Australian Nanotechnology Network

ANNUAL REPORT

2017

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Mission Statement and Objectives

MISSION STATEMENT

The Australian Nanotechnology Network's mission is to enhance Australia's Research in Nanotechnology and related areas, by effectively promoting and drawing together collaborations in this field.

Network was created in 2004 by four seed funding groups joining together in order to cover the broader areas and to create a larger more effective network.

The Australian Research Council funding came to an end in 2010. ANN received funding from the Department of Innovation, Industry, Science and Research towards the continuation of network operations until the end of 2013.

The following institutions have been contributing to the funding of the network operations which will be continuing.

Australian National University, CSIRO, Deakin University, Flinders University, Griffith University, Latrobe University, Monash University, Queensland University of Technology, RMIT, University of Melbourne, University of Newcastle, University of New South Wales, University of Queensland, University of South Australia, University of Sydney, University of Technology Sydney, University of Western Australia, University of Wollongong

OBJECTIVES

The Nanotechnology field is one of the fastest growing areas of research and technology. The Australian Nanotechnology Network is dedicated to substantially enhancing Australia's research outcomes in this important field by promoting effective collaborations, exposing researchers to alternative and complementary approaches from other fields, encouraging forums for postgraduate students and early career researchers, increasing nanotechnology infrastructure, enhancing awareness of existing infrastructure, and promoting international links. The ANN will achieve these goals through its dedication to bringing together all the various groups working in the field of Nanotechnology and related areas within Australia.

The Network aims to:

1. bring together key groups working in this area to communicate, innovate, share and exploit mutual strengths and facilities to make a major impact internationally
2. identify new areas of research
3. highlight the infrastructure that is available in Australia and promote use and sharing of these facilities
4. identify infrastructure needs to strengthen research
5. leverage off and interact with other networks for mutual benefit
6. develop industry and international links
7. interact with the wider community
8. encourage postgraduate students and early career researchers to enhance their skill base and training
9. become a national resource for industry, research and educational institutions, government and policy developers

MISSION STATEMENT AND OBJECTIVES

STRUCTURE AND MANAGEMENT

The Australian Nanotechnology Network management committee represents the wider membership and is chaired by an independent chair. The committee determines the priorities for each activity and allocates the budget for the network. A Network Manager manages the day to day administrative tasks under the Guidance of the Network Convenor.

Management Committee Chair

The duties of the Chair are to chair Management committee meetings, provide advice to the Network, confirm meeting minutes for circulation to Management committee members, represent the network at important meetings and provide general guidance to the network management. The current chair is Professor Erich Weigold.

Convenor

The convenor has overall responsibility for the Network operations and for meeting the network requirements and guidelines. Represent the network at key Nanotechnology meetings in Australia and key International network meetings. Supervise Network staff and provide overall direction to the network activities. The network Convenor is Distinguished Professor Chennupati Jagadish.

Management Committee Members

The management committee members participate in committee meetings. They serve on the Working Group sub committees, represent the Network and publicize network activities, organise and actively participate in the management of network activities, act as ambassadors for the Network and provide advice to the network members about network programs.

Working Groups

Committee members form into working groups that assess funding applications and other issues prior to the matter going to the full Management committee for voting. There are four working groups and their areas comprise.

Events Working Group *– evaluates all applications for sponsorship funding for Conferences, Workshops, summer and Winter Schools and Short Courses.*

Visits Working Group *– evaluates all applications for Short and Long Term Visits and Overseas Travel Fellowships.*

Outreach Working Group *– evaluates outreach proposals such as Public Lectures, Distinguished Lecturers visits, Outreach and Webpage.*

MISSION STATEMENT AND OBJECTIVES

Education Working Group *– evaluates applications for student, ECR and Entrepreneur Forums and educational activities.*

The Convenor fills in if a working group member is unavailable or when there is a conflict of interest.

The Management Committee (MC) comprises of the following members, representing 6 States, students and early career researchers and chaired by an Independent chair.

