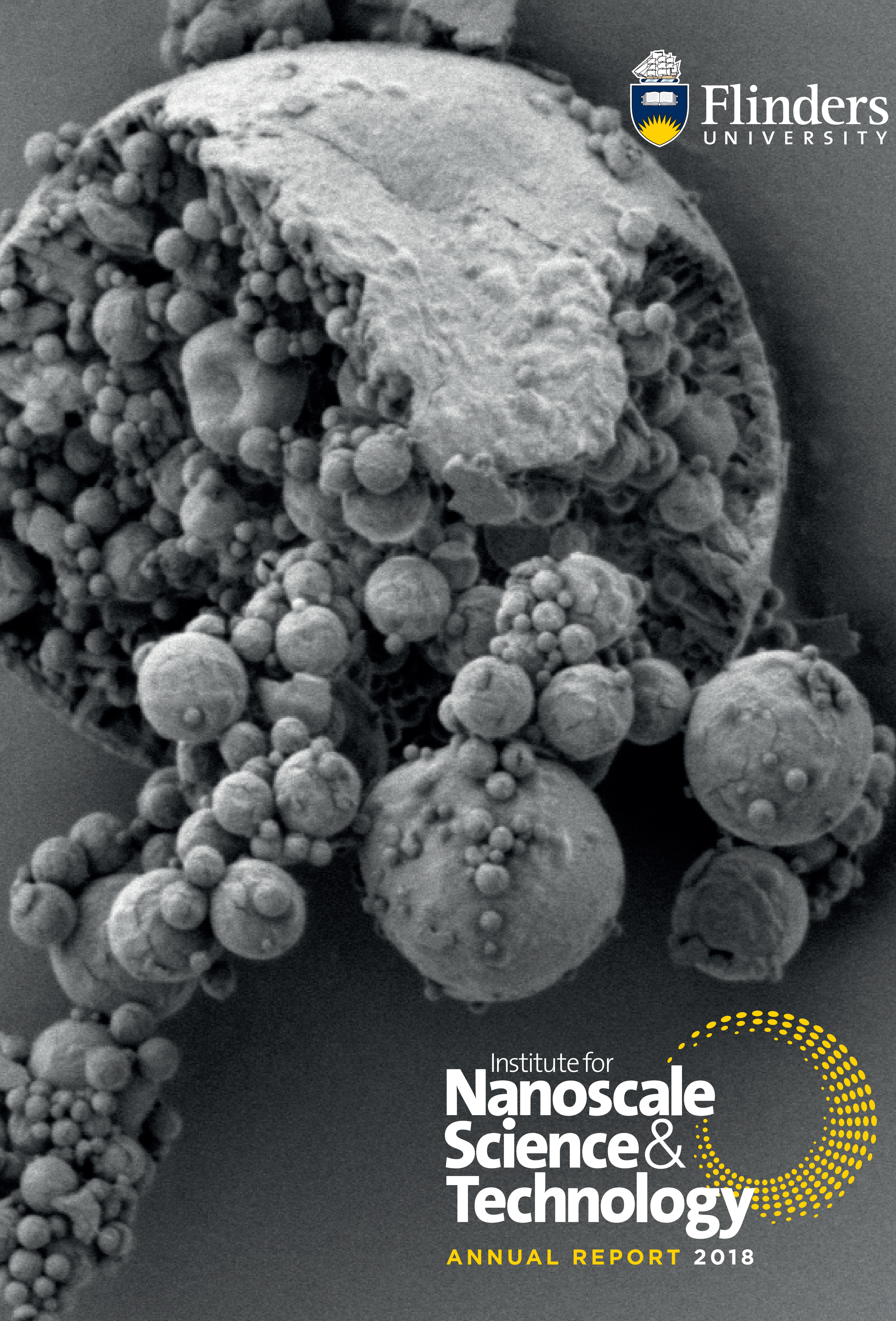


Flinders University

Institute for
Nanoscale Science & Technology

ANNUAL REPORT 2018

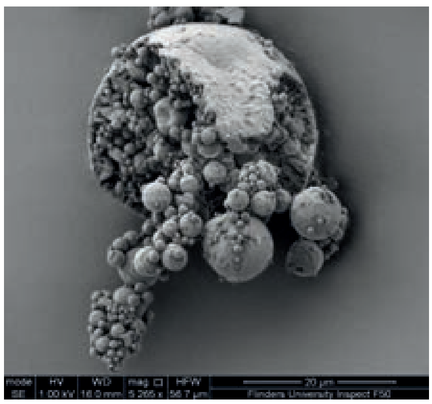
Cover Image:

2018 Scientific Image of the Year Winner

Grapes of Wrath

Captured by Dr Daniel Mangos and Dr Arthur Provatas (DST Group)

This is an electron microscopy image of an aggregate of coated particles being encapsulated by an exterior shell of what is believed to be the coating agent. This material is being developed for 3D printing applications.



INSTITUTE FOR NANOSCALE SCIENCE + TECHNOLOGY
ANNUAL REPORT 2018

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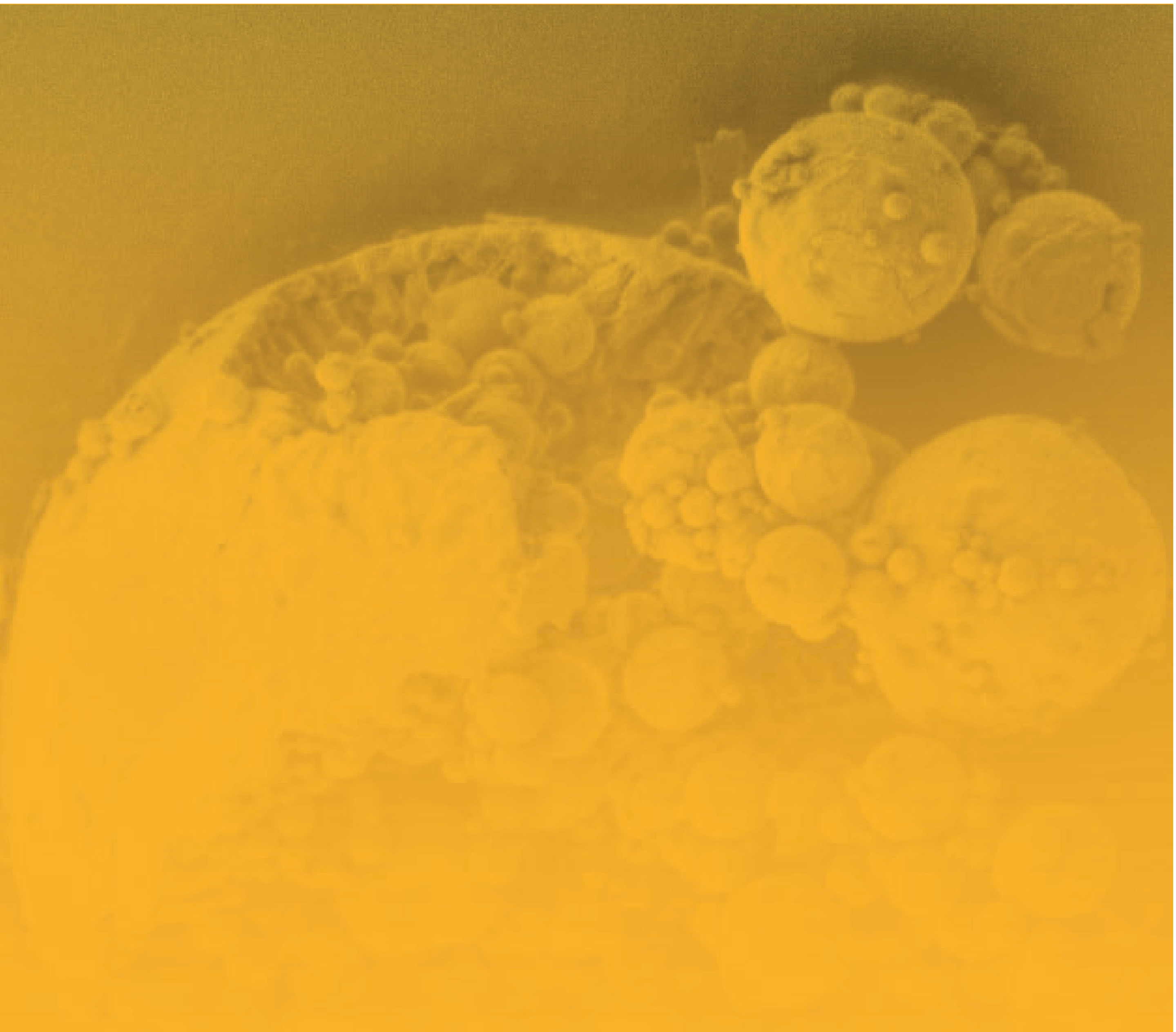


The Institute for Nanoscale Science and Technology houses over 130 researchers, with research broadly focused on the areas of energy, security, bio-nano and the environment.

DIRECTOR'S REPORT

2018 has been a big year for us, not the least of which is our elevation to an Institute – now the Flinders Institute for Nanoscale Science and Technology. We have grown in size and impact since our formation as a University Centre in 2010 and the status change is recognition of the quality and hard work of our Research Leaders, Early Career Researchers (ECR) and students over the past seven years.

To mark the milestone, we have changed the design of our Annual Report and in keeping with our continued focus on ECR, this year's cover is the result of a competition for the "most interesting" scientific image recorded through the year. This theme will continue in future years. I invite you to look out for a special issue of the journal Polymers that is dedicated to the change, focusing on one aspect of our research, "Nanotechnology of Polymers and Biomaterials", with contributions from current and former members, partners in other universities and friends of the Institute.

The quality of the Institute's outputs have made a major contribution to Flinders achieving the highest possible ranking of 5 ("Well above world average") in the areas of Nanotechnology, Condensed Matter Physics, Physical Chemistry, and Materials Engineering in the 2018 Excellence in Research Australia (ERA) assessment. While not contributing to this assessment, in 2018 50% of our publications were in the top 10% of journals in their field, with 80% being in journals ranked in the first quartile.

The year began with the regular National Institute for Materials Science (NIMS) "Summer School" in Tsukuba in January – not quite summer in Japan, but that didn't dampen the enthusiasm. As always, the aim was to put students out of their comfort zones and speciality as they work in multinational teams (from the Czech Republic, China, India, Japan, New Zealand, South Korea, Turkey, the USA, and Vietnam) to address a challenge, which this year was "to plan for the aftermath of a large asteroid strike". We had the traditional Summer school BBQ in the quad of Ninomiya house in -10°C weather, but it didn't really seem to bother anyone (except perhaps the other residents with noise, which also continues a tradition...).

At the end of the year, through the leadership of Sarah Harmer, the Flinders Microscopy and Microanalysis Facility was established, bringing together all of the major surface characterisation and microscopy capabilities.
This formalisation provides a clear front door for research and industry partners to access some of the very special and unique equipment that we have acquired over the course of more than a decade.

We have had many highlights this year, but I would like to single out three for special mention:

- Colin Raston was elected to the Australian Academy of Science
- Youhong Tang was elected a Fellow of the Royal Society of Chemistry
- Justin Chalker has continued his high profile, named an AMP Tomorrow Marker, the 2018 South Australian STEM Educator of the Year - Tertiary, and gaining media exposure for his research on sulfur-based polymers

I would like to offer a very special thank-you to Prof Jagadish Chennupati and Dr Rob Robinson as they retire from the Advisory Board. Both have been with us since the inception of the Advisory Board and their passion and support has certainly been appreciated and on a more personal level, I would particularly like to acknowledge their support and guidance to me. Jagadish was the founding Chair of the Advisory Board and he will be succeeded by Prof Paul Mulvaney from the University of Melbourne in this role.

Penny Crocker left us in February for personal reasons, so we have been without an Executive Officer for most of the year. By the time that you read this, Dr Mary Rieger, formerly with the SA Government will have started in the position. Nathan O'Brien has picked up a lot of the functions of this role as well as his own responsibilities over the past year, in a stand-out performance. I hope you enjoy exploring our highlights and research from 2018 with a view that all indications are that 2019 will be another big year for us,

David Lewis
Director

ADVISORY BOARD

The Institute Advisory Board consists of renowned professors and industry experts. The board meet once a year to review, advise and guide the institute's activities.

Professor Chennupati Jagadish
Chair of the Board

Distinguished Professor at the Australian National University and Convenor of the Australian Nanotechnology Network.

Professor Don Bursill

Water Industry expert and Former Chief Scientist for South Australia.

Professor Paul Mulvaney

Nanotechnology leader based at Bio21, University of Melbourne.

Mr Len Piro

Former Executive Director at the Department of State Development, South Australia.

Dr Robert Robinson

Former head of the Bragg Institute at the Australian Nuclear Science and Technology Organisation (ANSTO).

Professor Kohei Uosaki

Director of Global Research Centre for Environment and Energy based on Nanomaterials (GREEN) at National Institute for Materials Science, Japan.

Professor Robert Saint

Deputy Vice Chancellor (Research) Flinders University and expert in genetics.

Dr Greg Simpson

Deputy Chief of Industry Commonwealth Scientific and Industrial Research Organisation (CSIRO).

INSTITUTE MEMBERS

RESEARCH LEADERS
Professor Gunther Andersson
Professor Mats Andersson
Dr Justin Chalker
A/Professor Sarah Harmer
A/Professor Martin Johnston
A/Professor Ingo Köper
Professor David Lewis
Professor Jim Mitchell
Professor Jamie Quinton
Professor Colin Raston
Professor Joe Shapter
A/Professor Youhong Tang

RESEARCH STAFF
Dr Muneer Ahamed
Dr Munkhbayar Batmunkh
Dr Andrew Blok
Dr Jonathon Campbell
Dr Ashley Connolly
Dr Kendall Corbin
Dr Sait Elmas
Dr Louisa Esdaile
Dr Chris Gibson
Dr Wei Han
Dr Mahnaz Dadkhah Jazi
Dr Martyn Jevric
Dr Darryl Jones
Dr Daniel Mangos
Dr Muneer Syed
Mushakahmed
Dr Rebecca Norman
Dr Christiaan Ridings
Dr Raihan Rumman
Dr Anirudh Sharma
Dr Cameron Shearer
Dr Javad Tavakoli
Dr Stephen Trewartha
Dr Kasturi Vimalanathan

PHD STUDENTS
Ahmed Hussein Al-Antaki
Lisa Alcock
Thaar Alharbi
Firas Andari
Jakob Andersson
Abdulaziz Sadagah R Bati
Munkhjargal Bat-Erdene
Jonas Mattiasson Bjuggren
Belinda Bleeze
Liam Brownlie
Jessica Carlson-Jones
Benjamin Chambers
Alex Corletto
Emily Crawley
Jesse Daughtry
Bradley Donnelly
David Doughty
Liam Howard-Fabretto
Renzo Fenati
Jody Fisher
Melanie Fuller
Joshua Gethardt
Tom Grace
Adrian Hardy
David Harvey
Christopher Hassam
Zhen He
Nikita Joseph
Emma Kent
Mohammad Khorsand
Guler Kocak
Sian La Vars
Nicholas Lundquist
Xuan Luo
Oskar Majewski
Todd Markham
Jake Marshall
Stefan Martino
Rowan McDonough
Petri Murto
Muthuraman Namasivayam
Xun (Caroline) Pan
Kimberley Patterson
Zoe Pettifer
Jessica Phillips
Scott Pye
Connor Retallick
Nahideh Salehifar
Yuya Samura
Natalya Schmerl
Kym Scroggie
Altaf Shamsaldeen
Alexander Sibley
Jonathon Sierke
Ruby Sims
Gaurav Singhai
Eko Kornelius Sitepu
Tim Solheim
Jordan Spangler
Kaili Stacey
Daniel Suhendro
Jade Taylor
Herri Trilaksana
James Tsoukalas
Michael Wilson
Max Worthington
Yanting Yin

MASTERS STUDENTS
Tarfah Abudiyah
Sunita Guatam Adhikari
Bedia Al Harbi
Salah Fadhall K Alboaiji
Mai Alharbi
Amal Alsaedi
Ibrahim Khalaf M Alsulami
Angela Christian
Yu Han
Tao Peng
Jinjian Wu
Xinyi Zhang

HONOURS STUDENTS
Amira Alghamdi
Ahlam Alharbi
Abdulrahman Alotabi
Nikhil Bechoo
Clarence Chuah
Elliot Jew
Kudzai Kamanya
Gowri Krishnan
Renata Kucera
Esther Laisak
Samuel Pater
Jasmine Wiese

AFFILIATED RESEARCHERS
Schannon Hamence
Dr Lihe Mao, Visiting Scholar
Cheylan McKinley
A/Professor Weixin Ou
Yonghua Jiang
Tran Tam Anh Pham
A/Professor Hong Wang, Visiting Scholar
Dr Jing Wang, Visiting Scholar
Leping Yu

2018 HIGHLIGHTS

Dr Justin Chalker had another busy year, he was named an AMP Tomorrow Maker and the 2018 South Australian STEM Educator of the Year – Tertiary. Justin also won the ChemSocReview Emerging Investigator Award and the Organic and Biomolecular Chemistry New Talent Award, was named a Finalist for the Eureka Prize Outstanding Early Career Researcher and had his research featured in news articles around Australia and the world.

We teamed up with Flinders University's Design & Technology Innovation teaching team, giving first year Design Communication (DSGN1102) students the task of pitching a new trophy to be used at the Institute's Annual Conference. The winning design was pitched by Matthew Maher, with a design that included innovative applications of common nanotechnology imagery. The trophy is evocative of a scanning tunnelling microscope, capped with a C60 buckyball.

PhD Candidate Liam Howard-Fabretto was a finalist in the 2018 Flinders University 3 Minute Thesis Competition

Following the establishment of new agreements between Flinders University and Centrale Nante, researchers from the Institute will join Ecole Centrale Nantes' world-leading researchers on projects focused on two key themes of additive manufacturing, and Naval hydrodynamics. One focus of the collaboration involves marine propellers and will investigate the use of nano-composite technologies for manufacturing marine propellers to increase blade strength and reduce noise and corrosion, as well as reducing manufacturing costs associated with existing metal fabrication technologies. The project will develop experimental models to explore the feasibility of manufacturing "smart" composites with embedded sensors to monitor performance and assure structural integrity.

PhD candidate Melanie Fuller and Professor Colin Raston attended the 2018 Science Meets Parliament gathering, an opportunity for top scientists from around Australia to meet politicians and to promote STEM and the valuable role it plays in politics and society.

Dr Raihan Rumman was awarded the Best Presentation at the 15th International Symposium on Novel and Nano Materials in Lisbon, Portugal.

Professor Colin Raston was elected as a Fellow of the Australian Academy of Science.

Thaar Alharbi and Yanting Yin were winners of Best HDR Publication Awards for Science and Engineering at Flinders, with the Institute taking out both awards on offer.

Institute alum Dr Ben Flavel has been admitted to the German Research Foundation's prestigious Heisenberg Program.

PhD candidate Lisa Alcock was one of the six Australian delegates who attended the 10th HOPE Meeting with Nobel Laureates, held in Yokohama, Japan.

A new International Laboratory for Health Technologies was launched in 2018, with our very own A/Prof Youhong Tang as the Australian Deputy Director.

Dr Justin Chalker completed a whirlwind tour of Tasmania, visiting ten high school visits across 5 days for the Royal Australian Chemical Institute's Tasmanian Youth Lecture Tour.

The Institute once again had a strong presence at the International Conference on Nanoscience and Nanotechnology, with our contingent of PhD students and postdoctoral researchers descending on Wollongong to present their work at ICONN 2018.

2018 HIGHLIGHTS

2018 HIGHLIGHTS

The Biofilm Research and Innovation Consortium has been formed under the leadership of Associate Professor Sophie Leterme – a long-time collaborator of the Institute – bringing together expertise in surface science, microbiology, biological oceanography, and health in order to control and prevent the formation of biofilms on surfaces. Institute researchers will play an active role in the Consortium as we seek to tackle problems facing the health, mining, water and food industries. For more information please contact: biofilm@flinders.edu.au

In September 2018 the Institute supported the Soft X-ray Microscopy Masterclass, also supported by Microscopy Australia and held at the Australian Synchrotron in Clayton, Victoria. The two-day program included presentations on techniques and applications, and workshops on data collection and processing, presented by experts within Australia and from Canada and Europe. The masterclass was well attended by academics, ECRs and students from a strong emerging soft X-ray community.

Running as part of Biophysics Week for 2018, the Institute hosted a workshop on "Membranes and Health". Invited speakers from around Australia and New Zealand presented across a range of topics to guests from both inside and outside Flinders University. The presentations nicely complemented each other, each looking at the lipid membrane from a slightly different perspective.

