly desirable mechanical properties, Carbon Fibre Reinforced Composites continue to be used in greater amounts in the aviation industry. Composite materials make up 25% of the airframe of the Airbus A380 and 50% of the Boeing 787 Dreamliner. However, novel resin systems must be found if there is to be continual improvement of aircraft performance. The current methods of resin formulation and testing are extremely resource intensive and time consuming, especially considering the strict guidelines concerning aviation class materials. Molecular dynamics can be used to simulate epoxy resins at an atomistic level and potentially offers a method to characterise new resin systems in a more timely and cost efficient manner.

Aims

Firstly, this project aims to evaluate the accuracy and robustness of one specific method of modelling epoxy resin systems using molecular dynamics. The project then hopes to find structure-property relationships between molecular structures in the resin monomers and the final bulk and thermal properties of the resin.

Method

In order to determine the accuracy and robustness of our method of modelling resin systems, the thoroughly studied Diglycidyl ether of bisphenol A [DGEBA] epoxy cured with 4,4'-Diaminodiphenyl sulfone [DDS] was modelled. The properties of this resin system such as glass transition temperature, yield strain and density were then interrogated using molecular dynamics and results compared to experimental values in literature. The system was also modelled at various simulation sizes, measured by atom count, to see whether the size of the simulation affected the measured properties.

The DGEBA monomer was then systematically varied (See Figure 1) to exaggerate the effects of specific structures in the monomer. The resin systems modelled with these altered DGEBA monomers were also interrogated to see what effect these changes would have on the bulk and thermal properties of the resin.

Results

Key findings include;

- The thermal and mechanical properties of the simulated DGEBA-DDS system closely reflected experimental values found in the literature
- The error in the simulations reduced with increased simulation size
- Computational cost increased linearly with simulation size
- An increased density of aromatic structures in the polymer gives rise to higher glass transition temperatures whereas an increased density of aliphatic structures gives rise to lower glass transition temperatures
- The resins made with the DGEBA epoxy variants showed similar yield strain to the unaltered DGEBA resin save for the structure with aromatic groups pendent to the backbone of the resin

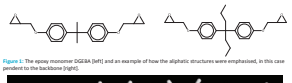


Figure 1: The epoxy monomer DGEBA [left] and an example of how the aliphatic structures were emphasised, in this case pendent to the backbone [right].

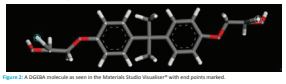


Figure 2: A DGEBA molecule as seen in the Materials Studio Visualiser® with end points marked.

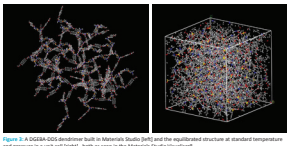


Figure 3: A DGEBA-DDS dendrimer built in Materials Studio [left] and the equilibrated structure at standard temperature and pressure in a unit cell [right] , both as seen in the Materials Studio Visualiser®.

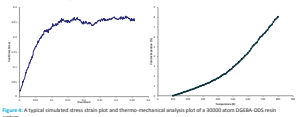


Figure 4: A typical simulated stress strain plot and thermo-mechanical analysis plot of a 30000 atom DGEBA-DDS resin system.

Industrial Training Outcomes

- Gained experience and an appreciation for working in a research role
- Developed my understanding of the scientific method and gained exposure to real life limitations a researcher may face
- Improved my presentation and public speaking skills through classes and presenting to my peers
- Was provided very helpful career advice and life stories by current staff on their journey to becoming a research scientist
- Developed connections with science and engineering students from all across Australia
- Attended the Carbon Fibre Future Directions conference in Geelong
- Research to be published in a scientific journal

FOR FURTHER INFORMATION ACKNOWLEDGEMENTS

Kara Poon - Taiwan Exchange

During the summer vacation from December 2013 to February 2014, I travelled to Taiwan with six other students from the School of Materials Science and Engineering UNSW on the AsiaBound Mobility Program for a research and cultural exchange.

During our stay, we lived and worked at Tunghai University, Taichung. Taichung is located on the west coast of Taiwan and is known for its industries. At Tunghai University, we were allocated to different schools within the Department of Engineering and assigned a supervisor and a research project. I worked within the Industrial Engineering department and I was given the project of determining the thermal effects on fused deposition modelling, which is a type of 3D printing. Through my research, I determined the variables which affect the quality of products printed using the Makerbot Replicator 2X Experimental 3D printer. I also determined the optimum adjustments that were required to produce the best quality product.