Chairman – Emeritus Professor Erich Weigold – Australian National University

Convenor- Prof Chennupati Jagadish - Australian National University

Events Working Group

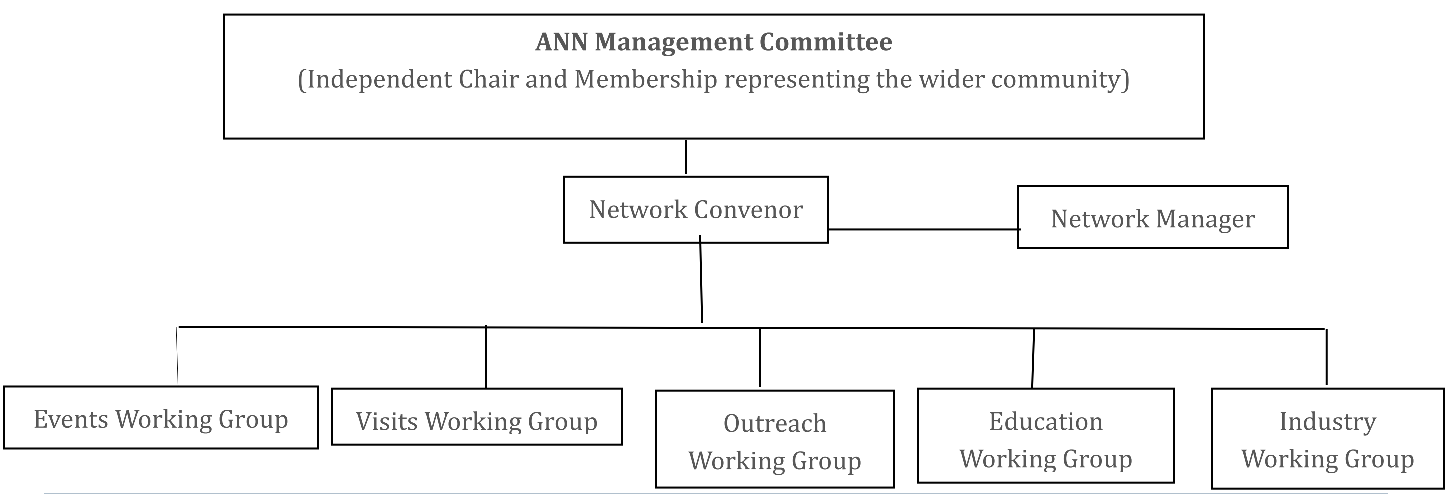
Prof. Laurie Faraone	University of Western Australia
Prof. Peter Majewski	University of South Australia
Prof Michael James	Synchrotron Light Source Australia
Prof Ian Gentle	University of Queensland

Visits Working Group

Dr Dane McCamey	University of New South Wales
A/Prof Michael Higgins	University of Wollongong
Ms Gayathri Rajeev	University of South Australia
Dr Stefan Herrar	IBM

Dr Anita Hill	Commonwealth Scientific and Industrial Research Organisation
A/Prof Paul Wright	RMIT-University, Convenor of NanoSafe Australia
Prof David Lewis	Flinders University
Prof. Deb Kane	Macquarie University
Prof Terry Turney	Micronisers Pty Ltd and Monash University
Ms Liz Micallef	Network Manager

ANN Structure



2017 IN REVIEW

2017 IN REVIEW

The work in 2017 was focused on enhancing the funding of programs and events related to Nanotechnology around the country.