2018 HAS BEEN ANOTHER SUCCESSFUL YEAR FOR PhD COMPLETIONS WITH FIFTEEN STUDENTS AWARDED THEIR PhD

PhD – SHAYMAA AKRAA
SUPERVISOR: H SHEN, Y TANG, G LEE, J LI
"Using a Smartphone for Point-of-Care Urinalysis of Chronic Kidney Disease"

PhD- JAKOB ANDERSSON
SUPERVISORS: I KÖPER & M PERKINS
"Mimicking Microbial Membranes"

PhD – BENJAMIN CHAMBERS
SUPERVISOR: G ANDERSSON & J QUINTON
"Spectroscopic Studies of 2D Nanomaterials"

PhD - GENEVIEVE DENNISON
SUPERVISOR: M JOHNSTON, P KIRKBRIDE, C RASTON
"A Lanthanide based multifunctional supramolecular system for the detection and decontamination of Organophosphorus chemical warfare agents"

PhD – WEI HAN
SUPERVISOR: Y TANG & D LEWIS
"Nanoparticles enhanced fibre-reinforced polymer composites used in marine environment"

MSC/SERP – GOWRI KRISHNAN
SUPERVISOR: G ANDERSSON & J SHAPTER
"Investigation of Ligand Protected Gold Clusters on Defect Rich ALD Titania using Electron Spectroscopies"

PhD - SIAN LA VARS
SUPERVISOR: S HARMER & J QUINTON
"The impact of microorganisms on the surface of pyrite: Implications for bioflotation"

PhD – XUN PAN
SUPERVISOR: M ANDERSSON & D LEWIS
"Green Solvent Processable Conjugated Polymers for Organic Photovoltaics"

PhD - KIMBERELY PATTERSON
SUPERVISOR: I KÖPER & CLAIRE LENEHAN
"Stability of Ampicillin Sodium"

PhD – NATALYA SCHMERL
SUPERVISOR: G ANDERSSON & J QUINTON
"An Electron and Ion Scattering Spectroscopic Study of Interfaces for Organic Photovoltaic Applications"

PhD – TAMSYNE SMITH-HARDING
SUPERVISOR: J MITCHELL, K SOOLE & J BEARDALL
"The Role of the Silica Frustule in Diatom Carbon Acquisition and Photosynthesis"

PhD – DANIEL SUHENDRO
SUPERVISOR: I KÖPER & J SHAPTER
"Model membranes for drug-membrane interaction studies"

PhD – HERRI TRILAKSANA
SUPERVISOR: G ANDERSSON & D LEWIS
"Analysis of the Dye/Titania Interface as Photo-Anode in Dye Sensitized Solar Cells"

PhD – CAXIA WANG
SUPERVISORS: J MITCHELL & S LETERME
"Cotutelle: Microbial Distribution and Community Composition of the Bohai Sea in the North of China"

PhD – LEPING YU
SUPERVISOR: J SHAPTER & D LEWIS
"Carbon Nanotube-based Solar Cells"

EIGHTH ANNUAL CONFERENCE

Our 8th Annual Conference was held at Flinders University's Tonsley Campus on June 14. At the conference, Professor Robert Saint, Deputy Vice-Chancellor (Research), made the announcement of our new name as the Flinders Institute for Nanoscale Science and Technology. This came on the back of an incredibly successful year for nanotechnology research within the Flinders Centre for Nanoscale Science and Technology. The conference was an exciting day, also including the signing of a new MOU for international collaboration. Invited speakers included Stefan Harrer from IBM Research who spoke on "From Wearables to THINKables: Artificial Intelligence in Healthcare and Life Sciences Research", and Leo DeYong from DST Group who spoke on "Research Challenges and Opportunities in Defence".

"This is a very exciting time for us and the elevation to Institute status reflects the performance and breadth of collaborations and partnerships across academia and industry." said Professor David Lewis, Director of the Institute.

"The MOU with the Green Research Centre in the National Institute for Materials Science in Japan that was signed today is another example of our high regard within international organisations."

In addition to keynote presentations and MOU signings, the delegates discussed ideas on how (and when) to best communicate their research, hearing from Dr. Lisa Bailey from Australia's Science Channel, and heard about opportunities in groundwater research from the 2015 South Australian Scientist of the Year, Professor Craig Simmons. A poster session ended the day, giving invited guests the chance to explore some of the cutting-edge nanotechnology research happening within the Institute. Professor David Lewis closed the conference by announcing PhD candidate Belinda Bleeze as the winner of the 2018 Best Poster Award. This award includes up to $300 towards the costs of attending an external conference and will help Belinda to present her research to the wider scientific community.

WORKSHOP ON EMERGING NANOSCIENCE AND NANOTECHNOLOGY AT NIMS IN JAPAN

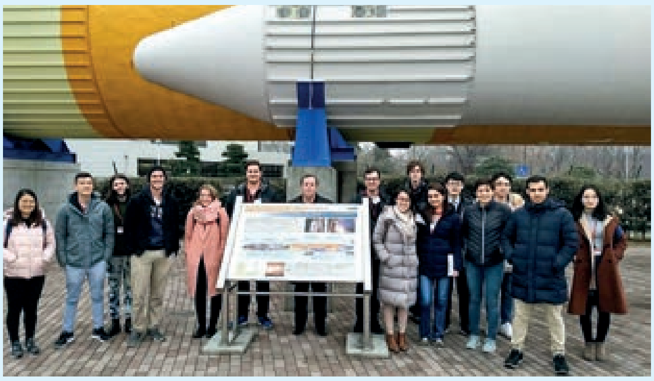
In January 2018 I and fellow Flinders students Liam Brownlie and Guler Kocak travelled to the National Institute for Materials Science (NIMS) in Tsukuba, Japan, to attend their Workshop on Emerging Nanoscience and Nanotechnology. This week-long workshop included nanotechnology PhD students from universities all over the world, with a number of different cultures and language backgrounds.

The aim of the workshop was to work as a group to perform an in-depth analysis on what would happen if a meteorite hit the Earth before presenting a detailed plan to the government on how to prepare for the strike, and the best plan for survival after the strike. This promoted collaborations and teamwork between people from different backgrounds who had never previously met, which is a crucial for being a researcher in the modern international age. This was also an excellent opportunity for me to learn about Japanese culture.

As part of the workshop we were also taken on a tour of the JAXA Tsukuba Space Centre, where they had replicas of satellites and other space equipment as well as a retired rocket which had previously been to space. Another great part of the trip was sampling all the local Japanese food, including a traditional sit-down sushi lunch in Tsukuba. This lunch was very adventurous for me as I am typically vegetarian so raw fish was a step out of my comfort zone, but worth it to try the traditional dish while I was in Japan.

After the workshop in Tsukuba finished, a number of us took the hour-long train ride to Tokyo to spend some extra time there. It was the dead of winter and we ended up experiencing the snowiest day in Tokyo for 4 years, which was fantastic as it was the first time I had ever seen snow! Throughout the workshop and while travelling afterwards we built international relationships on both a personal and professional level, a testament to the benefits of workshops and opportunities such as these.

LIAM HOWARD-FABRETTO
3RD YEAR PHD CANDIDATE, G. ANDERSSON GROUP

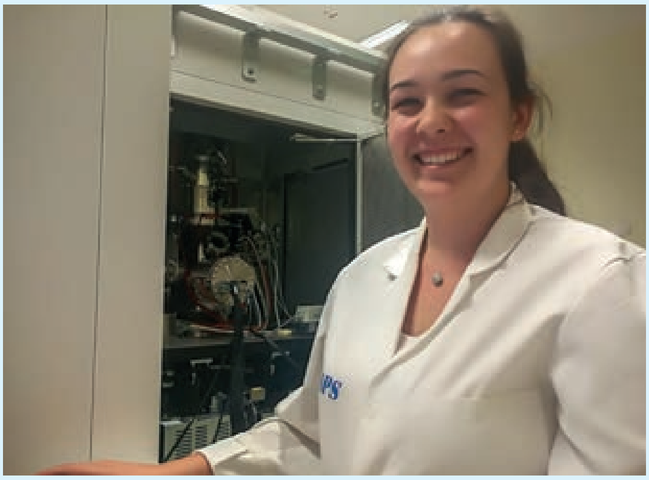


CAMBRIDGE EXPERIENCE

For the past 12 months, I have been conducting research as part of my PhD at the University of Cambridge, Department of Chemistry, in Dr. Gonçalo Bernardes' group. I was awarded an Australian Postgraduate Scholarship as part of the Australian Government's Endeavour Leadership Program, which allows recipients to undertake research at an overseas institution of their choice for up to 12 months.

My PhD research is looking at designing new chemical tools that can be used to detect biomarkers of oxidative stress for studying disease pathways in cells. For the first part of my PhD at Flinders, we designed and synthesised a new chemical tool capable of detecting the cysteine sulfenic acid biomarker, and validated its reactivity on small molecule and protein models. With the Endeavour funding, we have been exploring the biological aspect of my project at Cambridge by testing my chemical tools on proteins and living cells. We have successfully detected the cysteine sulfenic acid biomarker in living cells and are currently exploring the application of my chemical tool to study oxidative stress related diseases in cancer cells.

LISA ALCOCK
3RD YEAR PHD CANDIDATE, CHALKER GROUP



SUMMER SCHOLARSHIP

As a recipient of the Nanoscale Summer Research Scholarship I had the opportunity to gain laboratory experience under Research Leader Associate Professor Sarah Harmer for a period of 8 weeks over the summer.

My role was to assist PhD candidate Zoe in her efforts to study and characterise the surface chemistry of minerals, including Pyrrhotite and Pentlandite. Understanding of mineral surface chemistry is necessary to formulate potential attachment mechanisms for Biomolecules in order to develop an environmentally friendly alternative to existing mineral separation techniques.

Any hesitation I had throughout my first week was soon swept away, and I was quickly accepted by Zoe and fellow PhD candidates Belinda and Connor as a member of The Microbe Factory lab group. Throughout my 8 weeks, I partook in a variety of tasks such as re-culturing bacteria, synthesising minerals, XRD and FTIR analysis of mineral samples and learning valuable research skills that will benefit me in future studies.

The highlights of my time were the off-campus days at Adelaide Microscopy using the SEM, and days at the Mawson Lakes campus at UniSA using the monochromatic XPS. These experiences allowed me to undertake sample preparation processes, observe the use of and operate high performance scientific instruments, and get involved with physics based research through the collection and interpretation of data about mineral composition.

I would like to issue my sincerest gratitude to Sarah for giving me this wonderful opportunity, as well as my deepest thanks to Zoe, Belinda and Connor for allowing me to experience research based physics in a fantastic welcoming environment, for sharing their research experiences and for teaching me a wide variety of techniques I will be able to apply in my future endeavours.

To those that are on the fence about applying for scholarships, in particular with the Institute for Nanoscale Science and Technology, don't miss out on the opportunity. This scholarship has been the most exciting and profoundly beneficial experience of my young scientific career and will be beneficial to anyone else who applies.

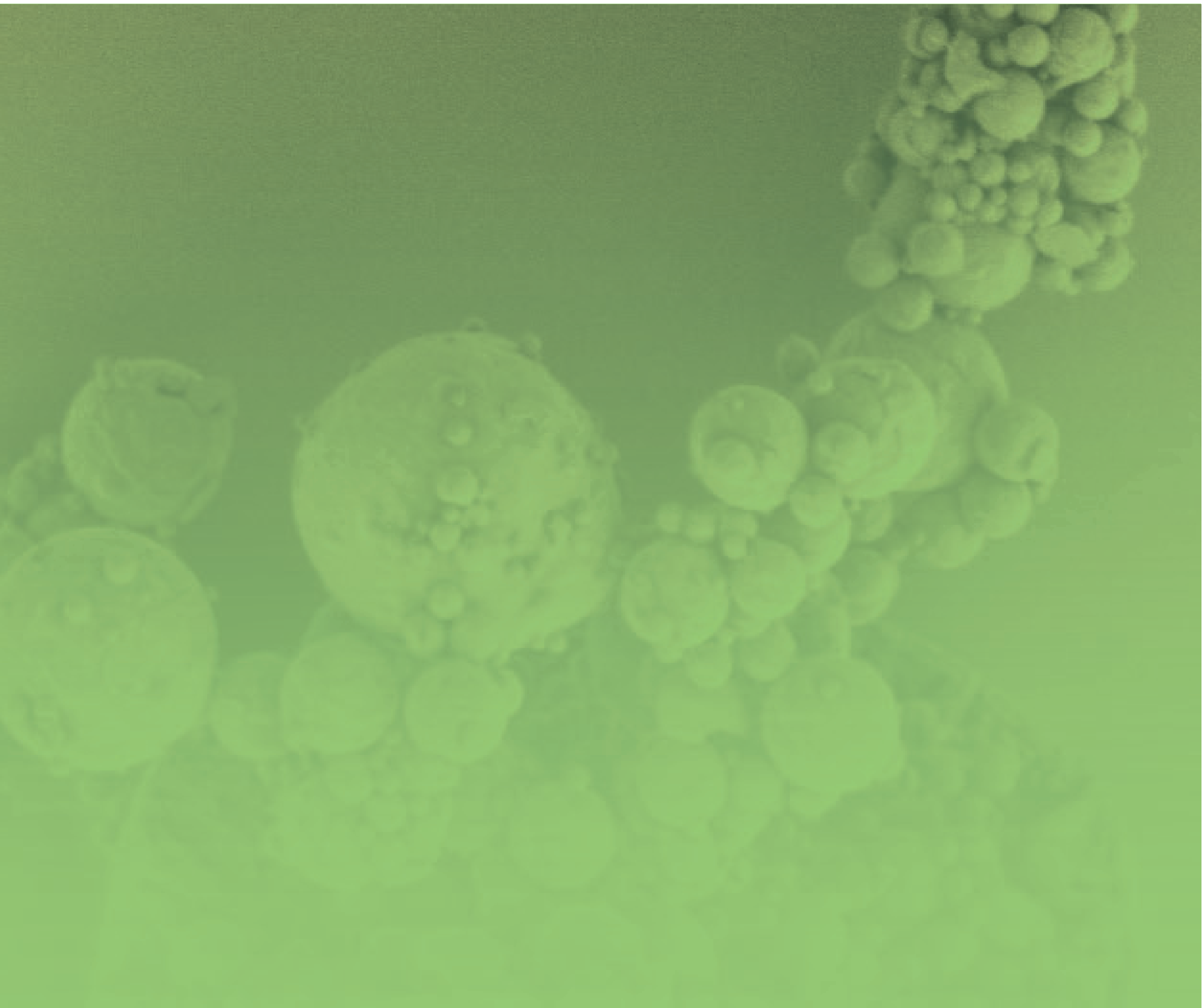
BY ALEX HAYES
2ND YEAR UNDERGRADUATE STUDENT

As was a recipient of the 2017/2018 Nanoscale Summer Research Scholarship, I have worked in Professor Jamie Quinton's research group during the 2017/2018 summer break. My role has been to observe and assist Jasmine Wiese on her Honours project. This project was focused around developing a thin-layer anti-microbial coating on magnesium to increase its durability and resistance to corrosion.
Through working with Jasmine I've helped her prepare samples, assisted her in the lab, and learnt about previously foreign analytical techniques such as Auger Electron Spectroscopy and XPS – from the science that makes them work to the data analysis of the samples. Over this time, I have been able to experience science and research in a way that has not been possible in my undergraduate studies so far. It has allowed me to connect and apply physical and chemical concepts to real world applications in ways that I didn't consider previously; as well as experience the realities of research.

While there have been challenges and times when things may not work in the way we want them to, this has allowed me to begin developing the skills required to adapt and deal with such challenges as they arise. Once the challenges were sufficiently resolved, we were able to obtain multiple XPS spectra of the samples we had previously prepared in the lab. This was to confirm the presence of a thin-layer film through survey and high resolution scans.

I'd like to offer my thanks to the Flinders Institute for Nanoscale Science and Technology for offering the opportunity, as well as Jamie and Jasmine for welcoming me into their group and allowing me to be as involved as I could and work with them over the past couple months. This has been an invaluable experience for me that has made me sure of what I hope to achieve in my future, both at university and after graduation. It is an experience that I would recommend to anyone who is considering a future in scientific research.

BY JAIMI ROSS
2ND YEAR UNDERGRADUATE STUDENT



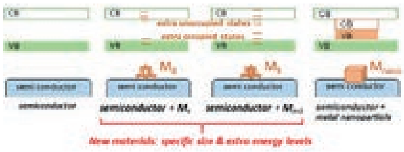
11 Research Leaders, with expertise spanning physics, chemistry biology and engineering.

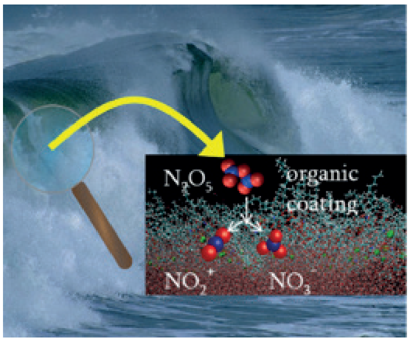
RESEARCH LEADERS

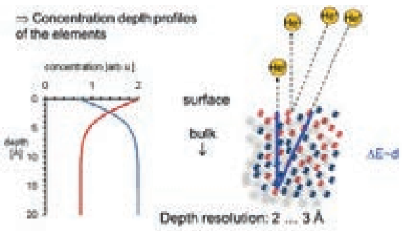
PROFESSOR GUNTHER ANDERSSON

Gunther Andersson's fields of research are surfaces and interfaces. His research activities are in clusters on surfaces, liquid surfaces and polymer interfaces.

His research group has developed methods and equipment for investigating surfaces from UHV conditions to liquid surfaces with finite vapour pressure. The latter capability allows analysing surfaces relevant for atmospheric research.







METAL CLUSTERS ON SURFACES

Metal clusters are objects on the nanoscale which consist of less than 100 atoms, are atomically precise and thus have specific size and shape. Metal clusters have unique properties that change with the type and number of atoms that form the cluster. Clusters also have discrete, individual electron energy levels, which i) differ from the levels in the constituting individual atoms and ii) depend on the number and type of atoms in the cluster. Metal cluster are ideal for modifying semiconductor surfaces.

Collaborations: Adelaide University, University of Utah (USA), University of Canterbury (NZ), Victoria University of Wellington (NZ), National Institute of material Science (Japan).

REACTIONS AT SURFACES OF SEASPRAY AEROSOLS

In collaboration with Prof Gilbert Nathanson from Madison, Wisconsin (USA), we are focussing on the role of aerosol particles formed over the ocean in altering global climate and coastal pollution as part of the Center for Aerosol Impacts on Chemistry of the Environment (CAICE). We are performing experiments to determine the precise interfacial composition of sea spray aerosols that in turn control key chemical reactions in the atmosphere. Determining the interfacial composition of sea spray aerosols is important for understanding the impact of aerosols on climate. Specifically it is important to analyse the composition of the surface of aerosols with atomic depth resolution.

HIGH RESOLUTION CONCENTRATION DEPTH PROFILES

We have recently upgraded our facility to measure concentration depth profiles with high depth resolution. The new instrument is capable to measure concentration depth profiles about 20 times faster than the previous facility with a depth resolution of a few Å close to the surface allowing to measure the layered polymer structure on the sub-nm scale.

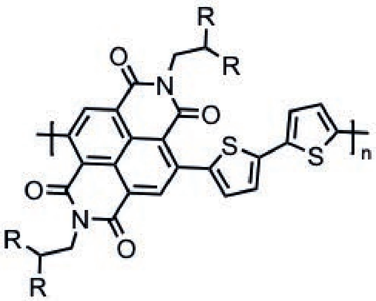
Examples for applying high resolution concentration depth are analysing interfaces in polymer electronics, corrosion at interfaces, liquid surfaces and nanoparticles on surfaces.

RESEARCH LEADERS

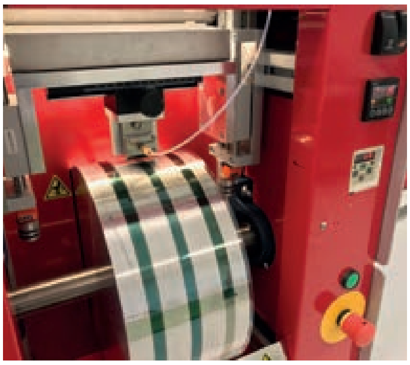
PROFESSOR MATS ANDERSSON

Prof Andersson joined Flinders University and the Institute in 2017, as a Matthew Flinders Fellow. Mats is also an affiliate professor at Chalmers University of Technology, Sweden, where he held a chair in Polymer Chemistry 2007 to 2015.

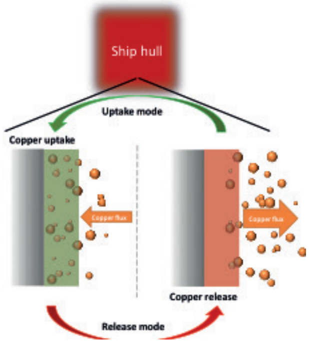
Prof Andersson's research interests include organic chemistry, polymer synthesis, structure – property relationships, conjugated materials, morphology characterisation, polymer nanoparticles, polymer electronics, polymer solar cells, polymers for insulation of high voltage cables, and antifouling coatings.



DESIGN AND SYNTHESIS OF CONJUGATED POLYMERS FOR SOLAR CELLS
The focus is on modifying and developing new electron acceptor polymers that can be used in all-polymer solar cells.



PRINTING POLYMER SOLAR CELLS ON FLEXIBLE SUBSTRATES
This project is focused on developing printing of polymer solar cells on flexible plastic substrates with a special emphasis on developing efficient solar cells using environmentally friendly fabrication processes.



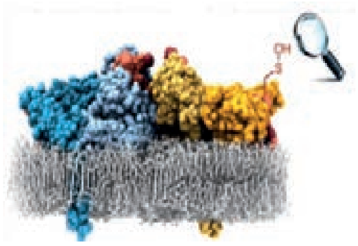
DEVELOPING ANTIFOULING COATINGS FOR SHIP HULLS
The idea is to find a solution for the controlled release and uptake of copper from the sea.

RESEARCH LEADERS

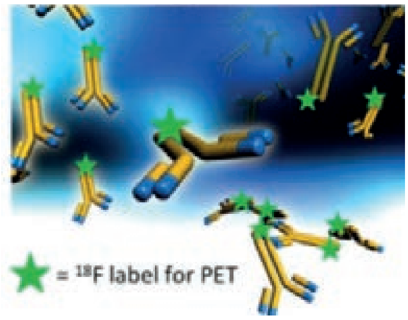
DR JUSTIN M. CHALKER

WWW.CHALKERLAB.COM

Dr Chalker joined the Institute in 2015, after spending several years as an assistant professor at The University of Tulsa where he established a diverse research program in organic chemistry, biochemistry and material science. In 2015, Justin moved to Flinders University as a Lecturer in Synthetic Chemistry and recipient of an ARC Discovery Early Career Researcher Award. In 2016, Justin was named Tall Poppy of the Year for South Australia in recognition of his achievements in research, teaching and science communication. In 2017, Justin was promoted to Senior Lecturer and in 2018 he was awarded the STEM Educator of the Year at the South Australia Science Awards. Justin's current research interests include organic chemistry, polymers, functional materials, sustainability, waste valorisation, environmental remediation, protein chemistry, chemical biology, sulfur chemistry, mercury, artisanal gold mining.