In conjunction with our research work at Tunghai University, we also travelled to local Taiwanese universities to give presentations on Australian history and culture, UNSW and university life in Australia. At these universities, we were introduced to the staff and students of the Materials Science and Engineering Schools and were shown the facilities and laboratories. We were fortunate enough to have visited 5 universities that were located in various regions in Taiwan. This provided us with the amazing opportunity to not only meet more Taiwanese students, but also to explore Taiwan whilst travelling.

Tunghai University also organised for us to visit three different types of manufacturing facilities. These included a machinery manufacturer, a semiconductor facility and a company which specialises in the production of aircraft parts and systems.

We also learned some basic Chinese through student-led tutorials and through socialising with the local students. After 3 months there, we were all able to speak some Chinese and where our Chinese lacked, our skills in charades excelled.

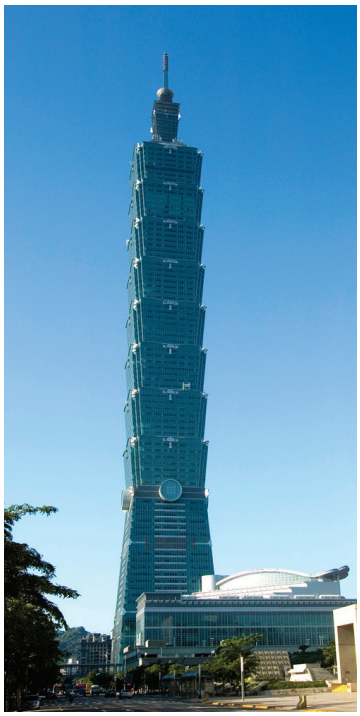
But our trip was not just work! We had plenty of time to travel and explore Taiwan and its many beautiful and different landscapes and to learn about the wonderfully friendly and welcoming people. We travelled to almost every county in Taiwan and were pleasantly surprised by just how different each location was.

During our first weekend in Taiwan, we travelled south to Kaohsiung where we explored the beach town on bicycles. Travelling on bicycles was one of the easiest ways to get around, when public transport was inconvenient and it also gave us plenty of exercise! We were able to have our first experience of just how seriously the Taiwanese take their night markets as the market we visited in Kaohsiung was one of the largest and most crowded in Taiwan.

We also travelled to the eastern side of Taiwan to Taroko Gorge, Hualien. Taroko Gorge is known for its natural beauty as it has stunning blue waters winding between canyons of limestone rocks.

One of the more memorable moments of the trip was our spur of the moment decision to travel to Taipei to watch the New Year's fireworks off Taipei 101. We left our university campus extremely early in the morning and got to Taipei at 3pm, only to realise the locals don't usually turn up for the fireworks till 10pm Despite the fireworks show only lasting around 3 minutes, getting no sleep and returning on the next 4am train back to uni, it was a fun trip which all our Taiwanese friends thought us crazy for doing.

Overall, our trip was enjoyable as we learnt a lot about Taiwanese culture, the people and its changing landscapes. We were introduced to many universities which helped us to understand how the Taiwanese universities and their campuses varied. Furthermore, we experienced working in a foreign setting and were able to experience Taiwanese student life. We were also able to continually improve our Chinese language skills and we were hugely fortunate to make many new and close friends.



The Materials Postgraduate Society (PGSOC)

The Materials Postgraduate Society (PGSOC) is the social organisation for all postgraduate students of the school. Established four years ago, the Society provides an outlet for students away from their ever-important research projects. An active research life, with a balance of work and fun, helps keep the students fresh and motivated. The Society aims to address this by conducting activities that cater to the students' interest and needs.

In 2013 PGSOC hosted the Postgraduate Presentation Competition, a series of rounds of conference-style oral presentations. True to its aim, the activity showcased many of the cutting-edge projects that are underway in the School, with the student researchers themselves elaborating on their work in their own words. Great presentation skills are an important asset for research, where scientists are called on to make their work more accessible to the general public and breakthrough science occurs through interdisciplinary collaborations. And, as was seen, the School is fortunate to have exceptional presenters in its postgraduate ranks.

This year entries were received from different levels, a majority of which surprisingly came from the first years and younger PhD students. The range of presentations was immense, and the competition equally fierce. Ultimately, Zhemi Xu, won the grand prize with her presentation entitled, "Reversible Hydrophobic to Hydrophilic Transition of Graphene under UV Irradiation: Experimental and First Principle Studies".

Several small initiatives were also begun in the year, such as informal get-togethers, and a growing degree of collaboration with the Materials Engineering Student Society (MATSOC) for undergraduates. The Society has also worked towards higher student awareness of School issues such as noise and facility use.