Early Career Researcher Workshop – University of South Australia

1 Young Nano Ambassador Award

1 Short Term Visit

2 Australian National Fabrication Facility Short Term Visits

11 Overseas Travel Fellowships

8 Events sponsored by ANN

Activities undertaken by ANN

List of Activities funded / organized by ANN

- Early Career Researcher Workshop – University of South Australia

Young Nanotechnology Ambassadors program

- Australian Capital Territory –Dr Mohsen Rahmani from the Australian National University

Short Term Visits

- Dr Yaping Chen from Monash University visit to the Australian National University

Australian National Fabrication Facility Short Term Visits

- Dr Natalie Holmes from the University of Newcastle (Centre for Organic Electronics) Visit to the Melbourne Centre for Nanofabrication, Victorian ANFF Node
- Dr Guanghui Ren From RMIT to visit the ANFF at the Australian National University

Overseas Travel Fellowships

- Dr Hoang Phuong Phan from Griffith University visit to Stanford University, USA for a period of eight weeks.
- Dr Pei Pei Jia from the University of Adelaide visit to the Medical Research Council (MRC)-Laboratory of Molecular Biology (LMB), Cambridge, UK, for a period of two months.
- Mr Liam Scarratt from The University of Sydney visit to the Max Planck Institute for Polymer Research, Mainz, Germany for a period of twelve weeks.
- Ms Jeeson Kim from RMIT University visit to the Korean Institute of Science and Technology (KIST) in South Korea for a period of six weeks
- Mr Jun Peng from the Australian National University visit to the King Abdullah University of Science and Technology (KAUST) Solar Center in Saudi Arabia, for a period of six months
- Dr Yichao Zou from the University of Queensland visit to TO TJE Ultramicroscopy Research Centre at Kyushu University for a period of one month
- Dr Philipp Reineck from RMIT visit to The Mochalin Lab at Missouri University of Science & Technology, USA for a period of eight weeks.
- Dr Tristan Clemons from the University of Western Australia visit to the Stupp Laboratory at the Northwestern University, Chicago, USA for a period of three months

ACTIVITIES UNDERTAKEN BY ANN

- Dr Mohsen Rahmani from the Australian National University visit to the Laser Zentrum, Hannover, Germany for a period of five weeks
- Miss Yuan Wang from the University of New South Wales visit to the Fritz-Haber Institute, Max Planck Society, Berlin, Germany for a period of three months
- Mr Deepak Dwivedi from Curtin University visit to Cambridge University for a period of eight weeks.

Workshops and Events Sponsored by ANN

- 8th Biennial Australasian Colloid and Interface Symposium. 29/01/2017 - 02/02/2017 - Coffs Harbour
- 11th Conference on New Diamond and Nano Carbons. 28/05/2017 - 01/06/2017 - Shangri-la, Cairns
- 7th International Conference on Nanomaterials by Severe Plastic Deformation. 02/07/2017 - 07/07/2017 – Sydney
- 8th International Nanomedicine conference 03/07/2017 - 05/07/2017 - Crowne plaza, Coogee beach, Sydney
- Nanotechnology Entrepreneurship Workshop for Early Career Researchers. 12/07/2017 - 13/07/2017 - Future Industries Institute, Mawson Lakes Campus, University of South Australia.
- International Symposium on Energy Conversion and Storage Materials 31/07/2017 - 03/08/2017 - Brisbane
- International Conference on BioNano Innovation. 24/09/2017 - 28/09/2017 - University of Queensland
- Nanostructures for Sensors, Electronics, Energy and Environment. 26/09/2017 - 29/09/2017 - Queensland University of Technology
- Emerging Polymer Technologies Summit 22/11/2017 - 24/11/2017 - RMIT University

Young Nano Ambassador Awards

The Young Nanotechnology Ambassador Awards were set up to promote science and science education in state and territory schools. Two awards are provided per state/territory and each award is valued up to $2000.

The young nanotechnology ambassadors are required to visit a minimum of four schools (preferably at least one regional school) to inspire students about nanotechnology, and more broadly science education. It is up to the ambassadors to decide which schools they visit and to arrange these visits with the schools. The ambassadors are encouraged to present a talk which could include visual demonstrations or simple experiments, slide shows or other multimedia presentations.