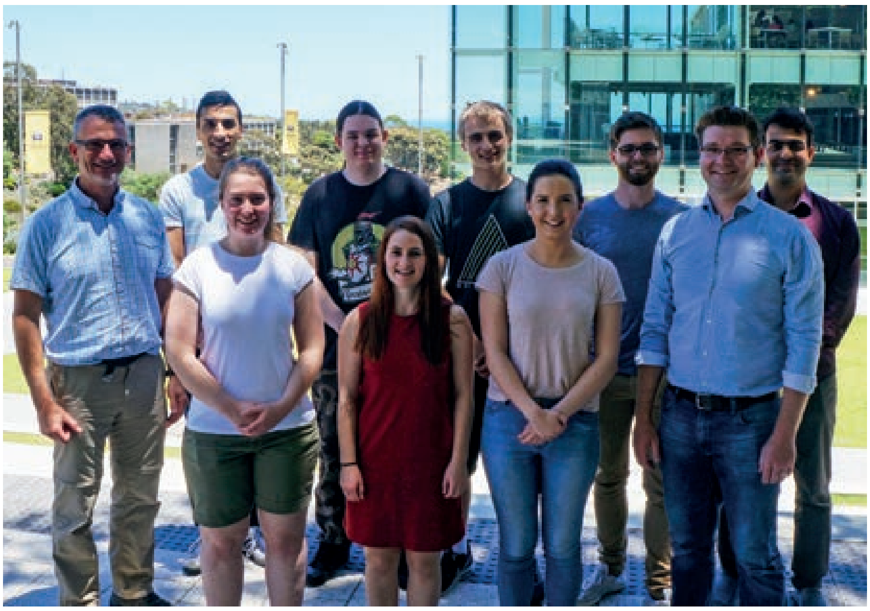


THE CHEMICAL BIOLOGY OF OXIDATIVE STRESS
Designing new tools to detect biomarkers for oxidative stress, aiming to build an understanding of how diseases develop in the body.



NEW TECHNOLOGY FOR MEDICAL IMAGING
Precisely labelling antibodies with a radioisotope, in order to enhance detection of cancer in its early stages.

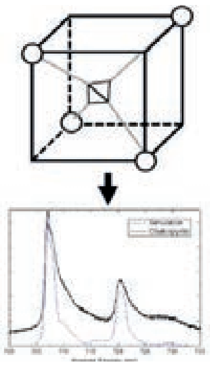
POLYMERS FOR MERCURY REMEDIATION
Using low cost and waste materials such as sulphur and plant oils to produce polymers which are able to capture mercury in the environment.



RESEARCH LEADERS

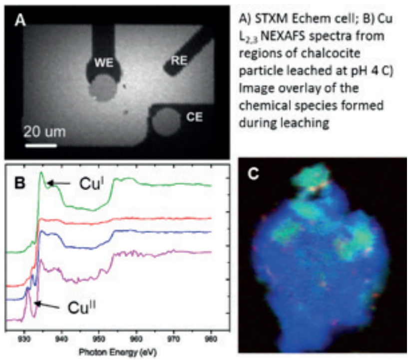
ASSOCIATE PROFESSOR SARAH HARMER

Associate Professor Harmer joined Flinders University in 2012 as an ARC Future Fellow. In 2018 she formed Flinders Microscopy and Microanalysis. Her research interests range from condensed matter physics, surface spectroscopy and bio-minerals processing. Her group collaborates with international institutions including University of Utrecht, McMaster University, University of Western Ontario, Canadian Light Source, Swiss Light Source, Norcada Inc. and BHP Billiton. Her research group has particular interest in the application and development of synchrotron microspectrocopic techniques for materials characterisation.



ELECTRONIC STRUCTURE OF 3D TRANSITION METAL COMPOUNDS

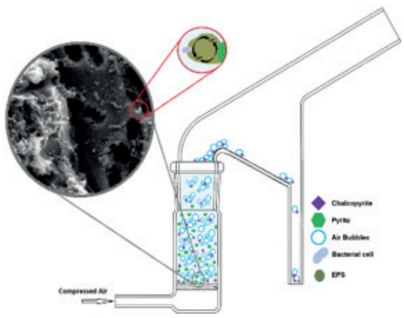
3D TM compounds are some of our most exploited materials for the extraction of metals, battery technologies and memory devices. Charge transfer MC-SCF calculations allows for the elucidation of their properties through spectral interpretation.



A) STXM Echem cell; B) Cu $L_{2,3}$ NEXAFS spectra from regions of chalcocite particle leached at pH 4 C) Image overlay of the chemical species formed during leaching

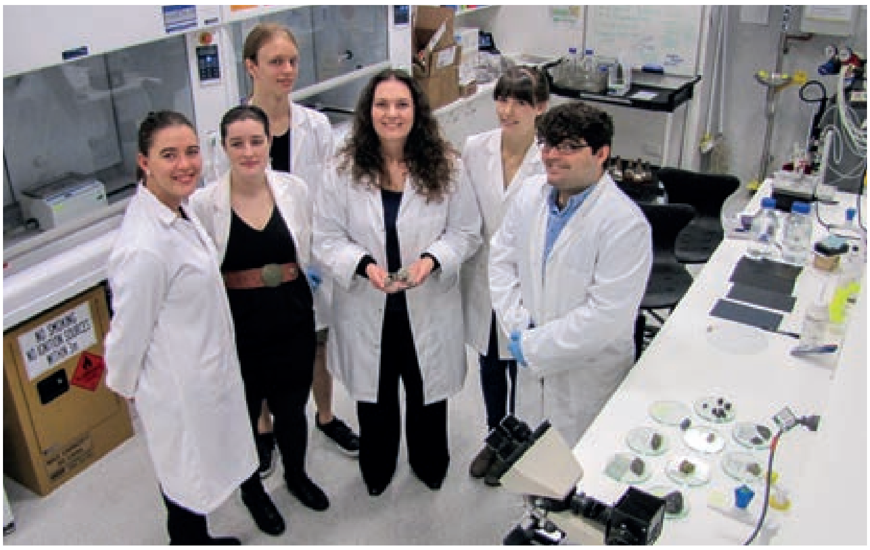
DEVELOPMENT OF IN SITU MICROSPECTROSCOPIC ANALYSIS OF MATERIALS

The prototype EChem enables high resolution spectroscopic imaging in hydrated and controlled electrochemical states. Example applications include structural analysis of dynamic microbial communities, and composition analysis of heterogeneous catalysts at the nanometer scale.



BIO-FLOTATION: A GREEN MINING PROCESS

The Harmer lab investigates the potential use of bio-flotation for the separation of sulphide ores using microbial metabolites extracted from bacteria naturally found at mine sites. The new technique promised to decrease the use of toxic chemicals as an economically viable, greener method for mineral separation.



RESEARCH LEADERS

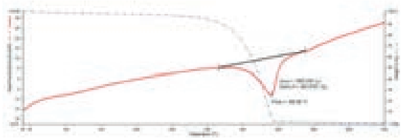
ASSOCIATE PROFESSOR MARTIN JOHNSTON

Martin is a supramolecular chemist who is interested in organic synthesis and spectroscopy. His current research interests are NMR spectroscopy, clandestine drug chemistry and organic countermeasure flares.

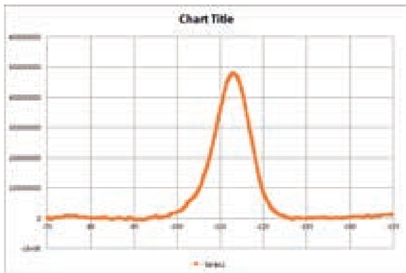
Martin has worked extensively in the defence field with the Defence Science and Technology Group (DST) in particular. Martin has worked with Forensic Science SA (FSSA) for many years investigating clandestine drug chemistry, forming collaborations with Drs Ben Painter, Paul Pigou, Peter Stockham and Clark Nash.

Martin also works collaboratively with CSIRO on a number of organic chemistry based projects.

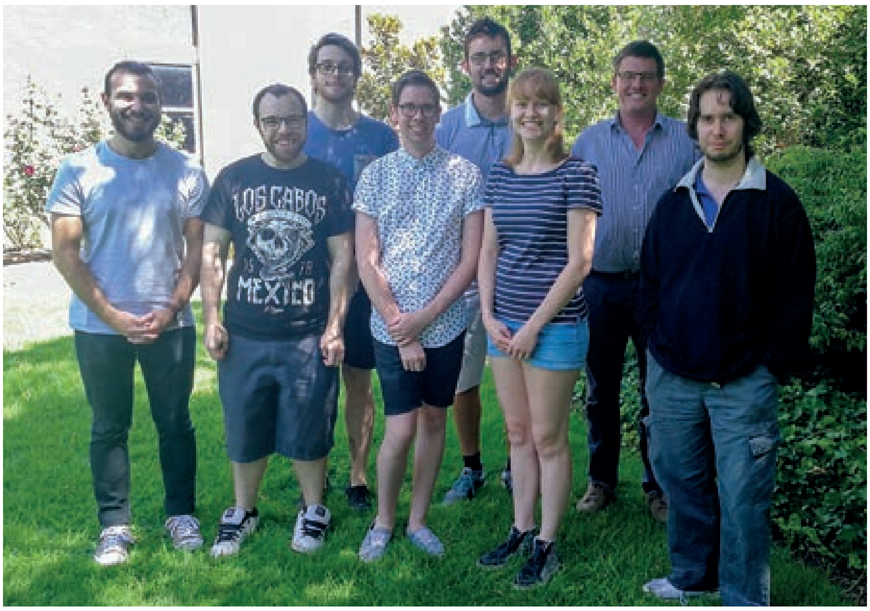
CLANDESTINE DRUG CHEMISTRY
Examination of novel chemistry used in clandestine drug laboratories.



SPECTRALLY MATCHED FLARES
Synthesis and testing of second generation organic fuels for use in spectrally matched flare formulations



OPAL CHARACTERISATION
Determining the chemical environment of silica within opal using solid state NMR.

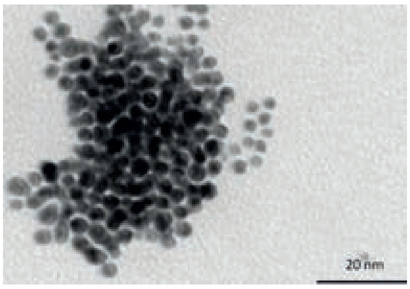


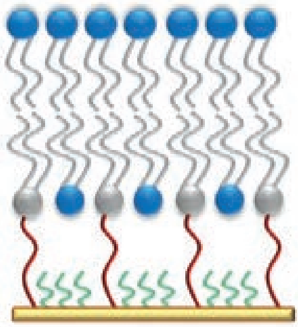
RESEARCH LEADERS

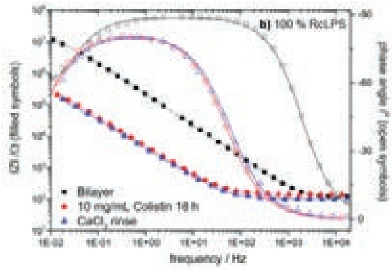
ASSOCIATE PROFESSOR INGO KÖPER

Ingo is a physical chemist and his research group focuses on biological aspects of nanotechnology.

His main interest is in the use and characterisation of model membrane systems, for example in biosensing application, but also to study drug-membrane interactions. Related research topics in Ingo's group are the synthesis and use of nanoparticles as drug-delivery vehicles. The main techniques used in his group are electrochemical impedance spectroscopy, surface plasmon resonance spectroscopy and neutron scattering.







NANOPARTICLE SYNTHESIS AND CHARACTERISATION
Using nanoparticles to deliver drugs.

MODEL MEMBRANE ARCHITECTURES
Design and characterise model platforms that mimic natural membranes.

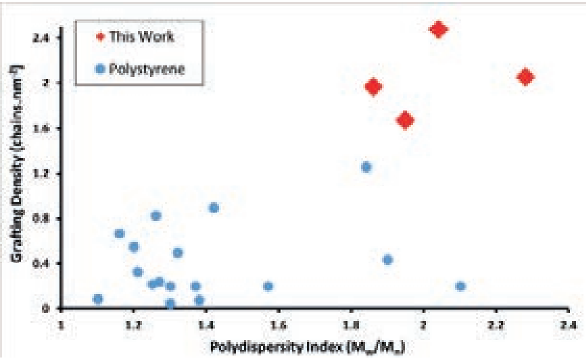
MEMBRANE-NANOPARTICLE-DRUG INTERACTIONS
Use model platforms to study membrane-related processess.

RESEARCH LEADERS

PROFESSOR DAVID LEWIS

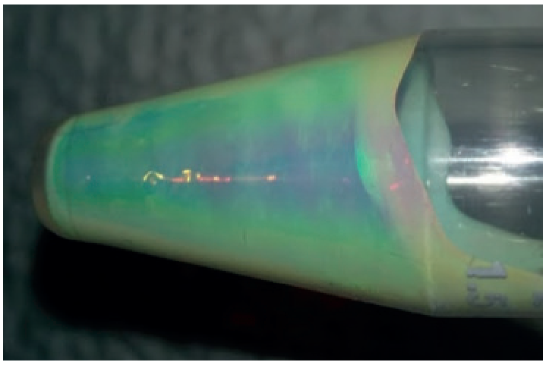
Professor David Lewis is the founding Director of the Flinders Centre for NanoScale Science and Technology.

Prof Lewis is a materials scientist with extensive experience in polymer chemistry through a career in both industry and academia, having held positions at IBM, SOLA Optical (now Carl Zeiss Vision) and CSIRO. His research areas include polymer electronics, functional particles and both fundamental aspects and applications of polymers including polymerisation mechanisms, morphology and grafting from surfaces.



FUNCTIONAL NANOPARTICLES

Exploring the properties of particles and surfaces with very high graft density polymer brushes attached to particles..



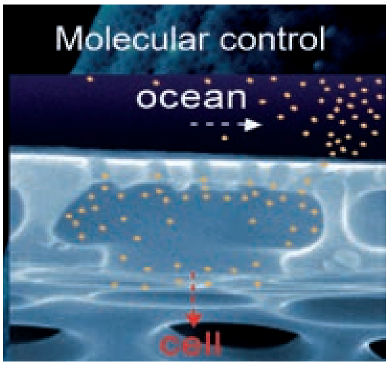
NANOFLUIDS

Exploring the properties of fluids with high loadings of very uniform particles can result in self assembled Photonic crystals.

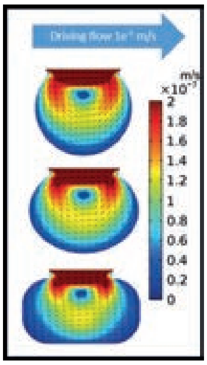
RESEARCH LEADERS

PROFESSOR JIM MITCHELL

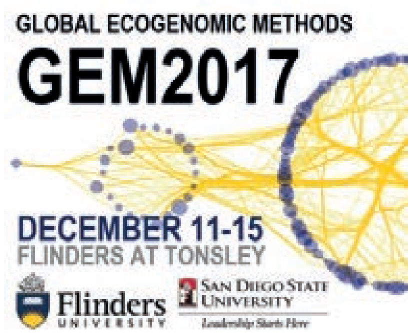
Prof Mitchell is the leading expert on small scale microbial processes with publications in Nature, Science and PNAS. He has given invited talks at the Masschusetts Institute of Technology, at Cambridge University and at the Gordon Research Conference on marine microbiology. He has collaborated with the University of Tokyo, MIT and the University of Chicago. His research group consists of 20+ people, including post doctoral fellows and scientific staff from all over the world. Research in his group focuses on the influences of nanometer to micrometer scale processes on microbial ecosystems. Research outcomes have been used in nanotechnology, including microfluidics and nanofabrication. As part of this research they investigate environmental viruses (>10^8/ml) and metagenomics.



THE INFLUENCE OF DIATOM NANOSTRUCTURES ON NUTRIENT DIFFUSION
We find that the submicrometre surface structures of diatoms control nutrient diffusion.



FEMTOLITRE CHAMBER FLOW
Micrometre scale surface geometry can create trapped micrometre scale fluid vortices.

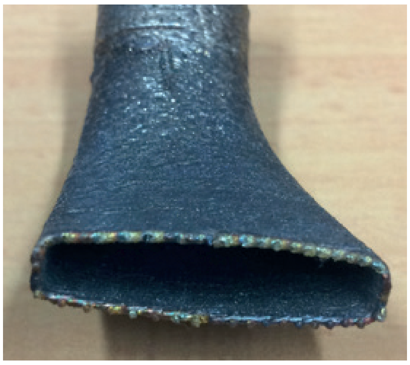


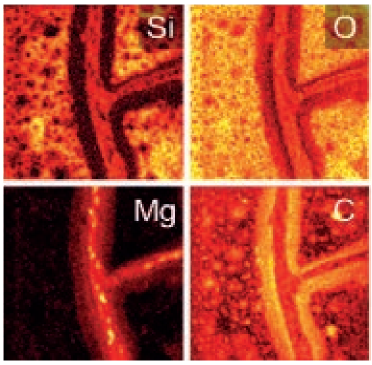
BIOINFORMATICS OF MICROENVIRONMENTS
A single microliter of environmental water can contain up to a million individual bacteria and hundreds of separate species carrying out distinct processes and interacting in unique ways.

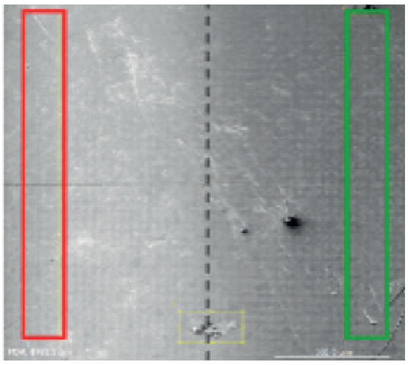
RESEARCH LEADERS

PROFESSOR JAMIE QUINTON

Jamie's research group seeks to understand the atomic and molecular mechanisms at surfaces and interfaces, in order to produce new improved technology enabling nanostructures. This includes interests in atomic and molecular surface nanostructures, surface modification, additive manufacturing materials, corrosion protection, applied surface science, and instrumentation development



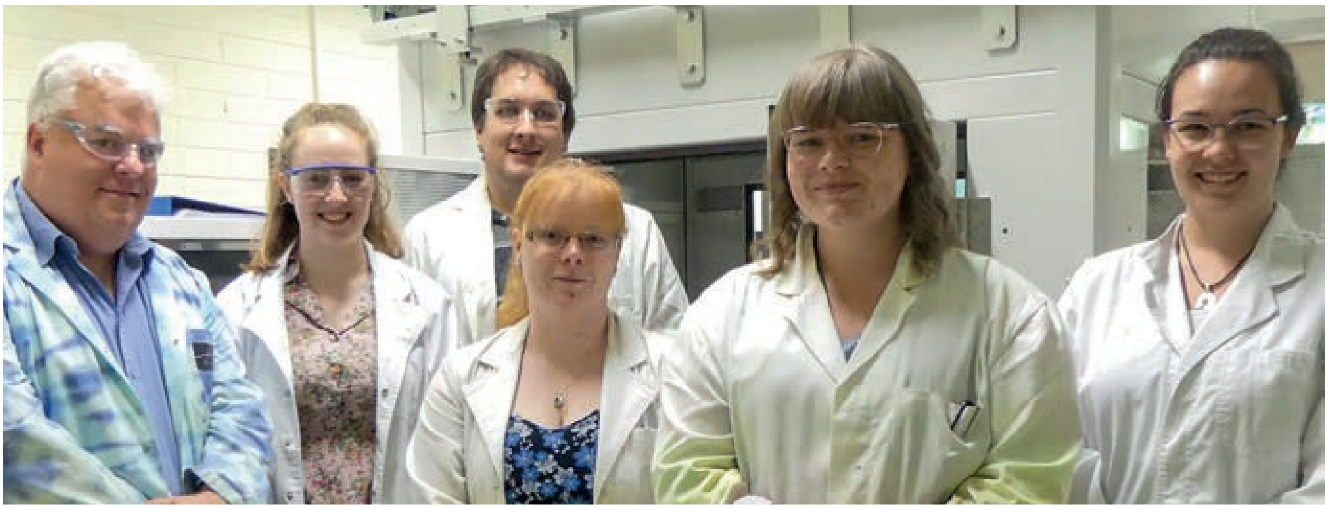




3D PRINTING OF METALS
The collaboration on 3D printing of metals with Prof Jean-Yves Hascoet, Director of the Joint Laboratory of Marine Technology for Additive Manufacturing at Ecole Centrale Nantes in France has continued in 2018. The facility is co-funded by Naval Group, France's key naval defence and maritime who will be building Australia's $50B submarines. Dr Raihan Rumman joined the institute in 2018 to work on this project.

PLASMA SURFACE MODIFICATION FOR CORROSION PROTECTION
Research has continued in the PhD projects of Alex Sibley and Ruby Sims on the development of environmentally benign anti-corrosion coatings on the surfaces of magnesium and aluminium, which are being increasingly used for weight reduced structural materials in industrial applications ranging from automotive to aerospace components.

CHARACTERISATION OF CARBON NANOMATERIALS
Research has continued in Jade Taylor's PhD project on the development of reliable surface imaging of sp2 and sp3 carbon nanomaterials using the Scanning Auger Nanoprobe. The ability to directly image these key forms of carbon will prove invaluable to anyone preparing, using and modifying carbon nanomaterials in all possible applications.