PGSOC would like to thank the members who have contributed greatly in the previous years, such as Jacky Cao, Karl Shamlaye, and Ronald Maran, and wish them the best in their forthcoming career ventures.

2014 promises to be a huge year for PGSOC, as we aim for more events to encourage student participation and initiative, with the overwhelming support of the MSE staff and student body. The Society has grown into a well-recognised student organisation, welcoming new people onto the executive committee, and establishing itself as a name that students can turn to for a slice of student life fun in Materials Science and Engineering.

Materials PGSOC Executive Committee
Neil Lazo – President
Akhila Mukkavilli – Vice President
Yanyu "Maggie" Zhou – Treasurer
Hsin-Hui "Sonia" Huang – Secretary
Zain Zaidi – ARC Delegate
Benjamin Pace – Media and Marketing Officer
Aurelien Prillieux – Social Officer
Amanda Wang – Women's Representative
Lance Tang
Scott Gleason
Cindy Wang
Caitlin Healy
Mahsa Hosseini

MATSOC 2013 report

The undergraduate student society of Materials Science and Engineering, also known as MATSOC, had one of the most successful years to date. Not only did were the age-old traditions of free barbeques upheld, but multiple new initiatives were introduced, which were very well received by both staff and students.

The majority of MATSOC Executive members were elected during an AGM in March, where 15 students volunteered their time and energy into reviving the student society. The first year representatives were elected in an AGM held in May, completing the Dream Team with a total number of 17 Executive members, as follows:

President	**Deep Kochar**
Vice Presidents	**Caitlin Healy, Zain Zaidi**
Treasurer	**Jonathan Lee**
Secretary	**Amanda Wang**
ARC delegate	**Alexandra Smith**
Social Director	**Brianna Ganly**
Industrial Liaison	**Claire Dwyer**
Fourth Year Representatives	**Charles Tweedie, Gavin Chan**
Third Year Representatives	**Kara Poon, Nadia Funayama**
Second Year Representatives	**Amanda Lai, Haydon Fung**
First Year Representatives	**Andrew Trimmer, Scarlet Kong**
Post-Graduate Representative	**Neil Lazo**

To aid in funding the numerous projects the Executive had in mind, a previous MATSOC President, Shah Timon, had organized for the 2013 MATSOC members to host a barbeque at Bunnings Warehouse in Mascot. Around ten volunteers helped out that day, grilling sausages and caramelizing onions. Almost $1300 was raised in total, motivating the Executive to start implementing each initiative.

MATSOC also hosted a total of five free barbeques throughout the year, welcoming and encouraging both staff and students to attend and mingle. It was interesting how the Executive were able to learn something new about the catering process in order to satisfy the needs of all who attended. Although the amount of food was increased each time a barbeque was held, this was still not enough to accommodate for everyone who attended. The Executive took this positively, as it reflected how successful each barbeque was.

MATSOC introduced two new initiatives, aimed at both the sporty and the geeky sides of students. A bowling event was hosted at the Strike Bowling Bar at Darling Harbour in late August, creating an opportunity for students to relieve tension and interact in a relaxing environment. Those who attended enjoyed the event so much, that they requested a second event be organized. For the gamers of Materials, MATSOC hosted an epic online DOTA 2 Tournament in early September, providing students with a legitimate reason to play games!

The most charitable MATSOC initiative of the year was the Red-Cross Blood Drive in March. Each person knows that one single donation can save three lives – but how many people actually sets aside the time to follow through? MATSOC used this opportunity to encourage students to spare an hour of their time in Semester 1 Week 2, so that they could help save three people. Regardless of whether the donation was whole blood or plasma, or attendance was strictly for moral support, MATSOC aimed to raise awareness of its importance within the School.

Perhaps the most highly anticipated project of the year was the MATSOC jersey initiative. As the execution process was relatively novel to the Executive members, much research was required before details on the company and jersey design could be advertised to the School community. 52 orders were received from undergraduates, postgraduates and staff – some purchased more than one as a gift to friends! Despite the jerseys only arriving in November, the general consensus was positive, with warm feedback from those who bought them and regretful feedback from those who didn't.