There was only one applicant for the Young Nanoscience Ambassador awards for 2017

- **Australian Capital Territory –Dr Mohsen Rahmani from the Australian National University**

Short Term Visits

Funding support is also available to **postgraduate students** and **early career researchers** (within 5 years of award of PhD degree) for travel and accommodation expenses associated with Short Term Visits to research Institutions within Australia. Up to $1,000 is provided for travel and accommodation to a location(s) within Australia.

Dr Yaping Chen from Monash University visit to the Australian National University

ANN Short-term Travel Award Report

The ANN short-term travel award was used to support my two-week visit to the Australian National University in Canberra, to work with Prof. Carola Vinuesa on the study of Bio-nano interface between immune cells and vertically aligned silicon nanowire (VA-SiNW) arrays.

The outcomes of this visit are:

1. By incorporating Prof. Vinuesa's expertise in immunology, especially the mechanism of B lymphocyte regulation, we were able to investigate into the interfacial interaction between VA-SiNW and primary mouse and human B cells (**Fig. 1a-c**). Primary mouse naïve B cells were isolated from splenocytes using magnetic-activated cell sorting (MACS) selection, and seeded onto VA-SiNWs at a concentration of 1 × 106 cells/ml in complete RPMI (10% FBS, 2 mM L-glutamine, 1% Pen-Strep, 1 mM sodium pyruvate, 1% MEM non-essential amino acids, and .1% 2-mercaptoethanol). After 12 h culture on NWs, cells were fixed for SEM/FIB-SEM imaging. The result showed the direct penetration of NWs into the cell membrane of primary B cells and thereby potentially can be used to transport exogenous biomaterials into the cells.

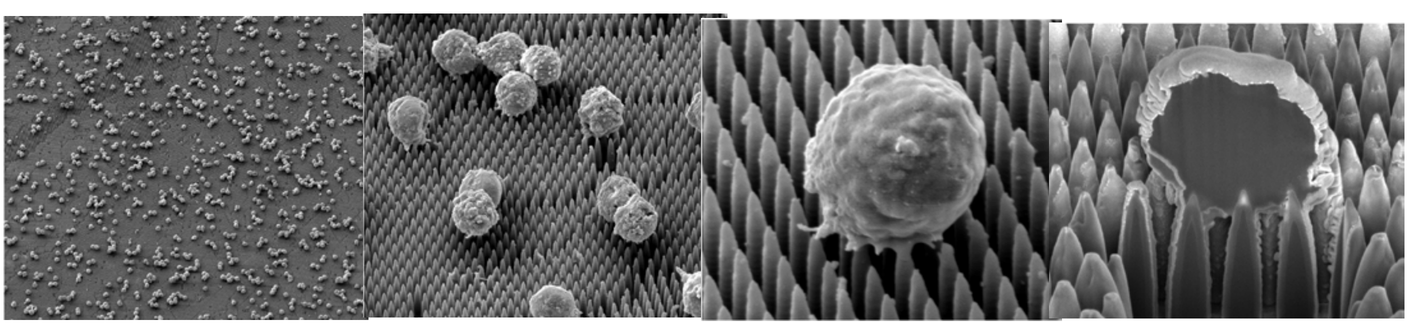


Figure 2. NW–cell interface. a-c) SEM imaging showing NW–cell interface from low **a**), medium **b**), to high magnification **c**). **d)** FIB-SEM imaging illustrating the NW–cell cross section and NW penetration through the cell membrane.

2. The next step is to utilise VA-SiNW system for gene delivery into the primary B cells. I led a series of pilot experiments to determine the effectiveness and efficiency of NW mediated transfection *in vitro*. By measuring the expression of a green fluorescent protein (GFP; here, reporter plasmid gWIZ-GFP), we were able to evaluate the success of transfection.