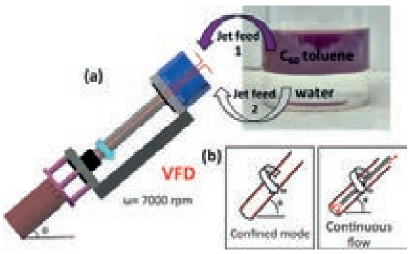


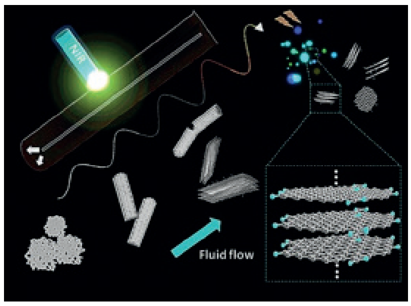
RESEARCH LEADERS

PROFESSOR COLIN RASTON AO FAA

WWW.RASTONLAB.COM

Prof Colin Raston is a Professor in Clean Technology, at Flinders University, and is a former President of the Royal Australian Chemical Institute (RACI). He has received the RACI's Green Chemistry Challenge Award, the H.G. Smith Award, the Burrows Award, the Leighton Memorial Award for outstanding contributions to the profession, and the Applied Research Award. In 2015 he shared the Ig Nobel Prize in Chemistry with colleagues at the University of California, Irvine and the University of Western Australia, in 2016 he was Appointed an Officer in of the Order of Australia, and in 2018 was elected Fellow of the Australian Academy of Science. His current research covers clean technology and green chemistry, microfluidics, nanotechnology and self-assembly, and is currently on the editorial advisory board of the international journals Green Chemistry and Nature's Scientific Reports. Professor Raston has published over 750 journal articles, a book, chapters in books, and has edited a book. He has a number of patents, a spin out company with colleagues (now ASX listed), and a new company created in 2018 – 2D Fluidics.





CONTROLLING SELF-ASSEMBLY
The vortex fluidic device (VFD) is effective in controlling the self-assembly of materials, including fullerenes, into functional materials.

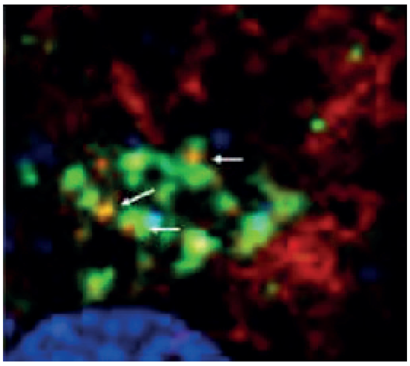
ORGANIC SYNTHESIS & CATALYSIS
Attaching enzymes and catalysts in general to the surface of the VFD tube allows catalytic reactions at the different zones along the tube, under continuous flow – scalable processing.

NANOMATERIALS
VFD synthesis of carbon quantum dots under continuous flow for security, medical and device application..

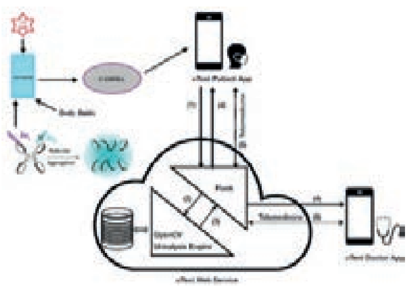
RESEARCH LEADERS

ASSOCIATE PROFESSOR YOUHONG TANG

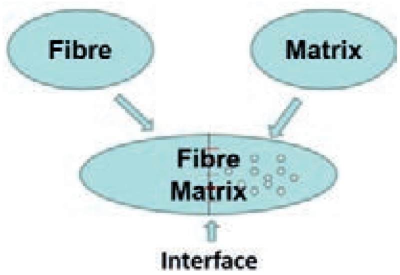
Associate Professor Tang obtained his PhD degree in the Hong Kong University of Science and Technology in 2007. He moved to Flinders University with an ARC-DECRA in 2012 from the Centre for Advanced Materials Technology, University of Sydney. He is a Fellow of Royal Society of Chemistry with research interests mainly focused on structure-process-property relation of (a) polymeric materials and nanocomposites, especially on rubber and epoxy based multifunctional and value-added nanocomposites (c) fibre reinforced composites and structures, particularly for marine applications and (c) bioresources, biomaterials and biosensors, especially incorporating the novel aggregation-induced emission material.



AGGREGATION INDUCED EMISSION
Apoptosis is an important process for maintaining tissue homeostasis and eliminating abnormal cells in multicellular organisms. Using Multiplexed imaging detection of live cell intracellular changes in early apoptosis with aggregation-induced emission fluorogens.



DEVICES FOR PERSONAL HEALTH MONITORING
Design and development of a smartphone-based urinalysis device that has the ability for chronic kidney disease patients to conduct rapid quantitative urinalysis of human serum albumin using an Aggregated Induced Emission fluorogen with their own smartphones.

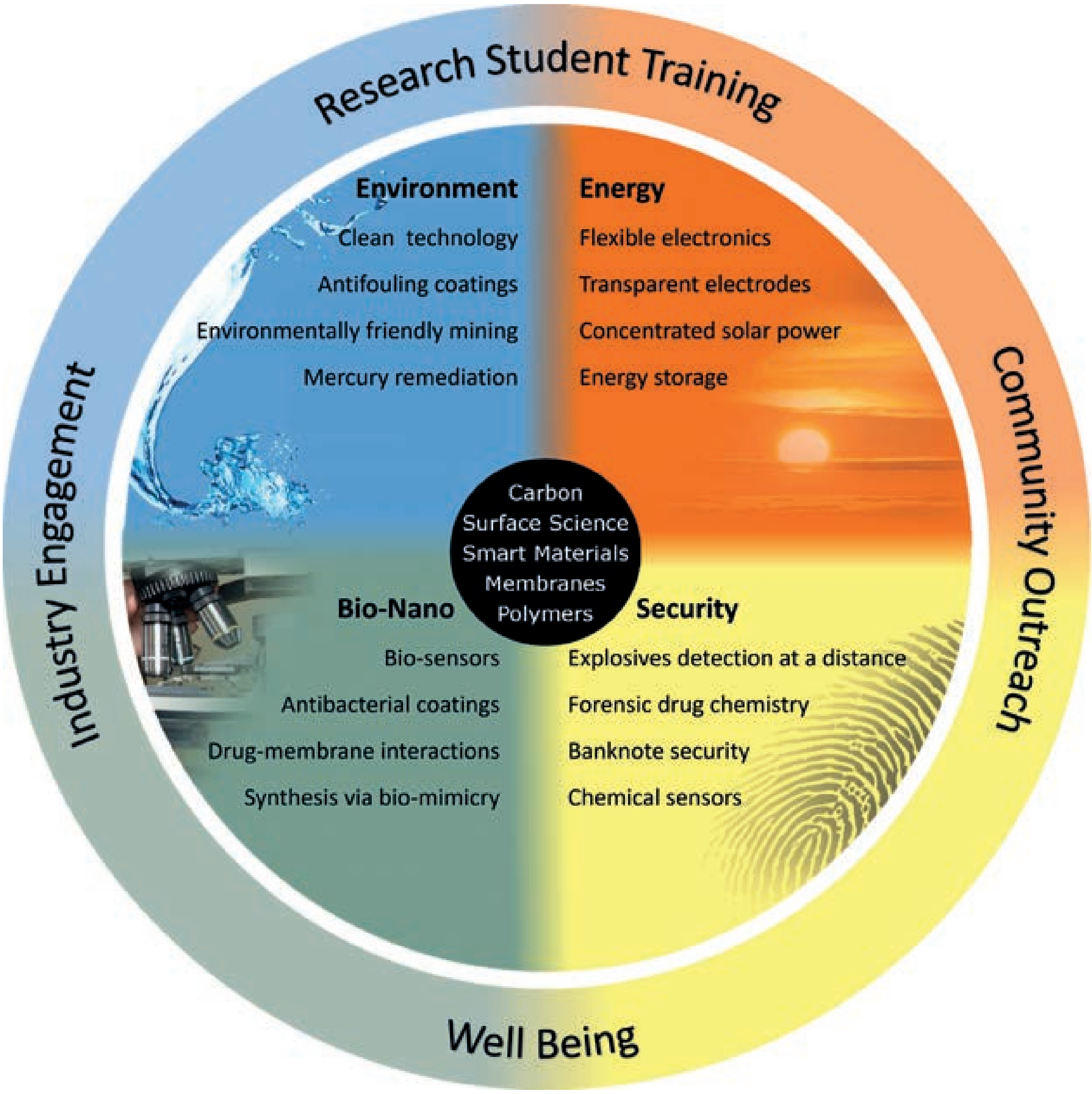


NANOCOMPOSITES
Enhancement of fibre reinforced polymer laminates for maritime applications, using commercially available nanosilica for matrix toughening and polydopamine for fibre/matrix interface improvement.

In 2018 we published over 100 articles, with 50% in journals ranked in the top 10% in their field and with an average impact factor of 6.1

RESEARCH

The Flinders Institute for Nanoscale Science and Technology was founded in 2010, initially as a University Centre. Since then, we have grown in size and scope through a focus on rigorous, high quality research that is relevant to our partners and community as demonstrated by many of the projects and collaborations presented in this report. We have enhanced our international reputation as a preferred research partner by providing robust solutions to the challenges facing the world in the general areas of energy, bio-nano, security, and the environment.



PROJECTS ENERGY

OPTIMISATION OF POLYMER SOLAR CELL FABRICATION VIA SLOT-DIE PRINTING

BRADLEY KIRK, GUNTHER G. ANDERSSON, MATS R. ANDERSSON

In recent years, large-scale printing of polymer solar cells (PSC) has been a promising method of manufacturing for future solar panel production, allowing for the fabrication of low-cost, flexible and light-weight devices. Compared to conventional solar panels, printing requires less energy and materials, thus reducing the manufacturing cost. This project aims to improve the overall performance and stability of printed PSCs by adjusting the printing ink for the active layer.

Though there is a lot of interest towards the production of high-performance PSCs, low manufacturing costs and decent life-spans are also critical for solar cell devices. For these reasons, this project focused on a semiconducting conjugated polymer called TQ1 mixed with fullerene derivatives, due to their stability, low material cost and good overall performance. A mini-roll coater (MRC) with a die-head attachment allowed for the fabrication of such devices at a large scale in ambient conditions.

By optimising the printing variables of the MRC for TQ1:PC61BM devices, an average of 2.6% efficiency was able to be achieved, however, the active layer ink contained halogenated solvents including orthodichlorobenzene (o-DCB), chloroform and 1-chloronaphthalene. These solvents can promote a more desired morphology for the active layer, however, they are considered harmful. Non-halogenated solvents including o-xylene may be friendlier but they generally phase separate in the bulk-heterojunction, decreasing the efficiency of the PSC devices.

Using high-temperature/low vapour pressure solvents as additives, such as 1-methylnaphthalene (MN), allows for the improvement of devices while allowing for the use of non-halogenated solvents such as o-xylene. Being the last solvent to evaporate during printing of the active layer, the additive can "set the morphology" for a more desired blend in the bulk-heterojunction with smaller size domains and improved mixing of materials.

With the use of 1% V/V of MN additive to the ink containing o-xylene, an average of 2.0% efficiency was achieved, compared to 1.4% for devices printed with ink containing pure o-xylene. While allowing for an increase in performance, it also allows for the use of friendlier solvents that would otherwise yield poor efficiencies.

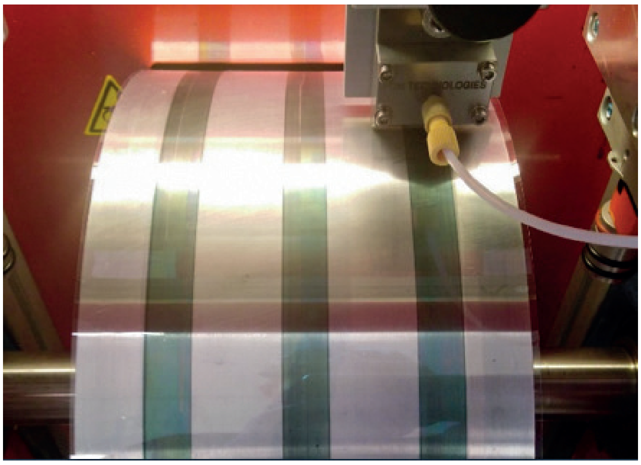


FIGURE 1
A mini-roll coater (MRC) with a die-head attachment.

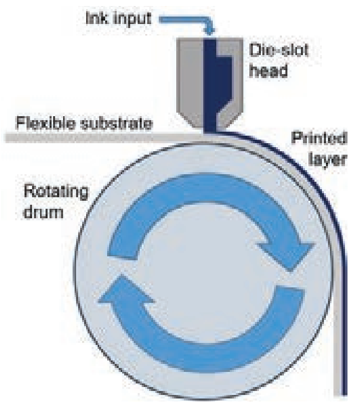


FIGURE 2
Diagram of a Die-slot printing setup.

ACKNOWLEDGEMENTS
The authors acknowledge the support of The Playford Memorial Trust, as well as the expertise, equipment and support provided by Microscopy Australia and the Australian National Fabrication Facility (ANFF) at the South Australian nodes under the National Collaborative Research Infrastructure Strategy.

PROJECTS ENERGY

ENVIRONMENTALLY FRIENDLY PREPARATION OF NANOPARTICLES FOR ORGANIC PHOTOVOLTAICS

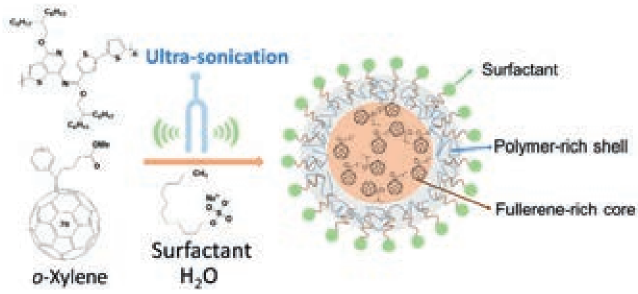
XUN PAN, MATS R. ANDERSSON

Organic photovoltaics (solar panels made form carbon-based materials) show great potential for the generation of renewable energy. Most current processes for making these devices use toxic solvents however, which is counterproductive to the environmentally friendly aims of solar power. This project is developing environmentally friendly ways of producing next generation solar panels.

Organic photovoltaics (OPVs) have experienced rapid development during the past decade, showing great potential in the utilisation of renewable solar energy. To realise the commercially competitive manufacturing of OPVs, tremendous efforts have been put into the design of novel conjugated materials and device engineering. However, the fabrication of OPVs, especially the deposition of photoactive layer is mainly processed using halogenated solvents, which is counterproductive to the environmentally friendly goal of OPVs.

Our research is focusing on the preparation of water-dispersed nanoparticles (NPs) from water-insoluble donor and acceptor materials for application in OPVs (Figure 1). Recently, we have successfully demonstrated a green way to prepare NPs via the miniemulsion method using o-xylene as a precursor solvent, which eliminates the usage of halogenated chemicals in both NP preparation and device fabrication, presenting promising photovoltaic performance (1.65% PCE). The results provide a guideline for developing green preparation of NPs for high performing OPVs. Furthermore, dynamic mechanical thermal analysis (DMTA) was utilised for the first time on conjugated NP system to study the thermal properties, which facilitate the choice of appropriate annealing temperature to achieve the coalescence of NPs in the solid state.

Reference: Pan, X., et al. Environmentally friendly preparation of nanoparticles for organic photovoltaics. Organic Electronics 2018, 59, 432-440.



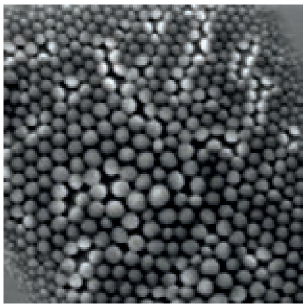


FIGURE 1
Illustration of the NP preparation using the miniemulsion method and the SEM image of NPs.

ACKNOWLEDGEMENTS
The authors acknowledge the expertise, equipment and support provided by Microscopy Australia and the Australian National Fabrication Facility (ANFF) at the South Australian nodes under the National Collaborative Research Infrastructure Strategy.

This research is supported by the Australian Research Council's Discovery Projects funding scheme (Project DP170102467).

PROJECTS **ENERGY**

HIGH CONCENTRATION NANOFLUIDS FROM FATTY-ACID TERMINAL SILICA NANOPARTICLES

CHRISTOPHER HASSAM, JONATHAN CAMPBELL, TAKASHI NAKANISHI (INTERNATIONAL CENTER FOR MATERIALS NANOARCHITECHTONICS), DAVID LEWIS

Dispersions of nanoparticles can have superior thermal properties compared to traditional heat transfer fluids used in solar thermal energy generation but are held back from applications due to poor flow behaviour. This research aims to produce nanoparticle dispersions with controllable flow behaviour, to overcome this limitation.

High concentration nanofluids are dispersions of large quantities of solid nanoparticles in liquids, and are a promising candidate for heat-transfer fluids for solar thermal applications. The incorporation of solid nanoparticles has been the subject of intense study worldwide for its potential to increase the efficiency of heat transfer fluids. However, incorporating high particle concentrations often results in undesirable effects, such as significant viscosity increases, and non-Newtonian behaviour, which can impede pumping the fluids, rendering them unsuitable for the desired applications.

This research focusses on producing high-concentration nanofluids with controllable, tuneable rheological properties. High-concentration dispersions of silica nanoparticles functionalised with fatty acids have been investigated for their ability to produce fluids with switchable, pH-controlled properties.

These particles can easily be redispersed in high concentrations in water at appropriate pH values, forming stable dispersions with near-Newtonian properties, even at high concentrations of particles. Further, they can easily be removed from solution at low pH, resulting in significant and rapid aggregation, producing highly shear thinning fluids. The particles have been found to be simply redispersible even after being stored dry, without permanent aggregation, a common problem for silica nanoparticles.

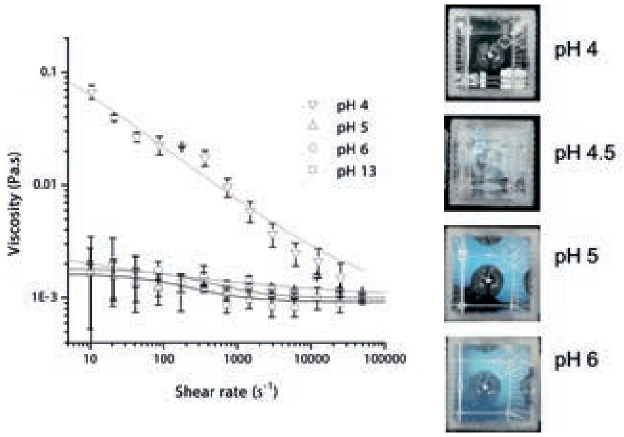


FIGURE 1
Rheological profiles of fatty-acid terminal silica nanoparticle dispersions at different pH values

ACKNOWLEDGEMENTS
The authors would like to acknowledge the Australian Government, the National Institute for Materials Science Japan, Australian National Fabrication Facility (ANFF) and Microscopy Australia.

PROJECTS ENERGY

PROBING STRUCTURE-PROPERTY RELATIONSHIPS DURING THE FORMATION OF POLYMER SOLAR CELL ACTIVE LAYERS

ELLIOT JEW, XUN PAN, DAVID LEWIS, MATS R. ANDERSSON, JONATHAN CAMPBELL

Understanding the materials used in solar cells/panels is crucial to improving their performance, we have used an instrument to measure how these solar materials behave across a large range of temperatures.

Structure-property relationships of classic and novel donor polymers used in organic solar cell active layers have been investigated with an aim of bridging the efficiency gap between small-scale and high volume printed cells.

Conjugated polymers are being used as donor materials (materials which absorb light to produce an excited electron, which is then transported through the rest of the cell to produce a current) in bulk heterojunction (BHJ) structure solar cells.

Dielectric thermal analysis (DETA) applies an oscillating electric field to the material, inducing a dipole moment, as the field oscillates the dipole tries to oscillate at the same rate but it can't keep up, resulting in a phase shift. This shift gives information about energy stored and dissipated by the material and is used to determine the frequency dependant transitions, such as main (Tg) and side (sub-Tg) chain movements. This gives information about how these polymers behave and interact at certain temperatures, including properties such as crystallinity. Using an Arrhenius plot DETA can determine the activation energy of these transitions.

We have measured the activation energy for a range of transitions seen between -50°C and 150°C in well-studied polymers such as poly(methyl methacrylate) (PMMA) and polyethylene terephthalate (PET) as well as novel conjugated polymers P3HT, TQ1, PTNT, PTB7-Th. The activation energy increases with the size of the side chain, generally within the range of 20 to 100 kJ/mol, which is to be expected. This information can be used to determine how the modification of side groups on conjugated polymer materials may impact the materials behaviour and performance in next generation solar cells.

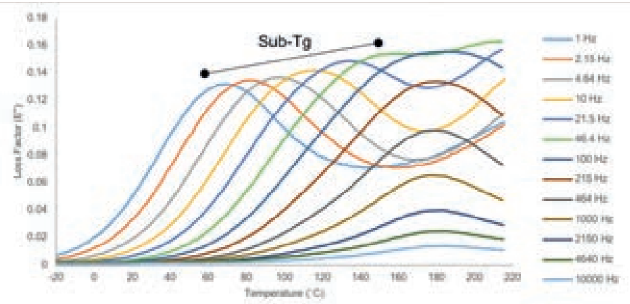


FIGURE 1 (ABOVE)
DETA plot for the conjugated polymer TQ1 between -20°C and 220°C, Larger differences in frequencies indicate a lower Ea. (Sub-Tg shows large changes between peaks and Tg shows very little)

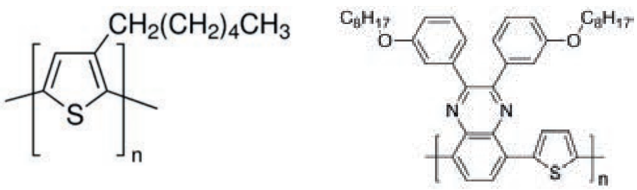


FIGURE 2 (ABOVE)

P3HT
Sub-Tg: 23 kJ/mol

TQ1
Sub-Tg:57 kJ/mol

ACKNOWLEDGEMENTS
Australian Nano Fabrication Facility (ANFF) and the Australian Microscopy and Microanalysis Research Facility (AMMRF).