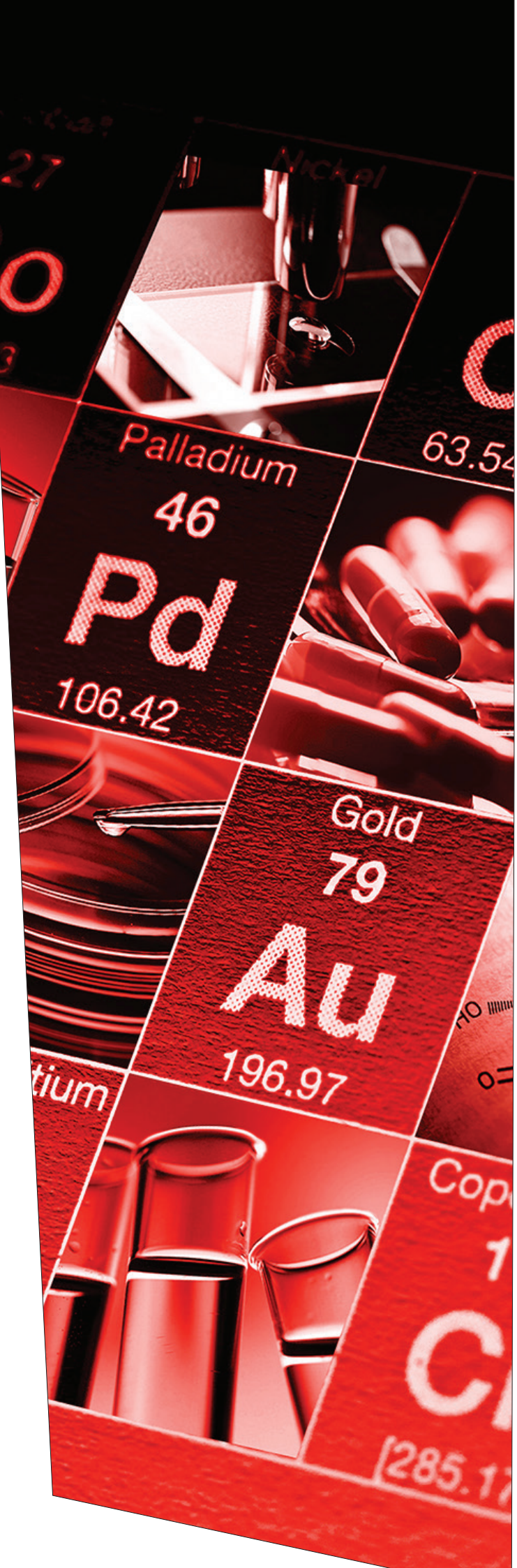
Exams tend to bring down even the best of us – especially final exams, when students push themselves in order to achieve grades to pass the course. However, even the most accomplished student has weak moments of procrastination. To motivate student to study more effectively, MATSOC had organized several study sessions throughout the week prior to final exams in both Semesters. For Honours students, rooms were booked with the express purpose of practising their presentations – complete with video camera, laser pointer and projection screens. Hopefully, those who had attended found these sessions useful and did well in their exams!

The 2013 Executives ended the year by hosting a second AGM to elect the 2014 MATSOC Executive members. By doing so, insight and wisdom from past errors could be passed to the next generation, so that the events they decide to hold will be even more successful than the year before. If you would like to support current and future MATSOC events, please join the Facebook group, which can be accessed through this link (https://www.facebook.com/groups/UNSWMaterials/).

As one of the Executives, I am proud to say I had served in this wonderful team. MATSOC 2013 – your legacy will reign throughout history!

Amanda Wang
Secretary, MATSOC 2013


UNSW
STUDENT
LIFE



PART FOUR:

RESEARCH

ARC Centre of Excellence for Design in Light Metals

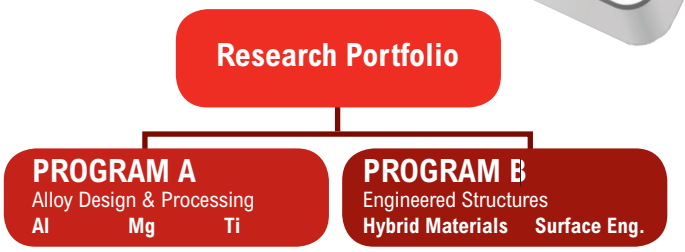
The *ARC Centre of Excellence for Design in Light Metals* was established in 2006 with the vision to be an innovative, internationally-competitive strategic fundamental research *Centre of Excellence*, advancing scientific knowledge and understanding in, and enhancing technology development, awareness and applications of, the light metals aluminium, magnesium and titanium. The Centre combines the expertise of the leading Australian light metals researchers based at Monash University, UNSW Australia, University of Queensland, Deakin University, University of Sydney and University of Melbourne.

The Centre embraces a '*design-directed*' approach to the systematic identification of research initiatives for maximising the competitiveness of light alloys and light metal hybrids based on *aluminium*, *magnesium* and *titanium*. The 'design-directed' approach provides an effective linkage between fundamental research and engineering application. The Centre has global linkages with major international Centres in Europe, North America and Asia.