To begin with, GFP plasmids were coated onto surface-functionalised NW arrays. Primary mouse B cells were then counted and seeded onto the NWs. After 4–12 h culture, cells were re-harvested and cultured in fresh media for two more days, before measuring their GFP expression by flow cytometry. The preliminary data, as hypothesised, have shown that short-term culture was sufficient for cells to uptake the plasmids coated on NW, and that they began to express GFP within 24–48 h. Up to 80–90% of cells were detected as GFP+ post-transfection. Notably, the transfection efficiency was significantly enhanced, from 37% up to 90%, when increasing plasmid concentration from 30 to 100 ng/µl.

3. This travel award also supported my attendance to the internal seminars and presenting as an invited speaker in Vinuesa's lab. The project enabled my training in specialised skills that will be crucial to R&D in the emerging CAR-T nanobiotech sector. Moreover, I have gained cross-disciplinary theoretical and applied skills by combining the disciplines of nanomaterials and immunology - in particular, the intricacies of constructing smart and functional bio-nano interface. The visit strengthens the collaboration between Prof. Voelcker's group from the Monash Institute of Pharmaceutical Sciences (MIPS), with Prof. Vinuesa's lab in John Curtin School of Medical Research, and promote the research of Bionano interface. The results showed potential in developing VA-SiNW as a novel platform for cost-efficient and high-throughput gene transfection, which can be used for cellular immunotherapy based on chimeric antigen receptor (CAR)-T cells.

4. The results were included in abstracts and accepted for oral presentations in ASBTE2018 conference.

I would like to thank the Australian Nanotechnology Network for selecting me for this award and for providing the funding that has helped me to successfully conduct that work

ANFF SHORT TERM VISITS

Australian National Fabrication Facility Short Term Visits

Funding support is also available to **postgraduate students** and **early career researchers** (within 5 years of award of PhD degree) for travel and accommodation expenses associated with the Australian National Fabrication Facility Short Term Visits to ANFF Facilities within Australia. Up to $1,000 is provided for travel and accommodation to a location(s) within Australia.

DR NATALIE HOLMES FROM THE UNIVERSITY OF NEWCASTLE (CENTRE FOR ORGANIC ELECTRONICS) VISIT TO THE MELBOURNE CENTRE FOR NANOFABRICATION, VICTORIAN ANFF NODE

Section A – Details of Research Trip

Researcher's Institution:	University of Newcastle, Centre for Organic Electronics
ANFF Node Visited:	Melbourne Centre for Nanofabrication, Victorian ANFF Node
ANFF Short Term Visit	19th Sept 2017
Dates of ANFF Node Visit:	7 – 8th Dec 2017
Title of Project:	Development of organic electronic sensor devices for detecting sodium ions in sweat analyte solutions.
ANFF Equipment Accessed:	FEI Helios Nanolab600 Dual Beam FIB-SEM with EDS detector.
Funding Provided by Other Sources:	The University of Newcastle provided funding for research consumables for sample preparation; materials P3HT, PVPy, P18C6, ITO patterned glass substrates; ANFF instrument time cost.

Section B - Outcomes of Research Trip

Dr Natalie Holmes from the University of Newcastle (Centre for Organic Electronics) to Visit the Melbourne Centre for Nanofabrication, Victorian ANFF Node

The ANN ANFF Short Term Visit funding was used to support a two day visit to the Melbourne Centre for Nanofabrication (Victorian ANFF Node) to use the FEI Helios Nanolab600 Dual Beam FIB-SEM with EDS detection to measure sodium ion organic electronic sensor devices. The ANFF facility enabled me to perform key experiments for the sodium ion organic electronic sensor research project that I was not able to perform at the University of Newcastle due to the lack of a FIB-SEM instrument.