This research is supported by the Australian Research Council's Discovery Projects funding scheme (Project DP170102467).

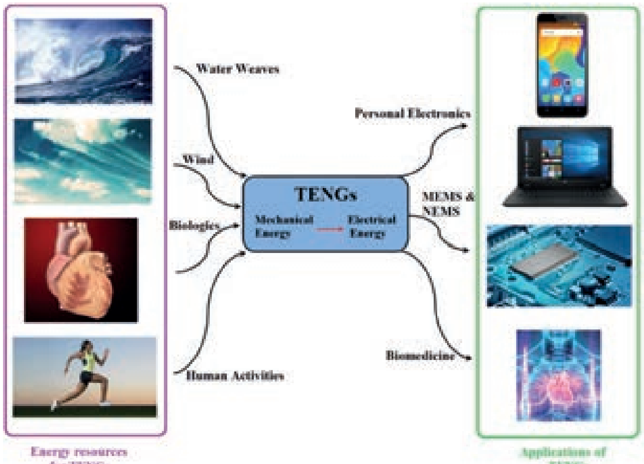
PROJECTS ENERGY

DESIGN OF TRIBOELECTRIC NANOGENERATORS FOR IN-SITU NANOTECHNOLOGY APPLICATIONS

MOHAMMAD KHORSAND, KUDZAI KAMANYA, YOUHONG TANG

Electronics - such as wrist watches, mobile phones, and sensors - can be driven wirelessly without any need for a battery or other power suppliers. The solution lies in converting renewable energy resources like vibration into electric power using triboelectric nanogenerators (TENGs).

In green and renewable energy technology, triboelectrification has emerged as an extremely cost-effective, readily scalable, and simple phenomenon that can transform irregular mechanical energy which is abundantly available in our living environment into electricity. In light of the rapid growth in microelectronic technology, TENGs have been explored as a sustainable method for energy scavenging as well as self-powered sensors. Meanwhile, the performance evaluation of TENGs is still lacking in order to demonstrate robust wireless micro/nano systems exhibiting the ability to operate wirelessly and sustainably. With respect to the importance of TENGs in renewable nanoenergy manipulation, the principal assignment of the current research is deciphering how TENGs can effectively and economically produce electric power from organic materials without the use of other energy suppliers or batteries. Here, an innovative concept is elaborated to substantially enhance the output power of micro/nano systems, miniaturize the structure, and choose the appropriate electrical characteristics. The outline proposed in this research is a new paradigm in the design process of biocompatible TENGs for scavenging energy from the diverse forms of mechanical motions in our everyday life (either sliding, rotation, lateral translation, or rolling). This has resulted in an overwhelming increase in power output, considerable decrease in the dimensions of the generators, and the delivery of appropriate voltage and current characteristics.



ACKNOWLEDGEMENTS
M Khorsand is grateful for the financial support of Postgraduate Research Scholarships (International) for his PhD studies at Flinders University.

PROJECTS ENERGY

DIPOLE FORMATION IN OPVS

YANTING YIN, GUNTHER G. ANDERSSON, DAVID A. LEWIS

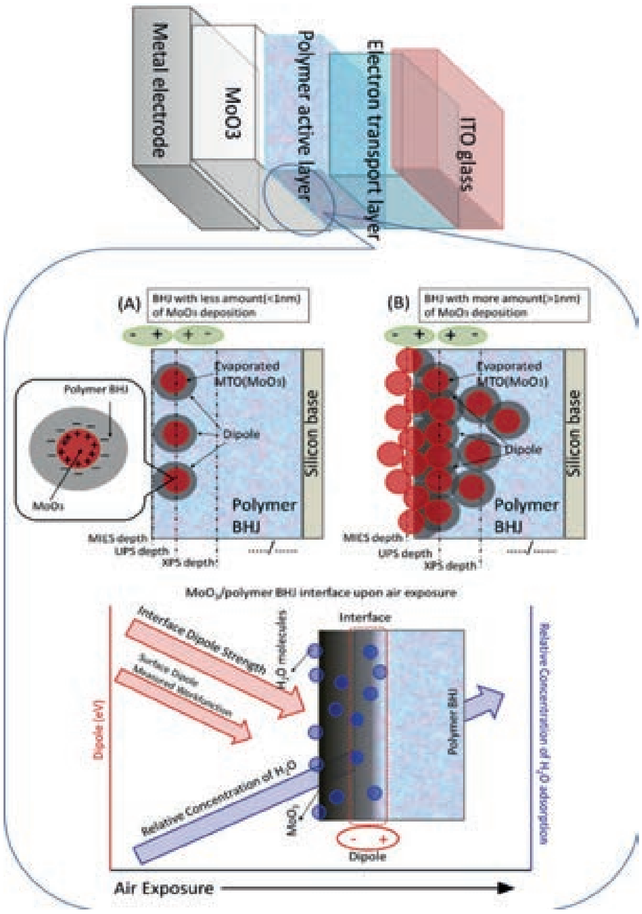
Next generation solar technologies – including organic photovoltaics – show considerable promise for broadening the use of solar power. If we are to fully exploit these technologies however, we need to understand how the materials used interact with each other. This project analyses the interaction between two commonly used materials, using a non-destructive technique.

Molybdenum oxide (MoO_3) is a high workfunction metal oxide which is used as an anode buffer layer in organic based solar cells because of its ability to extract electrons and inject holes from the active layer. A strong dipole is formed at the interface supporting the charge transfer over the interface. Understanding the chemical distribution and electrical interaction of interface materials such as MoO_3 with the adjacent polymeric active layer is crucial for optimising organic solar cell performance. However, the nature of these interfaces and the formation of the dipole which facilitates charge transport are not fully understood due to the lack of non-destructive techniques for directly analysing the interface.

In our research, the interface formed between MoO_3 and a conjugated polymer were investigated using a powerful combination of electron spectroscopy and ion scattering spectroscopy. The thickness of the MoO_3 deposition on the polymer layer was varied in order to study the formation of the dipole and any migration of MoO_3 into the polymer layer. Gradual changes of electronic structure such as the work function and valence electron states were observed from the analysis of spectra. A mathematical decomposition algorithm was used to quantify the maximum dipole strength as 2.1 eV. Thus, the complete energy bands at the interface were reconstructed. The mechanism of charge transfer over the MoO_3/conjugated polymer interface was revealed with a range of MoO_3 thickness.

Further investigation was conducted on the interface with a simulation of a commercial fabrication process, during which exposure to atmosphere is inevitable. The results show that a low degree of adsorption of H_2O onto MoO_3 from atmosphere will noticeably change the electronic structure of MoO_3 and eliminate the interface dipole. As a result, the charge transfer mechanism can be unfavourable after exposure to air. This finding is an important consideration for the mass production of photovoltaic devices using high workfunction metal oxides as an interface layer.

ACKNOWLEDGEMENTS
The authors acknowledge the expertise, equipment and support provided by Microscopy Australia and the Australian National Fabrication Facility (ANFF) at the South Australian nodes under the National Collaborative Research Infrastructure Strategy.



PROJECTS SECURITY

The Institute has a history of research in security and defence related areas, and these projects continue in collaboration with a number of partners. Due to the sensitive nature of these projects we are not able to disclose the details of much of the work we are doing.

Our work has included collaborations to investigate bank note security, organic countermeasures, anti-counterfeiting, forensic drug chemistry, and the fabrication of chemical sensors. Collaborators on projects have included the Reserve Bank of Australia, Forensic Science South Australia and the Defence Science and Technology Group.

These projects focus on low technology readiness (TRL) fundamental research on innovative solutions to far-reaching problems.

PROJECTS SECURITY

NOVEL ANITFOULING FOR ACOUSTIC SENSORS

BRADLEY DONNELLY, ASSOC PROF. YOUHONG TANG, PROF. KARL SAMMUT, IAN BEDWELL (THALES AUSTRALIA), DR. ANDREW SCARDINO (DEFENCE SCIENCE AND TECHNOLOGY GROUP)

This project has investigated how biofouling and antibiofouling coatings effect the acoustic properties of the surfaces they are adhered to. This is then used to develop a coating that aims to maintain acoustic performance and be free of fouling.

Fouling is the accumulation of unwanted substances, such as proteins molecules or organisms on structures, pylons boats or pipes due to exposure to their environment. As these foulants accumulate they can have many adverse effects on the structures they are fouling. They can reduce the maximum speed of a ship; weaken supports on oil rigs; reduce functionality of many sensors (such as sonar sensors) and increase fuel consumption which leads to further environmental issues.

Traditionally various toxic biocides, such as Tributyl-tin (TBT), were used to effectively combat the fouling process. However, TBT has been facing increasing regulations since the 1980's until it was completely banned by the International Maritime Organisation (IMO) in 2008. As regulations on many biocides become stricter, the need for an effective low/non-toxic environmentally friendly antifouling measure grows.

Currently most of the research in this area is focused on bio-mimicry, which aims to understand or replicate a solution already present in nature to develop or refine new solutions. Many of the new technologies significantly alter the surface chemistry of substratum at the water interface.

The application of these new technologies to acoustics sensors could significantly alter their acoustic properties. It is therefore important to characterise the acoustic properties of new antifouling techniques (both those that significantly affect the surface chemistry and those that don't) as well as commercially available antifouling paints. This needs to be done at various stages of the fouling process with and without antifouling measures.

This investigation led to the development of a coating containing low density hollow microspheres coated with copper. This work is ongoing and is an attempt to introduce antifouling components into a coating which is as acoustically transparent as possible, preserving the functionality of underwater acoustic sensors.

FIG 1
Nitrile samples with Fouling Ratings of 100, 60 and 20.

ACKNOWLEDGEMENTS
The authors gratefully acknowledge the support of the Research Training Centre for Naval Design and Manufacturing (RTCNDM), Thales Australia, and the Defence Science and Technology Group

PROJECTS BIO-NANO

BACTERIAL CELLULOSE-POLY (ACRYLIC ACID) HYBRID HYDROGELS AS DRESSINGS FOR CHRONIC WOUNDS

CLARENCE CHUAH, JING WANG, YOUHONG TANG

We have developed a composite material with promising properties for chronic wound dressings, including superior strength and pH sensitive swelling and drug release.

This investigation explored the potential of a biomaterial composite fabricated by poly(acrylic acid) (PAA) and bacterial cellulose (BC) for wound dressing applications. The FTIR analysis confirmed the successful production of BC-PAA composites. Morphological analysis showed that the composite had a highly microporous sponge-like structure with BC nanofibers being present throughout the composite. Mechanical testing found BC-PAA composite had superior strength when compared to the PAA hydrogel which is currently widely used as a wound dressing.

The results of the hygroscopicity test suggested that the BC-PAA hydrogel hybrid composite had a response to a change in pH. The composite showed the least amount of swelling in an acidic medium (pH 6), while the largest amount of swelling was absorbed in an alkaline medium (pH 8). This suggests that the composite would absorb more excess exudates at a higher pH, which is known to be observed in the wound beds of chronic wounds. Drug release from the composite also displayed a faster release under alkaline conditions when compared to the release rate under acidic conditions, suggesting that drug release is also responsive to pH changes. The results obtained from this investigation imply that the BC-PAA hydrogel hybrid composite could be used as a wound dressing, including for chronic wounds.

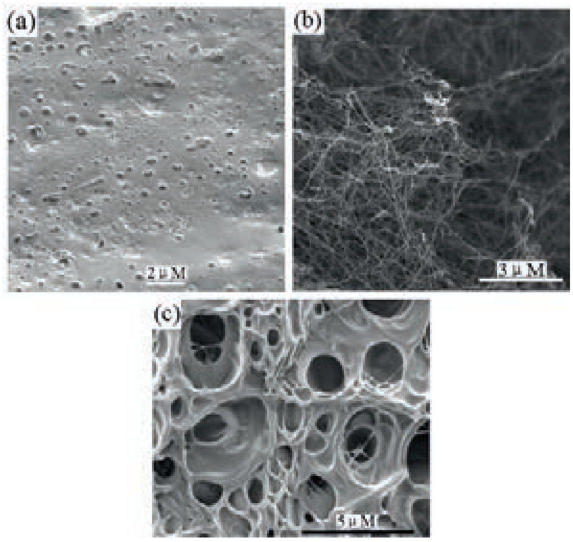


FIGURE 1
SEM images of (a) PAA, (b) BC, and (c) BC-PAA

ACKNOWLEDGEMENTS
The authors are grateful for support from a College of Science and Engineering start-up grant, Flinders University. We also acknowledge the expertise, equipment and support provided by Microscopy Australia and the Australian National Fabrication Facility (ANFF) at the South Australian nodes under the National Collaborative Research Infrastructure Strategy.

PROJECTS BIO-NANO

NOVEL BACTERIAL CELLULOSE / GELATIN HYDROGELS AS 3D SCAFFOLDS FOR TUMOR CELL CULTURE

JING WANG, LI ZHAO (THE FIRST PEOPLE'S HOSPITAL OF XUZHOU, CHINA),
AIXIA ZHANG (AFFILIATED HOSPITAL OF SHANDONG ACADEMY OF MEDICAL SCIENCES, CHINA), YOUHONG TANG

Three-dimensional (3D) cells in vitro culture are becoming increasingly popular in cancer research because some important signals are lost when cells are cultured in a two-dimensional (2D) substrate. In this work, bacterial cellulose (BC)/gelatin hydrogels were successfully synthesized and were investigated as scaffolds for cancer cells in vitro culture to simulate tumour microenvironment.

Bacterial cellulose (BC)/gelatin hydrogels were successfully obtained. Through a crosslinking reaction, gelatin was introduced into the BC scaffolds and wrapped the pure BC nanofibers. The morphology, chemical structure, mechanical properties, porosity, and wettability of the hydrogel were characterized. The BC/gelatin hydrogels were used for in vitro culture of cancer cells. A human breast cancer cell line (MDA-MD-231) belonging to a triple-negative breast cancer was seeded into pure BC and BC/gelatin scaffolds to evaluate the feasibility of scaffolds for 3D in vitro culture. The results showed that MDA-MD-231 cells with normal morphology could grow, proliferate, attach, differentiate, and penetrate into scaffolds. Moreover, such cells in BC/gelatin scaffolds showed superior vitality and formed multilayered growth and more cell clusters. For the same culture duration, cells seeded in BC/gelatin were significantly stronger than those in pure BC. Furthermore, the results of immunohistochemistry revealed clearly that MDA-MB-231 cell lines were estrogen receptor negative (ER (−)), progesterone receptor negative (PR (−)), and human epidermal growth factor receptor-2 negative (HER-2 (−)), retaining the triple-negative expression pattern of key breast cancer markers. These findings indicate that BC/gelatin scaffolds could support cell growth, promote cell proliferation, adhesion and differentiation, and possess excellent biological compatibility. Thus, BC/gelatin hydrogels would be a feasible and inexpensive candidate for tumour cells cultured in vitro for cancer biology studies, clinical diagnosis and tumour tissue engineering applications.

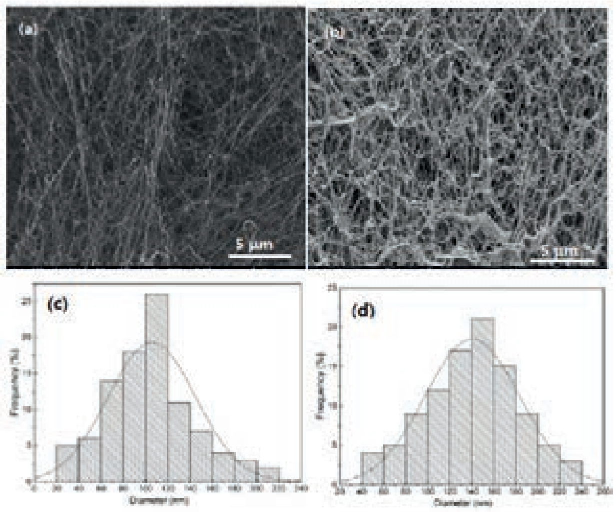


FIGURE 1
(a,b) SEM images and (c,d) diameter distributions of (a,c) pure BC and (b,d) BC/gelatin hydrogel.

ACKNOWLEDGEMENTS
The authors are grateful for support from College of Science and Engineering start-up grant, Flinders University.

PROJECTS BIO-NANO

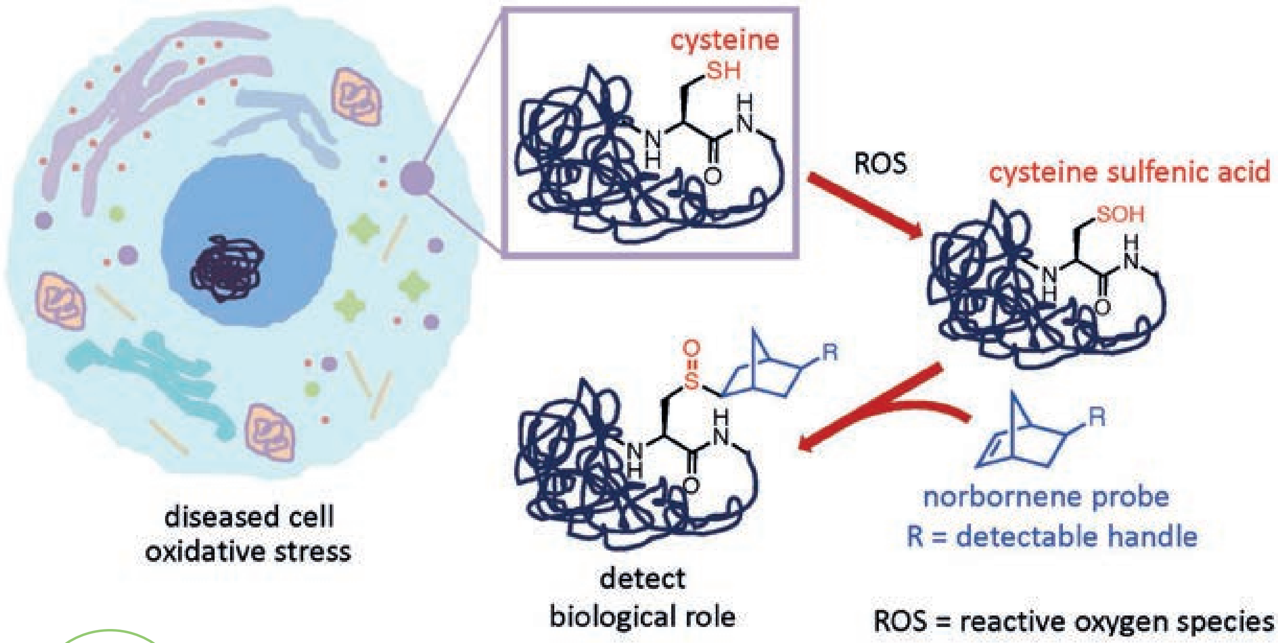
CHEMICAL TOOLS FOR DETECTING CYSTEINE SULFENIC ACIDS

LISA J. ALCOCK, BRUNO L. OLIVEIRA (UNIVERSITY OF CAMBRIDGE), TARA L. PUKALA (UNIVERSITY OF ADELAIDE), MICHAEL V. PERKINS, GONÇALO J. L. BERNARDES (UNIVERSITY OF CAMBRIDGE), JUSTIN M. CHALKER

Oxidative stress is a contributing cause of many diseases including cancer, diabetes, and heart disease. Studying what effect oxidative stress has on normal metabolic pathways is paramount to understanding the underlying cause of these diseases. This project focuses on design and implementation of a new chemical tool which can selectively detect a biomarker of oxidative stress, cysteine sulfenic acids, to assess their biological role.

In proteins, the amino acid cysteine is susceptible to oxidation to cysteine sulfenic acids by reactive oxygen species (ROS), which are generated as part of normal cellular function. Cysteine sulfenic acids are thought to be a biomarker of oxidative stress (influx of ROS), but also a key mechanism for many metabolic pathways. Since cysteines play many functional roles in proteins, understanding how oxidation to sulfenic acids may affect this function is vital for understanding the impact of oxidative stress in many diseases. Unfortunately, due to the highly reactive, short-lived, and unstable nature of cysteine sulfenic acids, detecting these post-translational modifications in proteins and live cells is a challenging task. Several chemical probes have been utilised for detection of cysteine sulfenic acids based around the dimedone core. However, they either suffer from limited selectivity, or slow reaction kinetics limiting the detection of short-lived, highly reactive species.

In this work, design of a new chemical tool utilising the norbornene scaffold has been explored which demonstrates increased selectivity and fast reaction rates compared to commonly used cysteine sulfenic acid trap dimedone, validated on both small molecules and purified proteins. A biotin-tagged norbornene probe was used to detect cysteine sulfenic acids in whole cell lysates as well as live cells. Whole cell proteomic analysis is currently underway to annotate the detected proteins and search for new potential cysteine sulfenic acids with functional biological roles in diseases.



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PROJECTS BIO-NANO

DELIVERING GOLD NANOPARTICLES AND ANTIBIOTICS USING NANOPARTICLES AND NANOFIBRES FOR BIOMEDICAL APPLICATIONS

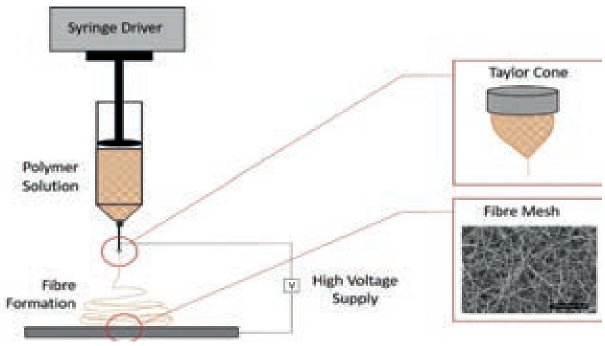
MELANIE FULLER, INGO KÖPER

Antibiotic resistance is quickly becoming a world health crisis and finding ways to enhance the antibiotic action of drugs is important. The delivery vehicle of antibiotics through nanoparticles and nanofibres are being explored and the antibiotic activity assessed.