The Centre's 8th and penultimate year of operation was highly successful, with some notable highlights including:

- Continuation of excellent research outputs from staff and students in the form of high-calibre publications, keynote & invited addresses at International Conferences, and visits to major international laboratories, and
- 7th Annual CoE Conference hosted by University of Queensland that attracted over 100 Centre participants including several eminent local and overseas Partner Investigators.

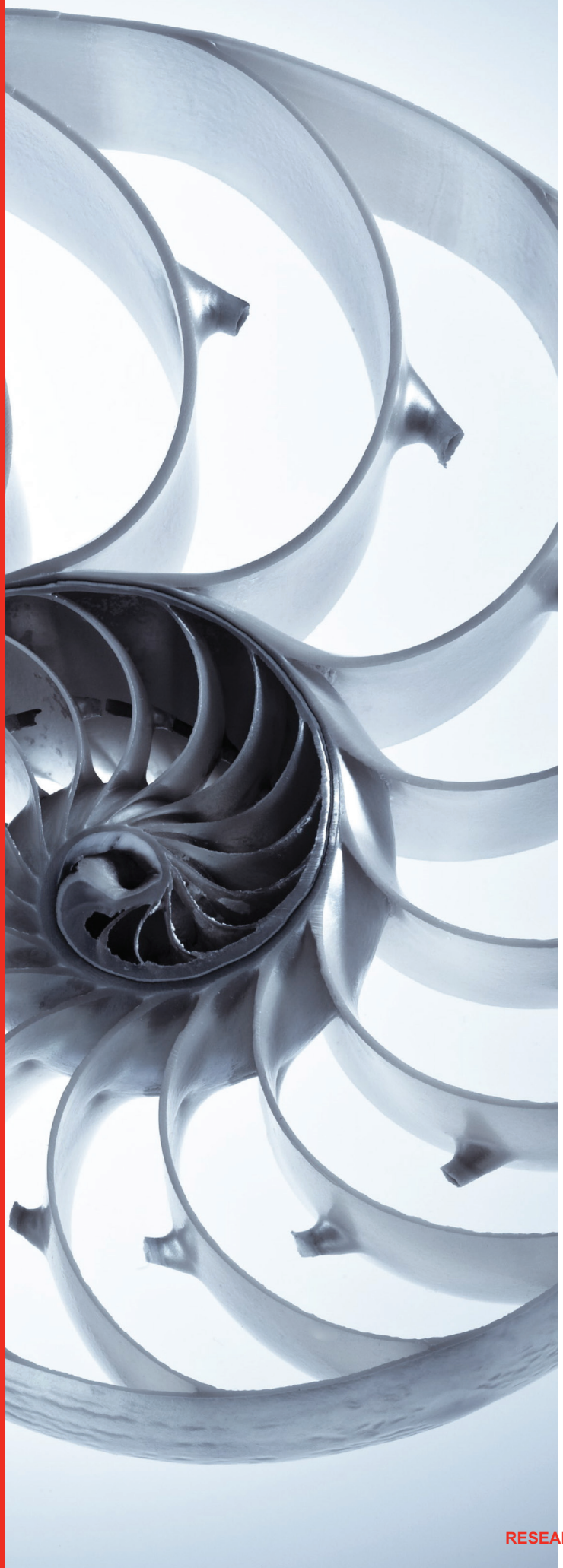
The School has played a major role in the Centre and is active in several of its research projects. Professors Michael Ferry and Mark Hoffman have continued with their major leadership roles in the two key research programs (see below): Program A consists of the six projects in Al, Mg, and Ti, and Program B consists of two projects in Hybrid Materials and Surface Engineering. Selected research highlights of UNSW researchers in two key projects within these programs are outlined as follows.



Project A4 – Lightweight Bulk Metallic Glasses

Researchers: Prof. Michael Ferry (Project Leader), Dr Kevin Laws (Project Manager), Dr Martin Xu, Dr Reza Mahjoub, Jake Cao, Karl Shamlaye, Jacky Cao, John Scicluna, Fitri Mohamad, Olga Biletska, David Miskovic, Nick Hamilton