Project Background

At the Centre for Organic Electronics, University of Newcastle, we have been developing sodium ion organic electronic sensors which provide an inexpensive and robust platform for measuring analytes in human sweat through amperometric monitoring of chemiresistor response. Sodium ions (Na^+) are key biomarkers for dehydration,[1] and monitoring the loss of sodium ions can help prevent the symptoms of electrolyte imbalance caused by dehydration. Early studies conducted at the Centre for Organic Electronics have shown that the incorporation of metal cations (such as Na^+ and Li^+) into organic thin-film transistors can lead to enhanced current modulation via doping near the dielectric-semiconductor interface.[2] We hence hypothesised that the same cations present in sweat could act as a source of doping for a semiconductor layer in chemiresistor devices for sensing applications. We incorporated a crown ether binding moiety into the chemiresistor architecture, as such molecules are known for their metal cation binding capacity,[3] and hence provided an experimental lever for us to control the *degree of doping* of the semiconductor. While there have been several technologies reported by the research community for the detection of cations in sweat for a dehydration monitoring system, the technology we are working on at the Centre for Organic Electronics has the benefit of low cost fabrication, no liquid filling components, the ability to be easily miniaturised, and compatibility with modern large-scale manufacturing processes.

Measurements at the Melbourne Centre for Nanofabrication

Organic electronic sensors of the ITO/P3HT/PVPy (Reference Device) and ITO/P3HT/PVPy/P18C6 (CE Device) architecture were fabricated at the University of Newcastle and transported to the Melbourne Centre for Nanofabrication for measurement. Indium tin oxide (ITO) formed the device electrodes, poly(3-hexylthiophene) (P3HT) formed the semiconductor layer, poly(4-vinylpyridine) (PVPy) the supporting matrix (and dielectric in other architectures), and poly[(dibenzo-18-crown-6)-co-formaldehyde] (P18C6) the ion binding matrix. Prior to transportation the electronic sensor response to sodium ion analyte solutions was tested, which enabled FIB-SEM/EDS measurements to be performed on the same devices for which electrical characterisation data had been collected.

At the Melbourne Centre for Nanofabrication, FIB milled cross-sections were generated for both Reference Devices and CE Devices. Scanning electron micrographs (SEM) were obtained of the FIB milled cross-sections enabling the visualisation of the layer structure of the sensor devices (Figure 1a and b). Energy dispersive X-ray spectroscopy (EDS) was utilised to collect point spectra at various locations on the device cross-section surfaces. The results of the EDS analysis showed that sodium ions were present in the crown ether (P18C6) layer of the organic electronic sensor devices (Figure 1c). As sodium is an element that is common only to the analyte and not the materials from which the devices were fabricated (ITO, P3HT, PVPy, P18C6), EDS was a suitable method to use for analysis. The EDS results supported the electrical characterisation data by providing evidence of the ability of P18C6 to bind sodium ions. The experiments conducted at the Melbourne Centre for Nanofabrication enabled us to further probe the operating mechanism of these organic electronic sensors and hence facilitate the ongoing development of this promising new technology.