Antibiotic resistance is becoming one of the greatest threats to human health, with infections becoming more difficult to treat with conventional methods. Incorporating multiple antibiotics including Colistin and Vancomycin within a nanomesh or nanoparticle could provide antibiotic action at the source of infection, theoretically reducing dosage and therefore side effects.

Gold nanoparticles can be coated in a series of oppositely charged polymer layers to create a shell structure. As part of this project, Colistin has been loaded onto one of the polymer shell's surrounding the gold nanoparticle to enhance drug delivery. Another delivery method being explored is a nanomesh which is formed by electrospinning fibres. Colistin and Vancomycin have been added to a polymer solution, which has been spun to form fibres by electrospinning as seen in figure 1. This fibre mesh has shown to release both antibiotics, with Colistin being delivered above the minimum inhibitory concentration of E.Coli for fourteen days. Thus, the nanofibre delivery platform can be used to prevent or treat an infection for up to two weeks. Further experimentation on the mechanism and kinetics of release is currently being conducted.

FIGURE 1
Electrospinning technique to form nanofibre meshes.



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The authors acknowledge the expertise, equipment and support provided by Microscopy Australia and the Australian National Fabrication Facility (ANFF) at the South Australian nodes under the National Collaborative Research Infrastructure Strategy, the expertise, equipment and support provided by the Australian Nuclear Science and Technology Organisation, as well as the support provided by the Australian Institute for Nuclear Science and Engineering Postgraduate Award, and the Australian Research Training Scholarship.

PROJECTS BIO-NANO

SULFUR POLYMERS FOR HUMAN HEALTH

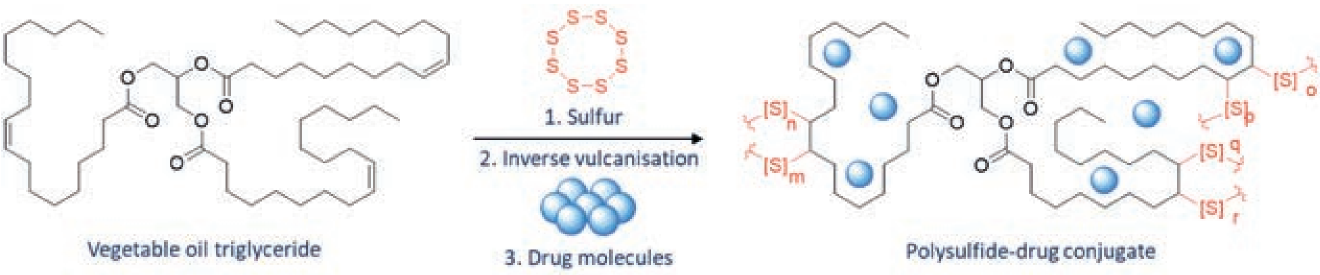
MAX WORTHINGTON AND JUSTIN CHALKER (FLINDERS UNIVERSITY)
ANA GUERREIRO, PADMA AKKAPEDDI, GONÇALO BERNARDES (IMM LISBOA)

Sulfur Polymers are a new class of materials designed to meet the needs of a carbon-scarce future and utilise the vast quantities of sulfur available globally that currently has limited industrial viability. Previous projects in the Chalker lab have looked at environmental applications of such materials, as sorbents for heavy metal and crude oil pollutants, but with this trip to Lisbon we planned to extend their capacity into biomedicine through the development of therapeutic-agent delivery platforms.

Over three months from September through November 2018 I travelled to the Instituto de Medicina Molecular (iMM) in Lisbon, Portugal and worked under the supervision of Dr Gonçalo Bernardes, investigating potential biomedical applications of a new sulfur polymer developed by our group at Flinders University. The material, a nano-structured renewable rubber prepared from the copolymerisation of sulfur and vegetable oil triglycerides has already been studied by the Chalker lab as a useful tool in a series of environmental applications, though the goal of this project was to take this material in a new direction and investigate its use in medical devices for the controlled release of bioactive cargo. Given that the polymer is made from only vegetable oils and elemental sulfur, it was theorised that it should have little deleterious effects as a medical implant, previous toxicity studies at the iMM corroborate this showing no loss in HepG2 or HeLa cell viability in its presence. The goal of the visit then was to determine the efficacy of canola oil polysulfide in the uptake and release a range of drug molecules, including anti-cancer agents, gene therapies and gaseous small-molecule therapeutics that require intricate control of spatial and temporal release to be most effective.

ACKNOWLEDGEMENTS
The authors gratefully acknowledge the support from Flinders University, Instituto de Medicina Molecular, Flinders Institute for Nanoscale Science & Technology, Microscopy Australia, Australian Nanotechnology Network, Royal Australian Chemical Institute, Australian Government Department for Education and Training.

FIGURE 1
Proposed mechanism by which drug molecules may be embedded during polymerisation



PROJECTS BIO-NANO

NEAR-REAL TIME, MULTI-ENVIRONMENT MICROBE TRACKING

JAMES PATERSON, SYLVIA SAPULA, LISA DANN, JESSICA CARLSON-JONES AND JIM MITCHELL

Tracking microbes across multiple environments in near-real time will make it easier to track the transmission of viruses through individuals and the environment. This information helps build a more complete picture before, during, and after outbreaks.

Pathogens are important to all biological systems, but their importance is seldom recognized until an acute, widespread mortality takes place. Then, the source of the pathogen is questioned. By this time, the pathogen may be spread throughout the system and its origin and infection pathways difficult to determine. Most animal pathogens have reservoir species and move around the environment. For this project we have developed near-real time enumeration and identification viruses so that they can be tracked in an environment. This allows assessment of the extent of transmission, the identity and dynamics of viruses in infected individuals and the environment.

To achieve near-real time viral tracking we increased sensitivity beyond current standards, employed portability (Figure 1) and streamlined chemistry to result in a cost of $2/sample and a sample measurement through put of every 2 minutes.

During 2018 we measured the Dengue and oyster herpes virus with this system using stains and primer probes. Success drew on Mitchell and his group's 20 years of experience in flow cytometry and 40 years of experience detecting microbes in the environment. The newly developed techniques applied here open a wide range of options for detecting microbes and possibly macromolecules throughout natural and anthropogenic environments.

The precision tracking of microbes in environments represents a new direction for the Flinders Institute for Nanoscale Science and Technology and relies on melding the chemistry of fluorophores and organic molecules with understanding microbial nanoenvironments.

FIGURE 1
A portable flow cytometer with modified settings and chemistry for fast, on-site analysis.

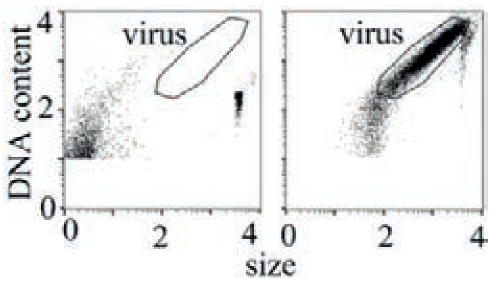


FIGURE 2
Cytograms from a single in situ herpes virus probe. Left, uninfected, right infected sample. Viruses challenge sensitivity. Our error is < 5% of titres (data not shown). Each dot is a measurement. Overflow of dots in virus box shows excess sensitivity for 50 µl samples.

ACKNOWLEDGEMENTS
Flinders University, the Oyster Cooperative Research Centre Program, Department of Education and Training and the South Australian Environment Protection Authority provided support and expertise. Merck-Millipore Australia provided consultation and advice.

ENHANCING THE BIO-SENSORS DETECTIVE LIMITATION OF ANIONIC SURFACTANTS BY DRIVING VORTEX FLUIDIC DEVICE

JINJIAN WU, CHENG FANG (GLOBAL CENTRE FOR ENVIRONMENTAL REMEDIATION, UNIVERSITY OF NEWCASTLE), COLIN RASTON, YOUHONG TANG

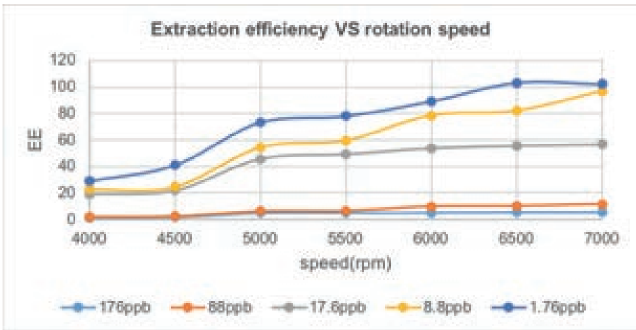
Perfluoroalkyl substances (PFASs) are a group of man-made chemicals which were firstly synthesised in the 1950s. The results of many studies showed strong relationships between the level of PFASs and several serious illnesses including cancers of different types. In this project, significant advancement has been made in developing a new method of improving the detection limit of the astkCARE kit 100-fold, using the Vortex Fluidic Device (VFD).

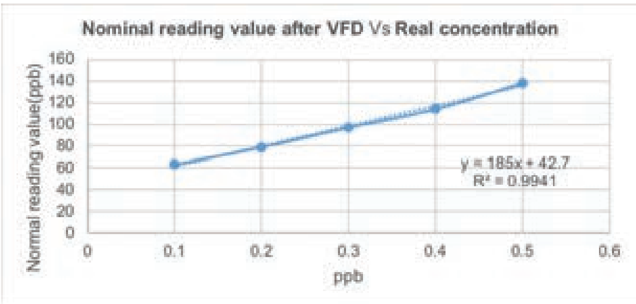
The results of many studies show strong relationships between the level of PFASs and several serious illnesses including cancers of different types. Therefore, the US Environmental Protection Agency (EPA) had decreased the allowable levels of PFASs in drinking water several times to 0.07 ppb to prevent more illnesses from being developed.

High-performance liquid chromatography (HPLC) is still the golden standard for detecting the PFASs in the water, but the its requirement of a well-trained operator, time-consuming analysis, huge size and high cost limit its application to onsite testing. The astkCARE kit is a portable device which was invented to detect the concentration of PFOS/PFOA in water using their patented reagent and capturing a picture through a smartphone camera.

In this project, the VFD technology was used to increase the effectiveness of extraction process of the sample pre-treatment. Conditions including rotation speed, flow rate, rest time and cycle time were optimized to achieve the best extraction efficiency. The results show that the maximum extraction efficiency can be determined with rotation speed of 6000 (± 50) rpm, 10 ml/ min flow rate, 10 min rest time and 3 cycles of pump process. The relationship between nominal reading value and real concentration was established.

A real water sample was measured based on the achieved relationship and the results show that it is a little higher than true value measured by HPLC. This aside, the detection limit of PFOS was increased over 100 times from 10 ppb to 0. 1ppb. The next steps in this project will focus on reducing the size of the astkCARE kit, making the VFD rotation part powerless and validating the relationship curve by HPLC under VFD conditions.





ACKNOWLEDGEMENTS
The authors are grateful for financial support from Defence Innovation Partnership Collaborative Research Funding, South Australia.

PROJECTS
ENVIRONMENT

PREVENTION OF MARINE BIOFOULING – AN ENVIRONMENTALLY FRIENDLY APPROACH TO ANTIFOULING COATINGS

SAIT ELMAS, SOPHIE LETERME, MATS R. ANDERSSON

Most of the anti-fouling coatings on the market are based on marine "copper-release paints", which become an existential threat to non-targeted marine species due to the increased copper levels in seawater. To protect the marine life in their harbours and coastal areas, some countries have already put a ban on copper to be used in antifouling paints on ship hulls and other marine constructions. The current project has the potential to overcome the ban on copper without dispensing with the copper-release paints.

The settlement of microorganisms (algae, bacteria, diatoms, etc.) on unprotected surfaces in marine environments results in a rapid growth of biofilms. This so-called biofouling is a multistep process that can cause severe damage to the marine constructions and costs billions of dollars annually for the transportation sector alone. The consequences of biofouling on ship hulls are increased fuel consumption due to the additional drag and reduced manoeuvrability when the vessels are moving. Once the biofilm has formed, the unprotected surfaces also start to corrode.

Most of the anti-fouling coatings contain copper as an antifouling material – known as copper-release paint – which is already known as cost-effective and excellent biocide. The slow release of copper prevents the settlement of microorganisms and hence the growth of biofilms. However, the increased use of copper in marine coatings has led to an increase of copper levels in harbours, which in turn has become an existential thread to non-targeted marine species. As a logical consequence, some countries have already banned copper-based antifouling paints in their harbours.

Within the scope of the current project, a polymeric material (cross-linked polyethylene imine, PEI) was successfully developed to uptake the available copper from seawater. It has also been shown that the copper withdrawn from seawater can be released when an electric current is passed through the same polymeric material. Note that the biocide activity of copper is enabled when the metal is slowly released from the coating.

Within this closed copper-cycle, there is the chance to stop the continuous increase of copper levels in harbours and seawater without dispensing with copper-release paints.

In the ongoing research, we are testing the copper uptake and release under fouling conditions (Fig. 1). However, optimised electrochemical parameters to reduce the electric current under oxidative conditions, stability of the coatings during multiple cycles and specification of the biofilms under different conditions are still to be addressed.

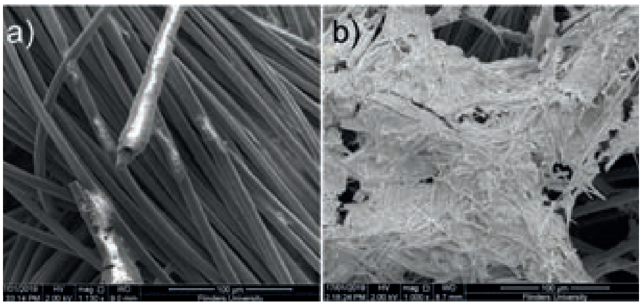


FIGURE 1
SEM image of the cross-linked PEI on carbon cloth containing 20 ppm copper a) before and b) after submersion in seawater and without electrochemical release of copper.

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The authors acknowledge the expertise, equipment and support provided by the Microscopy Australia and the Australian National Fabrication Facility (ANFF) at the South Australian Nodes of Microscopy Australia and the ANFF under the National Collaborative Research Infrastructure Strategy.

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PROJECTS
CORE CAPABILITIES

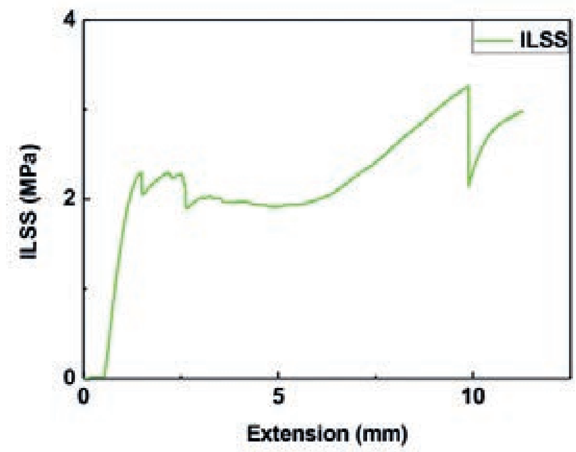
LIGHT WEIGHT SANDWICH STRUCTURE COMPOSITES FOR COMMERCIAL CAR ACCESSORIES

WEI HAN, JING WANG, YAKANI KAMBU, YOUHONG TANG

Alternative fuel vehicles or personal air vehicle (PAV) have high demands for light weight and high strength composites for non-structural components. Carbon fibre sandwich structure composites have great advantages to create these high specific strength materials.

Alternative fuel vehicles and personal air vehicles (PAV) are booming in the world. Light weight composite materials are a popular area of research for application in the novel vehicle industry. The use of sandwich composites in the vehicle manufacturing process is an effective solution to reduce weight and energy consumption and increase safety. Sandwich composites are able to be made with high ratios of stiffness and strength to weight, and the flexibility required for designing and manufacturing. In this project, rigid structural foam materials, such as PU and PC foams, are used as cores with carbon fibre and resin coatings. The sandwich composites were used to create various components, including car roof panel, car hood, door, seat unit, etc. The project includes product design, FEA analysis, mould design and design optimisation. We made our own moulds in-house and used a variety of lamination methods, such as prepreg heat pressing, hand lay-up with vacuum bagging and vacuum infusion. These fabrication methods were then evaluated using mechanical tests.

ACKNOWLEDGEMENTS
We acknowledge the funding support from Nano 6C Pty Ltd., Australia.



PROJECTS
CORE CAPABILITIES

SEPARATING THE ELECTRONIC PROPERTIES OF THE INNER AND OUTER WALLS OF DOUBLE WALL CARBON NANOTUBES

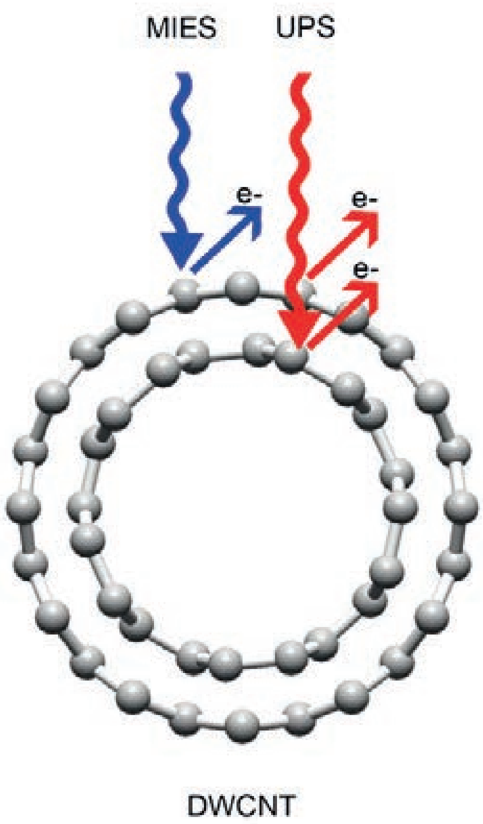
BENJAMIN A. CHAMBERS, CAMERON J. SHEARER (THE UNIVERSITY OF ADELAIDE), LEPING YU, CHRISTOPHER T. GIBSON, GUNTHER G. ANDERSSON

To use carbon nanotubes (CNTs) in electronic devices, one needs to modify its structure to build a device or circuit. Through changing the structure of a CNT it loses its electronic properties making it less suitable. Double wall carbon nanotubes (DWCNTs) have an inner and outer tube. It is possible that the DWCTs can be modified on the outer wall and maintain its electronic properties on the inner wall. A combination of spectroscopy methods are used to separate the information of the inner and outer tubes to prove if the inner walls retain their electronic properties.

The combination of ultraviolet photoelectron spectroscopy (UPS) and metastable helium induced electron spectroscopy (MIES) is used to determine the density of states (DOS) of the inner and outer coaxial carbon nanotubes. The DOS are the main factor that determine the electronic properties. UPS typically measures the DOS across the entire carbon nanotube, while MIES measures the DOS of the outermost layer alone. The use of DWCNTs in electronic devices requires the outer wall to be functionalised whilst the inner wall remains defect free and the DOS is kept intact for electron transport. Separating the information of the inner and outer walls of the DWCNTs allows for their individual properties to be measured and confirm material development that strives to allow functional attachment and charge transport.

ACKNOWLEDGEMENTS
The authors acknowledge the expertise, equipment, and support provided by Microscopy Australia and the Australian National Fabrication Facility (ANFF) at the South Australian nodes under the National Collaborative Research Infrastructure Strategy.

FIGURE 1
MIES probes outer wall, UPS probes outer and inner wall



PROJECTS
CORE CAPABILITIES

MONITORING HYDROGELS THROUGH FLUORESCENCE

JAVAD TAVAKOLI, YOUHONG TANG

Hydrogels with crosslinked networks and a three-dimensional structure have unique properties with a wide range of applications including drug delivery, wound dressings, and tissue scaffolds. We have developed new techniques for monitoring the swelling and degradation in hydrogels, minimising the uncertainties which are inherent in traditional methods.

The swelling and degradation properties of hydrogels must be well understood if they are to be successfully applied. The swelling and degradation of hydrogels are traditionally characterised by measuring the weight change of the gel [1], but this can prove difficult to perform consistently with minimal errors.

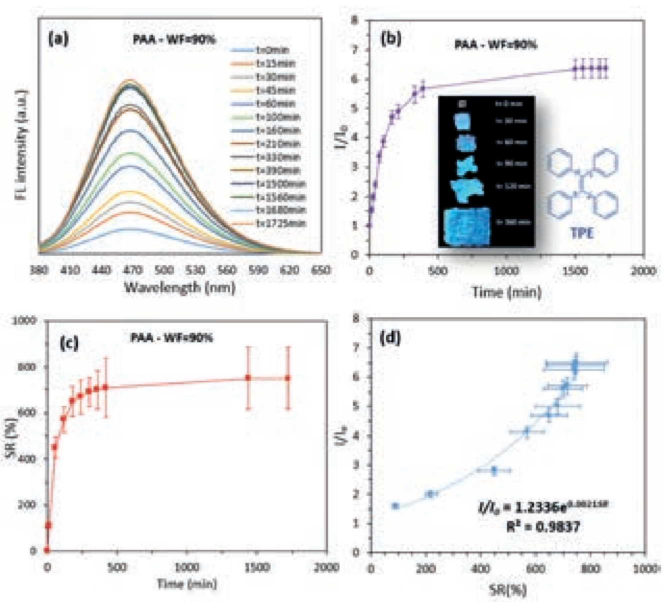
Our researchers have applied aggregation induced emission fluorogens to develop new methods, less prone to uncertainties. In one study, the release of calcium ions (Ca2+) from an alginate hydrogel was monitored in real time using the fluorogen SA-4CO2Na, while simultaneously monitoring changes in the hydrogel's weight. The relationship between fluorescence intensity and Ca2+ concentration was established, and then used to monitor the swelling and degradation of alginate over the course of two hours. A continuous release of Ca2+ (0.046 mM/min) from the hydrogel was observed during both the swelling (0 to 30 minutes) and early stages of degradation (30 to 60 minutes) of alginate. The rate of release of calcium decreased considerably after this period (0.0034 mM/min). As calcium is used to crosslink the alginate hydrogel, understanding the rate of diffusion of calcium from the hydrogel is essential if this gel is to be applied.