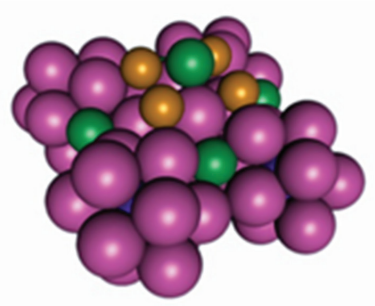
Bulk metallic glasses (BMGs) have a metastable amorphous structure and, hence, they generally exhibit attractive properties suitable for structural and functional applications. This major Centre project has three streams of research: Stream A aims to extend the types of BMG compositions based on a fundamental approach to alloy design of BMGs and involves investigations of their microstructure at the highest levels of sophistication; Stream B aims to generate actual devices and components for certain end-applications, and Stream C aims to generate BMG composites and components. Again, 2013 has been a productive year with a notable outcome being the paper led by Dr Laws on a new model of the atomic structure of metallic glasses that explains why only specific local configurations of different atom species result in high glass-forming ability. Indeed, the paper answers one of the most important questions in the field of metallic glasses: *How can glass-forming ability be predicted from simple, physical concepts drawn from atomic structure*? Another notable outcome was the UNSW PhD completions by Jake Cao, Karl Shamlaye, Fitri Mohammad, Olga Biletska and Nasima Afrin.

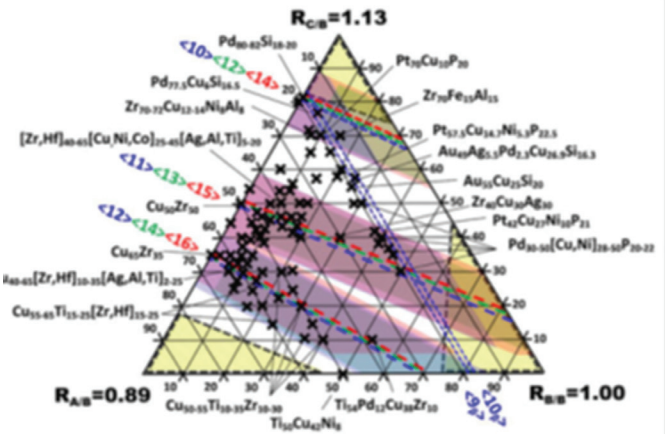


Project B1.1 – Hybrid Design for Exceptional Structural Performance – Low Density Structures

Researchers: Prof. Mark Hoffman (Program Leader), Dr Tania Vodenitcharova (Project Manager), Neil Lazo, Dr Emmanuel Flores-Johnson

This project targets lightweight structures with optimised architecture and material selection which provide superior capabilities over their bulk counterparts. It explores foam- and truss-cored laminates for their high absorption capacity, and bio-mimetic shell-based structures optimised to meet specific strength and performance requirements. Inspired by naturally occurring nacre structures, the project stream entitled '*Bio-inspired composite structures'* that commenced in 2012, with the aim at developing a layered nacre-like structure of high impact resistance, is well underway. The figure below shows: (a) nacre-like structure comprising bonded waving solid plates, and (b) FEA simulations of a projectile impacting the structure at various speeds. The ballistic performance of the composites was compared with that of bulk plates and was found to be superior in thicker-plates impacted at high velocity. This is attributed to the hierarchical structure that enables both localized energy absorption by deformation of the metallic tablet and tablet interlocking due to the waviness and inter-layered delamination which allows plastic deformation further away from the impact zone.



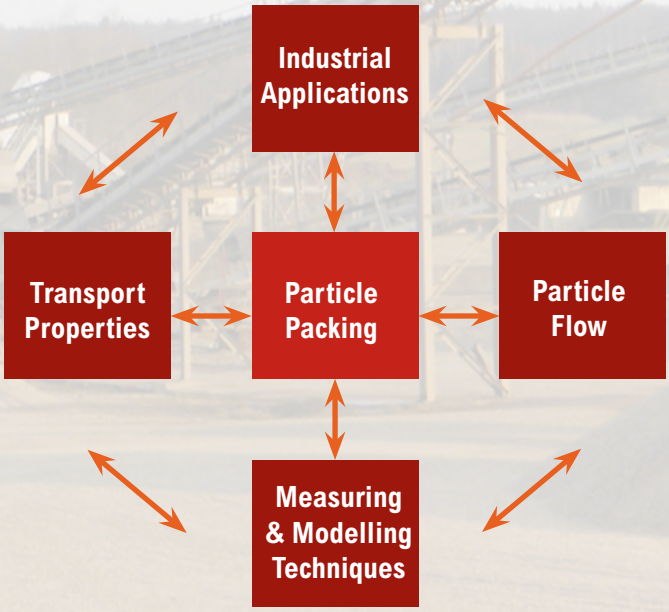


SIMPAS report 2013

The Laboratory for Simulation and Modelling of Particulate Systems (SIMPAS) is a world-class, multi-disciplinary research facility, established and directed by Professor Aibing Yu. Its research theme aims at understanding the mechanisms governing particulate packing and flow through rigorous simulation and modelling of the particle-particle and particle-fluid interactions at both microscopic and macroscopic levels, with its application oriented to the mineral/metallurgy/chemical/materials industries. Its goal is to be internationally recognised through excellence in fundamental and applied research in particulate science and technology.