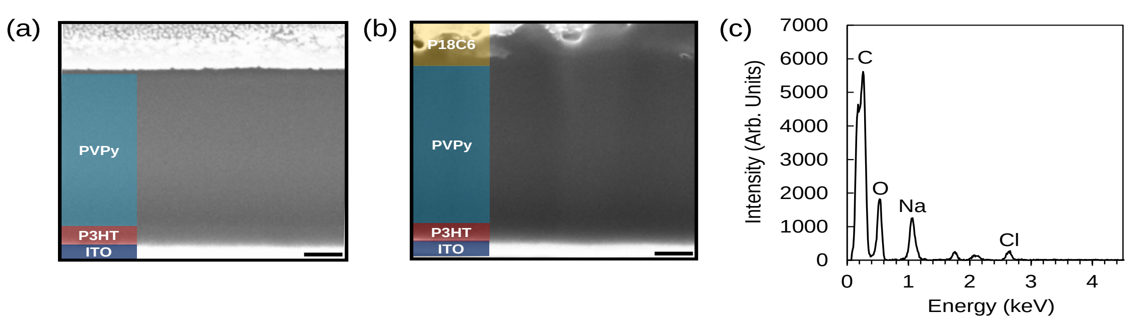


Figure 1. (a) SEM of FIB-milled cross-section of a Reference Device depicting ITO, P3HT and PVPy layers. (Note upon the PVPy layer there is an Au and Pt layer visible in the micrograph, added to facilitate FIB-SEM measurement). (b) SEM of a FIB-milled cross-section of a Crown Ether (CE) Device depicting ITO, P3HT, PVPy and P18C6 layers. Scale bars in insets are 200 nm. (c) EDS semi-quantitative elemental analysis of the cross-sectional face of the P18C6 layer in a CE Device following testing with a 130 mM NaCl analyte solution. P18C6 and analyte peaks have been identified.

Additional Outcomes of Visit

Visiting the Melbourne Centre for Nanofabrication had more than one advantage for my research in the field of organic electronics. In addition to enabling me to collect valuable data for the sodium ion organic electronic sensor project, the visit also gave me the opportunity to (1) tour the ANFF facility and its available instrumentation, (2) meet researchers and potential future collaborators, and (3) deliver a seminar. A tour of the Victorian ANFF Node and Melbourne Centre for Nanofabrication was beneficial to my research as it enabled me to obtain an overview of the resources available within the facility, I am now able to identify potential options for further collaborative work. Delivering a seminar titled 'Semiconducting Polymer Solar Cells and Electronic Sensors' while visiting the Melbourne Centre for Nanofabrication was another highlight of my visit, facilitating knowledge sharing between researchers in similar disciplines. I am thankful for the funding support from the Australian Nanotechnology Network that facilitated this research trip.

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Dr Guanghui Ren from RMIT to visit the ANFF at Australian National University

ANN short visit travel grant report - Guanghui Ren

I visited the ANU ANFF node on the 15th September, 2017, and got the training on silicon wafer bonding by using polymer adhesion layer. The training was given by Dr. Fouad Karouta, the manager of the ANFF ACT node, and Dr. Kaushal Vora. The procedure used the ANFF funded hot embosser, EVG520H to bond two silicon wafers together by using adhesive BCB layer.

This visit enabled me to explore Hybrid Integration of photonic chips using BCB bonding – a technique that is often used to bond active devices to passive silicon substrates. Through this process I successfully bonded silicon nitride chips to thin-film lithium niobate providing the silicon nitride platform with electro-optic properties. Through this mechanism we will open lines of communication between the ANFF node at ANU and the MNRF at RMIT building up standards and inter-operability.

I appreciated the travel grant which covered all my expense for the visit. Hope we can produce more collaboration among different ANNF nodes.

Guanghui Ren
Research Fellow
School of Engineering, RMIT University
Melbourne, VIC Australia

Overseas Travel Fellowships

Opportunities for Five to six Overseas Travel Fellowships valued at up to $5,000 each are offered every 6 months. This is a mechanism whereby Australian students and early career researchers can visit overseas laboratories to gain new skills and training in this emerging field of research. These fellowships are also offered for attending International Summer Schools of minimum one week duration, or longer.

Applications are ranked and Fellowships awarded to the top 5-6 ranked applications.

MS MUN TENG SOO FROM THE UNIVERSITY OF QUEENSLAND VISIT TO THE INSTITUTE MICROSTRUCTURE AND PROPERTIES OF ADVANCED MATERIALS, BEIJING UNIVERSITY OF TECHNOLOGY (BJUT), CHINA.