Another study used Tetraphenylethylene (TPE) to monitor the fluorescence intensity as a poly(acrylic acid) hydrogel swelled in a water-tetrahydrofuran mixture. An increase in flouresence intensity in the hydrogel was observed as it swelled, attributed to the diffusion of TPE into the hydrogel. The change in flouresence intensity was monitored in conjunction with changes in the weight of the hydrogel. Using this information the relationship between fluorescence intensity and swelling ratio was determined, enabling a new methodology for measuring the swelling ratio of hydrogels. Given the nature of the technique, this approach will be incredibly useful for characterising hydrogels which have high swelling capabilities or have a delicate structure.

[1]. J. A. Rowley, G. Madlambayan and D. J. Mooney, Biomaterials, 1999, 20, 45-53.

ACKNOWLEDGEMENTS
The authors are grateful for support from the International Laboratory for Health Technologies, Flinders University.

FIGURE 1.
Change in the (a) fluorescent spectra, (b) relative intensity, (c) swelling ratio and (d) the established relation between the relative fluorescent intensity and swelling ratio for a poly(acrylic acid) hydrogel during the swelling process in water- TPE/ tetrahydrofuran swelling media with water fraction= 90%.



PROJECTS
CORE CAPABILITIES

VORTEX FLUIDIC MEDIATED TRANSFORMATION OF GRAPHITE INTO HIGHLY CONDUCTING GRAPHENE SCROLLS FOR USE AS CIRCUIT INTERCONNECTS

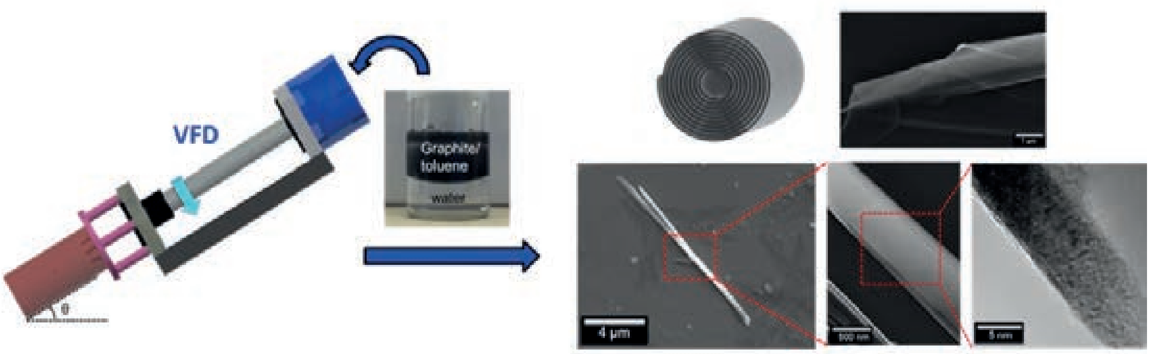
KASTURI VIMALANATHAN, IRENE SUAREZ-MARTINEZ (CURTIN UNIVERSITY), CHANDRAMALIKA PEIRIS (CURTIN), JOSHUA ANTONIO (CURTIN), CARLA DE TOMAS (CURTIN), YICHAO ZOU (UNIVERSITY OF MANCHESTER), JIN ZOU (UNIVERSITY OF QUEENSLAND), XIAOFEI DUAN (UNIVERSITY OF GLASGOW), ROBERT N. LAMB (UNIVERSITY OF MELBOURNE), DAVID P. HARVEY, THAAR M.D. ALHARBI, CHRISTOPHER T. GIBSON, NIGEL MARKS (CURTIN), NADIM DARWISH AND COLIN L. RASTON

Controlled fabrication of nanocarbon with exquisite control over their morphology, shape and size using a sustainable metric is pivotal for harnessing their full potential in a diverse range of applications.

Two-dimensional graphene has remarkable properties that are revolutionary in many applications. Monolayer graphene scrolls with precise tunability are an attractive alternative to the two-dimensional form, retaining many of the desirable properties of both multi walled carbon nanotubes and graphene sheets. The scrolls exhibit the excellent electronic and mechanical properties of MWCNTs as well as maintaining the high carrier mobility of graphene itself. The combination of these unique properties can be exploited for a plethora of applications, in particular in supercapacitors and lithium ion batteries. We have now established the ability to fabricate monolayer graphene scrolls in high yield directly from graphite flakes under non-equilibrium conditions at room temperature in dynamic thin films of liquid using a green metric. Using conducting atomic force microscopy, we demonstrate that the graphene scrolls form highly conducting electrical contacts to highly oriented pyrolytic graphite. These highly conducting graphite-graphene contacts are attractive for the fabrication of interconnects in microcircuits and aligns with the increasing interest in building all sp2-carbon circuits. We have also established that above a temperature of 450 °C the scrolls unravel into buckled graphene sheets, and this process is understood on a developmental theoretical basis. These findings augur well for new applications, in particular for incorporating the scrolls into miniaturized electronic devices.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge support of this work by the Australian Research Council and the Government of South Australia. The authors also acknowledge the expertise, equipment and support provided by the Microscopy Australia and the Australian National Fabrication Facility (ANFF) at the South Australian nodes of Microscopy Australia and the ANFF under the National Collaborative Research Infrastructure Strategy.



PROJECTS
CORE CAPABILITIES

THE PRE-TREATMENT OF ALUMINIUM POWDERS FOR 3D PRINTING

RUBY A. SIMS, STÉPHANE TOUZÉ (ÉCOLE CENTRALE DE NANTES (ECN), FRANCE), JAMIE S. QUINTON AND JEAN-YVES HASCOËT (ÉCOLE CENTRALE DE NANTES (ECN), FRANCE)

The ability to 3D print metal structures is set to transform the additive manufacturing field. Our research is focused on improving starting materials for ease of printing with preliminary results indicating not only the successful modification of metal starting materials but also the creation of a new 3D printed material.

This following research was conducted at École Centrale de Nantes in France and supported by the Nicolas Baudin Travel Grant under the supervision of Professor Jean-Yves Hascoët. The Nicolas Baudin Travel Grant is a prestigious scholarship which allows both undergraduate and postgraduate students from Australia to conduct research at a French University with the support of an industry partner. All research and associated travel was jointly funded by The French Embassy in Australia, École Centrale de Nantes and Flinders University in collaboration with Naval Group. The collaboration between Flinders Institute for Nanoscale Science and Technology and École Centrale de Nantes brings together Flinders' expertise in nanoscale surface modification and characterisation and the additive manufacturing expertise of ECN.

Laser Metal Deposition (LMD) is a novel method of 3D printing which allows for the manufacture of 3D printed materials from powdered starting materials and allows for the creation of novel composite materials not possible with conventional metal manufacturing processes. Small quantities of powdered metals are deposited in a stream of argon and sintered to existing layers using a laser. Typical granulometries used for LMD printing sit in the range of 40-90µm; small particle sizes are preferred as they possess a higher surface area to volume ratio and thus require less energy for melting. This results in printed products with less porosity and increased density. However, these small granulometries make printing with aluminium powders challenging.

Our research is focused on the modification of these powdered starting materials to improve characteristics, along with characterisation of the cross-sectional microstructure of materials after printing. Preliminary results have not only confirmed the ability to modify aluminium powders using an environmentally benign, easily scalable process, but has also resulted in the creation of a novel 3D-printed composite material from these modified powders. Our pre-treatment process is widely applicable and has broadened the range of printable granulometries.

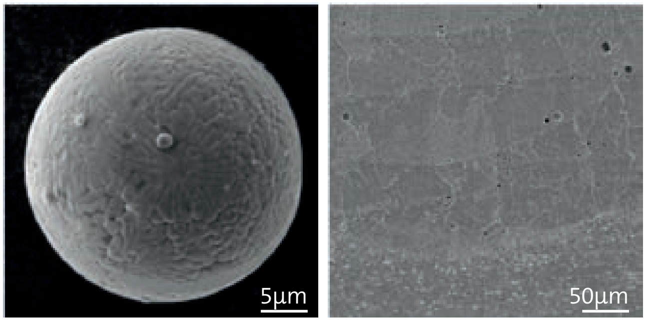


FIGURE 1
SEM images of a modified Al powder particle (left) and a cross-section of the resulting LMD 3D printed material (right).

ACKNOWLEDGEMENTS
The authors wish to acknowledge The French Embassy in Australia, École Centrale de Nantes and Naval Group for their contributions to the Nicolas Baudin Travel Grant.

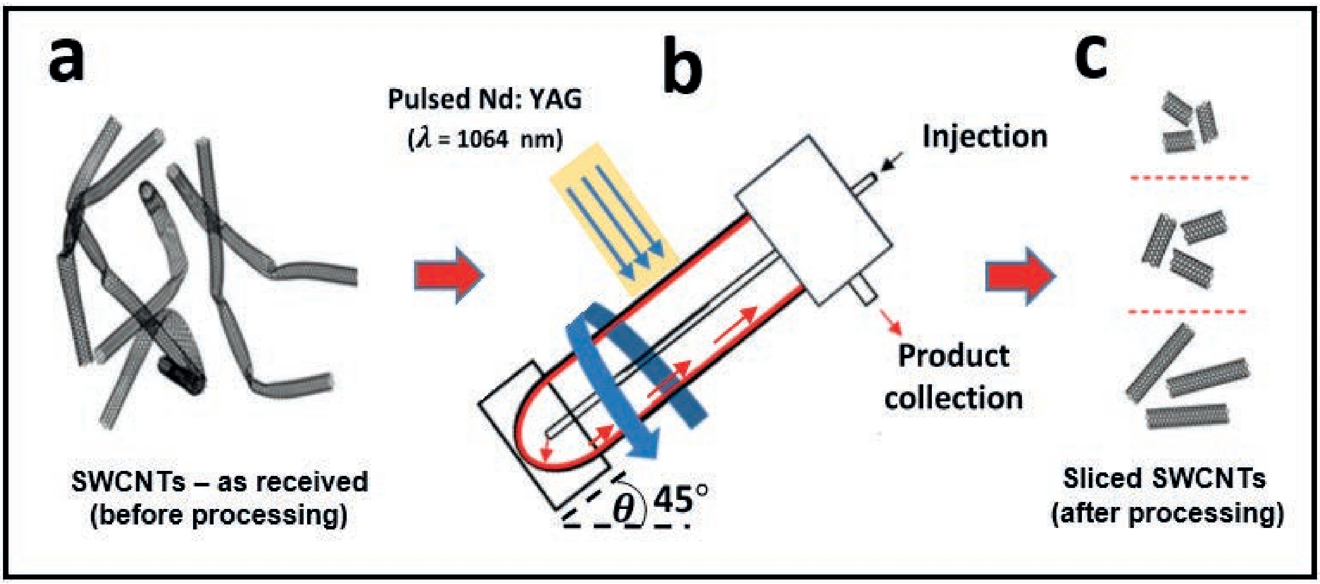
CONTROLLED SLICING OF SINGLE WALLED CARBON NANOTUBES UNDER CONTINUOUS FLOW

THAAR M.D. ALHARBI, KASTURI VIMALANATHAN, WARREN D. LAWRANCE, COLIN L. RASTON

A one step method for precisely controlling the length of short length single walled cabon nanotubes has been developed, for use in diverse applications, ranging from electronics to biomedicine.

We have established the ability to control the length distribution of single walled carbon nanotubes (SWCNTs) using a laser simultaneously with shear stress generated within dynamic thin films in a microfluidic platform, the vortex fluidic device (VFD). Length control depends on a number of operating conditions, which includes the laser pulse energy, the flow rate of the liquid entering the device, the speed of the rapidly rotating tube and its tilt angle, choice of solvent and concentration of the starting dispersion. The induced mechanoenergy in the thin film while being simultaneously irradiated with a Nd:YAG pulsed laser operating at 1064 nm wavelength results in slicing of the SWCNTs, with laser pulse energies of 250, 400 and 600 mJ affording 700, 300 and 80 nm length distributions of SWCNTs respectively. The processing avoids the need for using any other reagents, is scalable under continuous flow conditions, and does not introduce defects into the side walls of the SWCNTs. This technology shows great promise in diverse applications such as solar cells, electronic devices, and drug delivery.

ACKNOWLEDGEMENTS
The authors thank Australian Research Council, The Government of South Australia, and Microscopy Australia for their support of this work. Thaar. M. D. Alharbi would like to thank Taibah University (Ministry of Education, Saudi Arabia) for funding his scholarship.



PROJECTS
CORE CAPABILITIES

FABRICATION OF NANOMATERIALS USING VORTEX FLUIDIC DEVICES & THEIR BIOMEDICAL APPLICATIONS

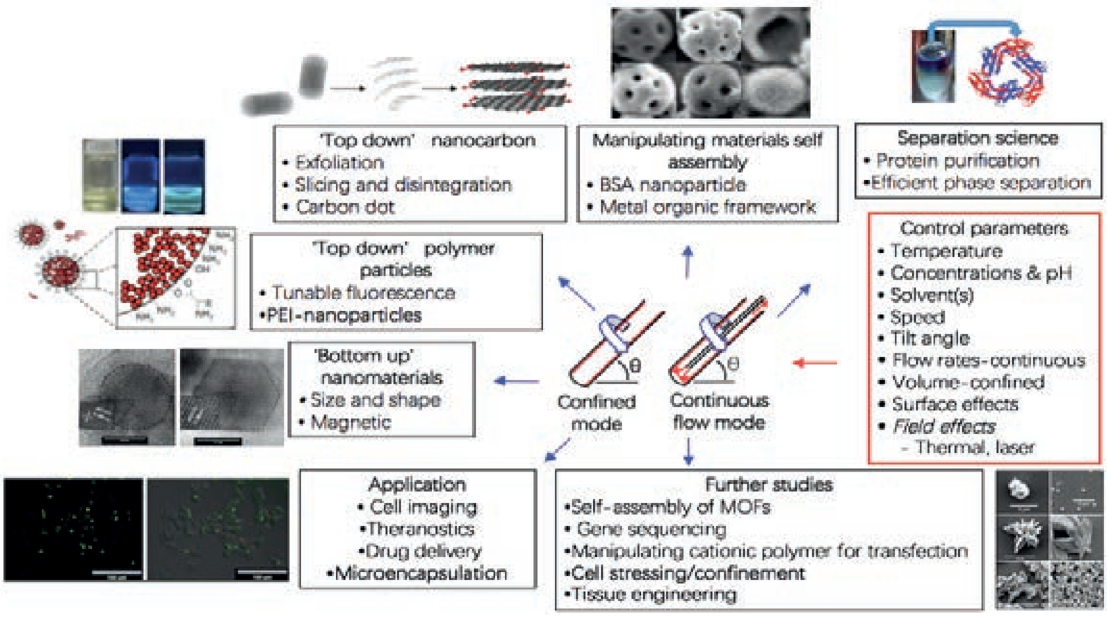
XUAN LUO, WEI ZHANG, COLIN RASTON

We employed a thin film intensified process, using the vortex fluidic device (VFD), to achieve well-controlled and scalable fabrication of functional materials for biomedical applications. This green technology moves away from traditional batch processing, instead using a continuous flow process which creates high-valued functional materials at affordable prices with minimal generation of waste.

Over the last few decades, there has been a considerable interest in the area of developing particulate systems with various sizes. These nano and microsized materials play significant roles in many applications such as cell imaging, cancer theranostics, in vitro diagnosis and drug delivery. In each of these fields, the shapes and homogeneity of the particles can have significant influences on their applications and efficacy. An efficient, controllable, scalable and reproducible technique for the synthesis of micro-/nanoparticles with well-defined properties is ideal.

Microfluidic technology provides an alternative strategy for the synthesis of such materials with precise control over size, shapes and homogeneity. The focus of this project is to create a paradigm shift in nanoscience by employing the thin film intensified process, enabled by the vortex fluidic device (VFD), towards well-controlled and scalable fabrication and manipulation of nanostructures from various raw materials including carbon, metal, polymer and proteins. Carbon nanodots produced using the VFD have a relatively narrow size distribution, between 3 to 13 nm, and have high colloidal stability and are non-toxic up to 200 µg/mL against skin fibroblast cells. We have established that this process is also effective in forming superparamagnetic magnetite nanoparticles of spheroidal and hexagonal shapes with a narrow size distribution in a one-step continuous flow process. The VFD could also be applied to manipulate polyethylenimine-based nanoparticles with tunable fluorescence, macroporous bovine serum albumin-based nanospheres or nanopockets and even to be used as a protein purification tool for crude microalgae extracts. This project presents a significant opportunity to explore the potential application of the VFD in generating high-valued biomedical materials in a more benign way, working toward a variety of industrial applications.

ACKNOWLEDGEMENTS
The authors gratefully acknowledge financial support from the Australia Research Council and the Government of South Australia, also the expertise, equipment and support provided by Microscopy Australia, and the Australian National Fabrication Facility (ANFF) at the South Australian nodes of Microscopy Australia and ANFF under the National Collaborative Research Infrastructure Strategy.



IDENTIFICATION OF SULFUR SPECIES ON THE FRACTURE SURFACE OF PENTLANDITE (FE,NI)9S8

ZOE PETTIFER, JAMIE QUINTON, SARAH HARMER

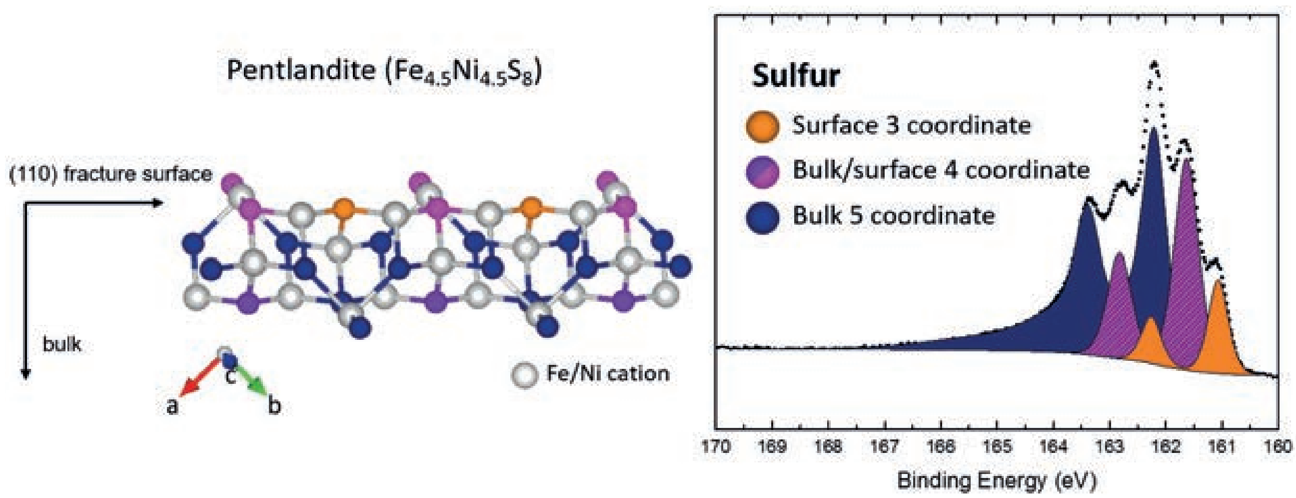
This project uses one of the brightest light sources in the world to illuminate the fracture surface of a small band gap semiconductor. (Fe,Ni)9S8 has recently been investigated for its possible use as a catalyst in hydrogen generation, however the misinterpretation of X-ray photoelectron spectroscopy (XPS) data has led to erroneous assignments of catalytic sites on the material's surface. This project has comprehensively defined the fracture surface of this semiconductor and has defined new XPS fitting parameters for pentlandite's surface and bulk states, which allows for more accurate studies of its surface states in the future.