The research in SIMPAS is developed in five inter-related areas at three levels, including the development of simulation and modelling techniques (level 1), fundamental studies of particle packing and flow, and the transport properties of static/dynamic particle systems (level 2), and industrial application (level 3), as shown in Fig. 1.

Figure 1. Reseach areas and their links in SIMPAS



Since 1993, SIMPAS has attracted over $27M external research funds to UNSW including >50 grants from the Australian Research Council, and graduated 70 PhD and 14 MEng students while hosting >38 postdoc researchers.

Research collaboration has been conducted with various industrial organizations including Bluescope Steel, BHP-Billiton (including BMA), Alcoa, Xstrata, ACARP, Rio Tinto, Johnson and Johnson, Minco Technologies, DSTO, Cement Australia, and many overseas R&D organizations such as Kawasaki Steel (Japan), China Steel (Taiwan), Posco Steel (South Korea), Tata Steel (India), BaoSteel and Long-King (China); RecyCoal (UK) and other universities and research institutes including CSIRO, Australian Defence Department. Clearly, SIMPAS has established its leading position in the main theme research areas such as particle packing, particulate and multiphase flow/processing (in, e.g. ironmaking and coal preparation), and simulation and modelling.

In 2013, SIMPAS was comprised of 17 teaching/research/administrative staff and 40 postgraduate research students and 2 visiting scholars. It attracted >$ 4.0M research funds (~ $3.28M external and ~$0.73M internal); graduated 6 PhD and 1 MEng students; published 3 edited conference proceedings and journal special issues, 1 book chapter, 55 journal and 5 conference papers, plus delivering 6 plenary/keynote and >20 presentations at various international conferences. It also received >30 academics' visit. In particular, SIMPAS successfully organized the 7th International Conference on Powders and Grains in Sydney on 8-12 July 2013, which attracted more than 300 delegators worldwide.

After 22 years' service for UNSW Australia, Prof Aibing Yu moved to Monash University from May 2014 to become its Pro Vice-Chancellor and President of Monash-Southeast University Joint Research Institute. Many SIMPAS members will move with him. Therefore, after >20 years' operation, it will have different branches: SIMPAS@UNSW, SIMPAS@Monash, SIMPAS@NEU, and probably others in the future (e.g. SIMPAS@UWS and SIMPAS@SEU). Expectedly, it will play a more and more important role in the future in particle science and technology, and process engineering, in Australia and China.

SMaRT Centre report – Green Steel

Professor Veena Sahajwalla, Daniel Miles and the team at SMaRT@UNSW and OneSteel

Reducing the ecological footprint in the steel industry

Globally the cost of raw materials for the production of steel has increased significantly, while on the other hand the competitiveness of the global steel market continues to intensify. In light of the world's ever increasing appetite for steel, and an increasing awareness about earth's environment, steel producers are under constant pressure to reduce their global footprint. The steel industry accounts for 3-4 per cent of greenhouse gas emissions worldwide and, on average, 1.7 tonnes of carbon dioxide are emitted for every tonne of steel produced. These are clearly incompatible trends which, if we persist with business as usual, will only increase tensions for the industry. Consequently, there is an important place in steelmaking for alternative resources to reduce the cost of raw materials along with environmentally sustainable ways to produce steel[1].

The accumulation of waste piles ranging from plastics to biomass are growing at a rapid rate, reflecting the pace of economic flow, shorter replacement cycles for goods and increasing intensity of global trade. The United States Environmental Protection Agency (US EPA) has reported that in 2012 over 32 million tons of waste plastics were generated in the United States alone, out of which only 9 per cent was recovered for recycling[2]. In Australia, the recycling rate of polymer waste was 20.5% in year 2011-12, with around 80% of wastes going to landfill[3]. Used automotive non- biodegradable tyres represent a significant and rapidly growing waste burden, with the underlying threat of leaching toxic chemicals into the environment. Nearly 20 million passenger tyres are disposed of every year in Australia, 64 per cent go to landfill, only 23 per cent are recycled, and the remainder are dumped illegally[4]. Worldwide, more than one billion used tyres are discarded annually and an estimated four billion waste tyres are currently in landfills, posing a potential risk to human health and the environment.

However, the majority of waste materials like tyres and plastics consist mainly of carbon and hydrogen elements which are vital resources in metallurgical industries due to their role as reductants and carburizers. Furthermore, plastics and tyres are long chain hydrocarbons with high volatile matter and low ash content. These advantages open an opportunity for steelmakers to use waste streams as low cost raw materials for steel production.

Transforming waste to resource

At UNSW's Centre for Sustainable Materials Research and Technology (SMaRT@UNSW), our research focuses on various high temperature reactions with the goal of transforming waste to resource. In a practical sense that means utilising waste streams as an alternative source of carbon during the steel making process. SMaRT@UNSW in collaboration with OneSteel pursued the goal of using polymer waste in the steelmaking process, which in turn gave rise to Polymer Injection Technology (PIT). PIT technology leverages steelmaking temperatures of 1550-1650°C to enable steelmakers to utilise carbon bearing waste streams, such as waste tyres and waste plastics, as a substitute for a significant proportion of the non-renewable coke traditionally used as a carbon injectant in electric arc furnaces. The result is a novel recycling solution that requires minimal modifications to the manufacturing process and retains the quality and performance of the end product[5]. PIT is now a standard practice at OneSteel's EAF facilities in Sydney and Melbourne, and has been used in the production of over 66,000 heats of steel. During this time the equivalent of more than 1.9 million discarded passenger tyres has been consumed. The technology is now also benefiting steelmakers, and the environment, outside of Australia with PIT having been licensed to steelmakers in Thailand, South Korea and the United Kingdom.

The concept behind this proven technology, however, has significant potential beyond this particular study which means steelmakers can transform "waste to value". High temperature reactions offer an important addition to the environmental 3Rs (Reduce, Reuse, Recycle). We are now proposing a fourth "R", that is; RE- FORM. This is a new way to think about waste materials because they can now be considered as potential raw materials that can be effectively reformed through chemical reactions into resources for industry. This is a novel, industrial scale recycling revolution that the steel industry has the potential to lead and can act as effective waste management system along with cost effective strategy for future.

Team members who contributed to the development of PIT include: Prof Veena Sahajwalla, Paul O'Kane, Andrea Fontana, Zheshi Jin, Catherine Skidmore, Paul Vielhauer, Ravindra Rajarao, Magdelina Zaharia, Irshad Mansuri, Renu Dhunna, Farhana Nur Yunos, Rita Khanna, Rifat Farzana, Narendra Saha-Chaudhury, Uttra Benton, Darren O'Connell, Daniel Miles, David Knights, Tony Dixon, Jonathon Dicker, Muhammed Rahman

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3 Pacia 2011-12 National Plastics Recycling Survey

4 Qipeng Guo
Personal Chair (Chair Professor), Institute for Frontier Materials at Deakin University, in
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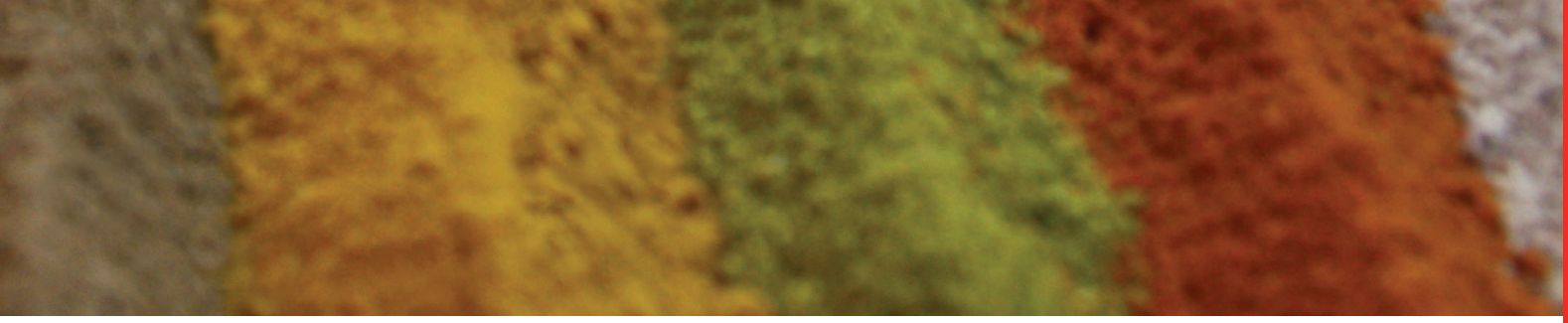

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