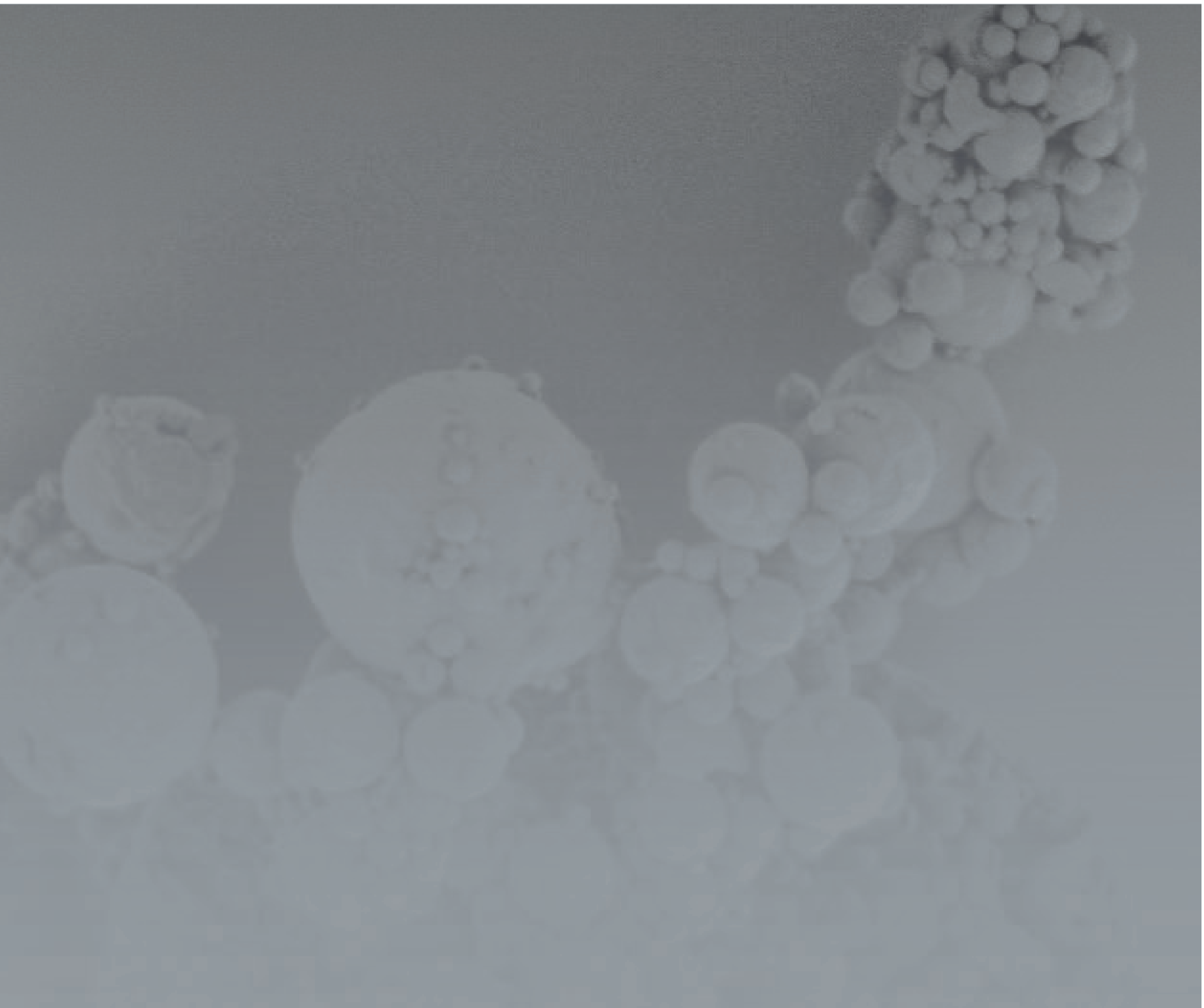
Many transition metal sulfide structures are semiconductors and display interesting electronic properties, rendering them useful for novel electronic devices or catalysts. Evaluating the surface species on a catalyst is essential for understanding the catalytic activity of the material. XPS is a useful tool for characterising the surfaces of materials and has been used frequently for this purpose. However, the spectra for transition metal sulfides in particular are often not well understood and are misinterpreted due to the overlap of multiple bulk and surface states in the spectra.

This project has investigated a pristine fracture surface of pentlandite (Fe,Ni)9S8 using synchrotron XPS. The tunable synchrotron light source has allowed us to study the structure of pentlandite and isolate the surface and bulk features, thereby characterising the surface more precisely than in any previous studies. It has been found that the unreacted fracture surface reveals multiple non-polar fracture planes with Fe and Ni cations and sulfur species at the surface. Of the surface cations, the iron atoms react more readily than the nickel atoms. The sulfur atoms at the surface lose at least one bonding partner to form undercoordinated surface monomers with distinct binding energies that allow them to be distinguished in the spectra. Furthermore, the two distinct sulfur sites in the bulk material have been identified and are distinguishable in the spectra. This study also identifies the required line shapes for the sulfur spectra and has allowed us to develop an accurate fitting procedure for these spectra. This fitting procedure will allow future studies of pentlandite to accurately fit the spectra and more effectively use XPS as a technique to identify the species formed on these semiconductor surfaces.

ACKNOWLEDGEMENTS
The authors thank the Australian Research Council for their support of this work (FT110100099).

FIGURE 1
The sulfur 2p spectra for the pristine pentlandite surface shows three distinct doublet features representing 3- 4- and 5-coordinate sulfur species.





We enhance our partners through industry-relevant fundamental science.

COLLABORATION

AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION (ANSTO)

ANSTO manages both Australia's national nuclear facility in Lucas Heights in NSW as well as the Australian Synchrotron in Melbourne, Vic. Researchers from the Institute benefit from this partnership through access to state-of-the-art equipment, participation in their research network and the opportunity to apply for ANSTO research grants through AINSE, the Australian Institute of Nuclear Science and Engineering.

AUSTRALIAN SOLAR THERMAL RESEARCH INITIATIVE (ASTRI)

ASTRI is an $87 million, eight year international collaboration with leading research institutions, industry bodies and universities with the aim to position Australia in concentrating solar thermal (CST) power technologies. Flinders University is a key partner is this initiative, a partnership which operates through the Institute and contributes to projects in high temperature corrosion and materials compatibility, catalysts for solar fuels and coatings for heliostats.

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION (CSIRO)

CSIRO is the federal government agency for scientific research in Australia. Its primary role is to improve the economic and social performance of industry, for the benefit of the community. The Institute has partnered with CSIRO on several projects in the Energy, enzyme reactions as well as light assisted RAFT polymerisation.

NATIONAL INSTITUTE FOR MATERIALS SCIENCE (NIMS), JAPAN

NIMS is not only one of the largest research centres in Japan but also one of the world leaders in nanotechnology research. In 2011 Flinders University signed an MOU with NIMS, this relationship has gone from strength to strength. In addition to ongoing research collaborations between academics, the Institue is also the only Australian participant in the International Graduate Cooperative Program in which PhD students work at NIMS for 6-12 months. In 2015 this collaboration was extended further with the Institute participating in an Annual International Summer School with students from NIMS,

DEFENCE SCIENCE AND TECHNOLOGY GROUP (DST GROUP)

DST Group is responsible for leading technology development for Australia's defence forces and is a partner in the Centre of Expertise for Energetic Materials (CEEM) based at Flinders. Research collaborations that leverage our unique capabilities are expanding and offering new and exciting projects to Flinders researchers.

As an example, we have been exploring the development of photochromic dyes as part of a collaborative program with DST Group on adaptive camouflage for combat uniforms, nets and coverings. The development aims to allow the camouflage pattern to adapt to changes in environmental lighting conditions and thereby improve signature management effectiveness.

PURATAP COLLABORATION

In partnership with South Australian company Puratap, the Salisbury Council and the Defence Department, along with the Universities of South Australia and Newcastle we have begun a 12-month trial of new ways to detect and remove perflourinated alkyls substances (PFAS) from water.

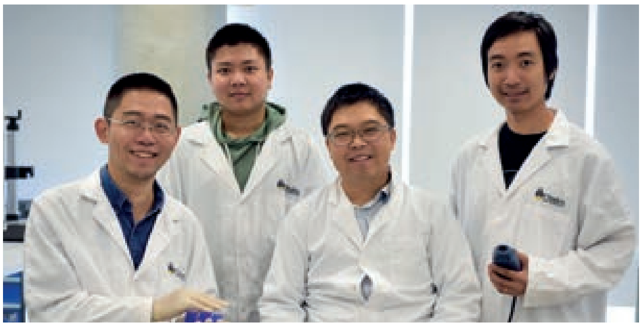
PFAS have been used by the defence forces in the past as an ingredient in fire extinguishers. Though not used now, these substances persist in the environment and have led to contaminated soil and water surrounding the RAAF base at Edinburgh. This trial will employ novel sorbents for PFAS capture, as well as new detection methods suitable for on-site detection. Monitoring PFAS concentrations on-site throughout the remediation process will ensure the most effective treatment, without interruptions for lab based analysis.

The remediation approach is utilising a composite material made from activated charcoal (a gold standard for water treatment) and a newly developed sulphur copolymer which also has adsorption affinities for PFAS and heavy metals. This copolymer is derived from industrial waste products (such as sulphur and used cooking oils), ensuring the final product is cheap and readily scalable. Preliminary data for the composite shows that we are able to manipulate the material properties and that the composite material is more effective at removing perfluorooctanoic acid (PFOA, a perflourinated alkyl substance) than activated charcoal alone over short contact periods. Continuing work aims to improve this effectiveness even further to allow for the rapid treatment of contaminated water, including the possibility of remediation at the point of use.

With recommended limits as low as 0.07 parts per billion (ppb) for some PFAS molecules in drinking water, incredibly sensitive methods are needed to monitor PFAS concentrations in the environment to ensure the safety of water supplies and the effectiveness of remediation approaches. Our solution is using a smartphone app coupled with the vortex fluidic device (VFD), developed by Prof. Colin Raston at Flinders University, to quickly and easily monitor PFAS levels in water. Initial trials showed that the approach was able to detect PFAS in the 10 to 1000 ppb range, with continued work exploring the use of a novel aggregation induced emission fluorogen to improve the sensitivity of the technique.

Throughout these trails we are sampling water from wetland and managed aquifer recharge systems in the Salisbury Council area, ensuring that the approaches developed are readily applied to the affected areas.

We gratefully acknowledge the support provided by the South Australian Government and Defence Science Technology Group in the form of a Defence Innovation Partnership Collaborative Research Grant.



2D FLUIDICS COLLABORATION

Following on from a research partnership with First Graphene in 2017, researchers from the Institute, including Professor Colin Raston and Dr Kasturi Vimalanathan, have been part of the formation of a new company, 2D Fluidics Pty Ltd.

2D Fluidics is equally owned by Flinders University and First Graphene and will commercialise the SA-designed Vortex Fluidic Device (VFD) to produce environmentally safe supplies of high-grade graphite at a price and scale viable for use in energy storage devices, coatings, polymers and other modern materials.

The Vortex Fluidic Device was invented at Flinders University by Professor Colin Raston and allows for new approaches to manufacturing processes. The VFD received considerable attention in 2015 when Professor Colin Raston and his colleagues were awarded an Ig Nobel Prize for using the VFD to partially unboil an egg. Since then, the VFD has been used to produce a range of existing nanomaterials, as well as developing new materials, all without the use of harsh or toxic chemicals.

Two patents have been assigned to 2D Fluidics by Flinders University around the production of carbon nanomaterials. The ability to cheaply produce high-quality graphene and other nanomaterials with safe, scalable processes opens up opportunities for commercialisation of technologies using these new materials. These materials have been predicted to revolutionise a range of industries from engineering to medicine, replacing metal in circuits, supercapacitors, and batteries. Their superior strength could also see them being used in novel plastics and composite materials.

Commercial availability of the VFD will also have a big impact on teaching and research around the globe, as it is expected to become an in-demand next generation research and teaching tool for universities worldwide.

US ARMY COLLABORATION

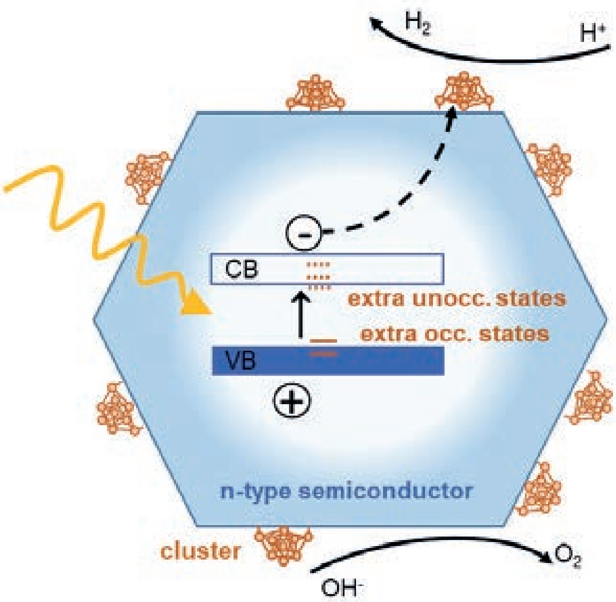
Though current solar technology has achieved considerable uptake, the challenges of electricity storage still present a significant hurdle to portable renewable energy generation for remote locations. Partnering with the United States Army, researchers from the Institute are working on storing solar energy in chemical form by fabricating an efficient, low-cost photocatalyst.

Commonly used technologies currently convert sunlight directly to electricity, which generally then requires storage in batteries. Current batteries are heavy and expensive, resulting in unfavourable energy densities. As an alternative, this project uses metallic gold clusters to catalyse the production of hydrogen by splitting water. These gold clusters are between 5 and 100 atoms in size, and are deposited in very small quantities (< 0.5% by weight) on a semiconducting substrate. By altering the size of the clusters and the substrate used the available energy levels may be tuned to maximise their catalytic activity.

Depositing metal clusters from the gas phase allows the size of the clusters to be readily varied, with no post-treatment required. Once optimised combinations of cluster size and semiconducting supports have been identified, chemical processes will be used to produce the catalysts on an industrially relevant scale.

Using metal clusters as the active sites overcomes two problems faced by existing photocatalysts. First, the amount of precious metal required is much lower, as a higher fraction of the gold atoms are on the surface compared with the nanoparticles which have already been developer for photocatalysis. Second, systems developed using gold clusters are already higher in efficiency than catalytic systems using nanoparticles.

Once the hydrogen has been produced using these catalytic systems it can either be used as a storable fuel, or be used as a feedstock along with carbon dioxide for further reactions to convert the hydrogen into other fuels such as methanol or ethanol. This process may even use a source of carbon dioxide such as a combustion engine to create the hydrocarbon fuel. On the long term this may lead to closed cycle systems being used for power generation, where the exhaust is cycled back into the system as a feedstock.

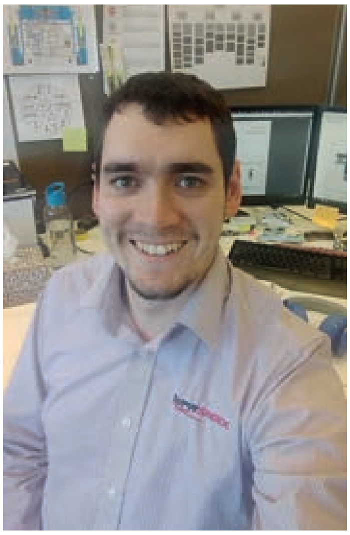


SUPASHOCK COLLABORATION

The Institute's relationship with Supashock has continued to grow, with Research Leader Professor Jamie Quinton spending Semester One of 2018 on sabbatical leave with Supashock. Jamie was embedded within Supashock's Control Systems Team, where he was working with a team of robotic, electrical and mechanical engineers to develop an active suspension system for a US client's autonomous vehicle fleet. Jamie's expertise was used to help develop and troubleshoot the algorithms and mathematics required to combine input from three separate sensors to calculate the absolute position of the piston within a damper, and to think about how to develop next level technologies. Apart from working with and mentoring the young engineers in the Control Systems Team, Jamie was treated like a Thinker in Residence across all of Supashock's projects. Bringing his perspective as an experimental physicist, Jamie added value through his knowledge and perspectives of materials science, physics and mathematics to a range of projects across the company.

Supashock also had an eventful year, as the company has grown to over 35 employees they have relocated their premises to Edinburgh Park in Adelaide's north, hosting a visit from Federal Defence Minister Christopher Pyne to demonstrate their automatic load handling system (ALHS), which was launched at an international defence fair in France in June 2018.. So far Supashock has also employed around 9 Flinders graduates, including former Institute members Andrew Webb and Sean Reynolds.

2019 promises to be another exciting year for this collaboration, with Jamie being part of a Defence Innovation Partnership project which involves Supashock, Defence Science and Technology Group, and all three South Australian Universities.



Unique, world-class instrumentation underpins our innovative, cutting-edge research.

INFRASTRUCTURE

FLINDERS MICROSCOPY AND MICROANALYSIS

Flinders Microscopy and Microanalysis was formed in 2018, bringing together the capabilities in microscopy, microanalysis, spectroscopy and imaging from across Flinders University, including many instruments housed in the Institute. This state-of the art facility is led by a multi-disciplinary team of experts and combines both optical microscopy and materials characterisation facilities to support the characterisation and imaging needs of researchers, government, and industry in South Australia and beyond.

Flinders Microscopy and Microanalysis instruments include:

MATERIALS CHARACTERISATION

Large-Volume Micro-CT (coming in 2019)

- Nixon XTH 225ST CT Scanner

Atomic Force Microscopy

- Multimode 8 AFM with Nanoscope V controller
- Dimension FastScan AFM with Nanoscope V controller

Confocal Raman Microscopy

- WITec alpha300R confocal Raman microscope

Tip Enhanced Raman Spectroscopy

- Nanonics TERS with XplorRA Horiba Scientific confocal Raman microscope

Scanning Electron Microscopy

- FEI Inspect F50

Scanning Auger Nanoprobe

- PHI-710 AES

Neutral Impact Collision Ion Scattering Spectroscopy (NICISS)

- Custom built

Metastable Induced Electron Spectroscopy

- Custom built, also includes:
- Ultraviolet Photoelectron Spectroscopy
- Inverse Photoemission Spectroscopy
- X-Ray Photoelectron Spectroscopy
- NICISS

Nuclear Magnetic Resonance

- 400 MHz NMR – Bruker AVANCE III
- 600 MHz NMR – Bruker AVANCE III with autosampler

BIOMEDICAL AND OPTICAL IMAGING

Confocal fluorescence imaging

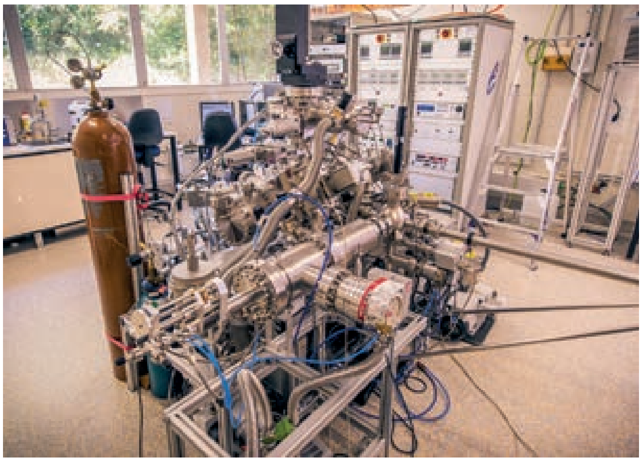
- Confocal Leica SP5 (inverted)
- Confocal Olympus FluoView 1000 (inverted)

Laser scanning microscopy (coming in 2019)

- Zeiss LSM 880 Fast Airyscan Confocal Microscope

For more details on Flinders Microscopy and Microanalysis and how we can support your research please visit flinders.edu.au/microscopy, or email microscopy@flinders.edu.au

FLINDERS MICROSCOPY AND MICROANALYSIS



INFRASTRUCTURE

FABRICATION AND MODIFICATION

The Institute hosts fabrication facilities enabling the production of nanoscale materials such as porous silicon, lipid bilayers, carbon nanotubes, functional nanoparticles, microfluidic devices, and quantum dots, as well as instrumentation to modify the surfaces of these structures and to print materials for applications such as next generation solar power.

MATERIAL PROPERTIES

Capabilities within the Institute not only enable the characterisation and analysis of materials, equipment is also available to define the properties of the material structure such as measuring the hydrophilicity/hydrophobicity of a surface, assessing the reactivity of materials using the electrochemistry suite, investigating particle size and film thickness and also exploring particle-particle interactions.

POLYMER CHARACTERISATION

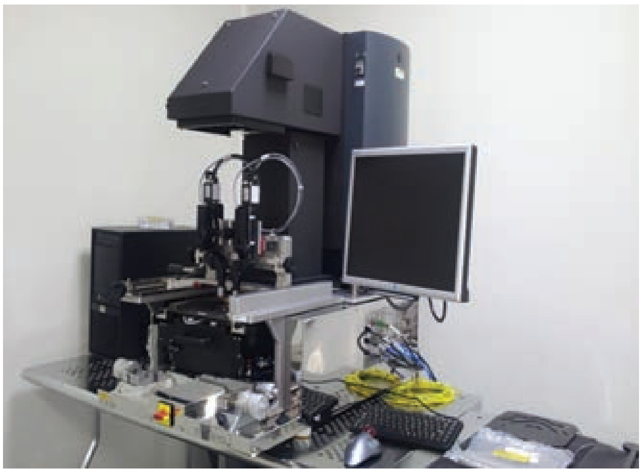
Equipment for characterisation of nanomaterials at the centre are extensive and include a complete range of polymer characterisation equipment with methods such as: Gel Permeation Chromatography (GPC), Dynamic Mechanical thermal Analysis (DMA), Differential Scanning Calorimetry (DSC), Simultaneous Thermal Analysis (STA), tensile testing and a rheometer.

TONSLEY LABORATORIES

Flinders at Tonsley is designed to be an interface between university and industry. It is the main base for the New Venture Institute and the Medical Device Research Institute, as well as some of Adelaide's leading businesses and key industries. The Institute for Nanoscale Science and Technology is co-located between the main campus and Tonsley, occupying several offices, a meeting space and two laboratories;

- The Advanced Materials laboratory, shared with the materials engineering group. This space houses an FTIR spectrophotometer, tensile and impact testing machines, salt spray durability test, ovens and 6 fume cabinets for chemical synthesis research.

- A clean room, used for fabrication of electronic devices, and other high sensitivity material and device preparation work. Also present are a lithography processing system, glove box and other preparation equipment.



INFRASTRUCTURE

NATIONAL RESEARCH FACILITIES

The Institute is a member of Microscopy Australia (formerly AMMRF) and ANFF, these networks provide access to cutting edge facilities throughout Australia.

MICROSCOPY AUSTRALIA

This is a national collaborative research facility for the characterisation of materials at the micro, nano and atomic scales. Microscopy Australia facilities are accessible to all Australian researchers, comprising of over 300 instruments and 100 expert staff nationwide, dedicated to supporting research. This enables all researchers to access expert support, training and instruments and facilitates world-class Australian research and innovation. Research leader Associate Professor Sarah Harmer is the Deputy Director of the South Australian Research Facility (SARF), the SA branch of Microscopy Australia. SARF is an alliance of Flinders Microscopy and Microanalysis, Adelaide Microscopy and the Future Industries Institute.

THE AUSTRALIAN NATIONAL FABRICATION FACILITY

The ANFF links 8 university-based nodes to provide researchers and industry with access to state-of-the-art fabrication facilities. Each node offers a specific area of expertise including advanced materials, nanoelectronics & photonics and bio nano applications. The ANFF SA node is co-located at the Future Industries Institute and Flinders University, and brings together expertise in surface modification, characterisation, nanotechnology, and advanced materials.

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