Theme of Research: Using Cs-corrected STEM to understand the growth mechanism of GaAs nanowire catalyzed by Ni nanoparticle

Collaborator: Professor Syo Matsumura, Department of Applied Quantum Physics and the Ultramicroscopy Research Center, Kyushu University, JAPAN

Travel date: Jan – Feb 2017

Research motivation

In the past decade, significant research efforts have been devoted to III-V nanowires for understanding their fundamental physics and for their potential applications in nanophotonics, nanoelectronics and sensing devices.[1, 2] Ongoing efforts have been put forth in to metallic nanoparticle used to induce nucleation and vapor-liquid-solid or vapor-solid-solid growth of III-V nanowires, particularly GaAs nanowires. Au has been widely used to catalyze the growth of III-V nanowires,[3, 4] while limited studies have been carried out using non-Au catalysts.[5, 6] Due to the incompatible of Au with Si wafer, it is an undesired metal for Si-based technology. As a consequence, the use of Si-compatible metals such as Cu, Pd or Ni as a catalyst to induce nanowires growth has been studied.[7-9] Besides, by using non-Au metal catalyst, the catalyst-nanowire interface can be modified which affect the morphology and crystal structure of nanowire.[6] In particular, Ni is anticipated to be one of the prominent catalysts since it is greatly cheaper than Au, and is in principle compatible with Si-based electronics,[10] which are two important criteria for the realization of industrialized Si-based III-V nanowires functional devices. Ni also can function as the contact of the III-V nanowire for functional electronic devices. However, achieving well-controlled over epitaxial defect-free III-V nanowires growth using Ni catalysts poses a substantial challenge due to the ability of Ga and As to form a solid alloy with the Ni nanoparticle at typical growth temperatures (between 400 - 600 °C).[11, 12] Besides, the growth window of Ni-catalyzed III-V nanowires is narrow. Therefore, urgent need is required so that a comprehensive understanding of the related growth mechanism can be obtained, which is based on detailed electron microscopy analysis of the nanowires, especially at the catalyst-nanowire interface.

Major purpose of overseas visit

To gain deeper and comprehensive understanding of the growth mechanism of III-V nanowires at atomic-scale using world-best advanced TEM facilities (Cs-corrected STEM).

Research activities at The Ultramicroscopy Research Centre, Kyushu University

- Using Cs-corrected TEM/STEM facilities operated between 60-120 kV to obtain high quality atomic resolution images and area mapping at the catalyst-nanowire interface. The selection of the operation of TEM between 60-120 kV so that the *e*-beam will not damage the nanowire. Figure 1 is one of the atomic resolution analytical TEM in the center (JEM-ARM200CF).
- Experiment observation of *in-situ* heating experiments using ultrahigh voltage TEM (operated at 1250 keV).
- Using the Crystal Maker software in the lab for crystal models and diffraction patterns drawing.
- Presentation of my research works to Professor Matsumura's group.

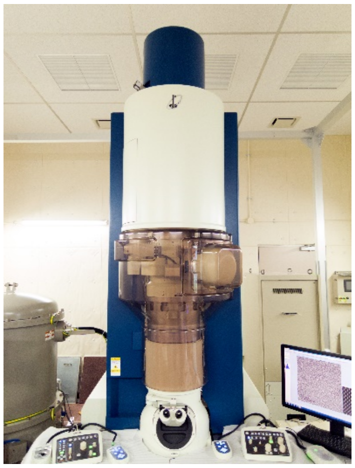

Fig.1. JEM-ARM200CF TEM located at The Ultramicroscopy Center, Kyushu University.

Key outcomes

Outcome 1: Atomic resolution of Cs-corrected HAADF STEM images at catalyst-nanowire interface

Atomic resolution of Cs-corrected HAADF STEM images at the catalyst-nanowire interface for different types of nanowires were obtained successfully. Figure 2a is the example of the aberration-corrected HAADF STEM image of GaAs nanowire. The atomic resolution imaging is challenging because the nanowires are thin and easily damaged by *e*-beam. Advanced TEM and skillful operation of TEM is needed to obtain good quality atomic resolution STEM images. This result is important to gain better understanding on how the interface affects the growth of nanowires.

Outcome 2: Atomic resolution area mapping at the catalyst and nanowire

Using the Crystal Maker software in the lab for crystal models and diffraction patterns drawing. Presentation of my research works to Professor Matsumura's group.

Atomic resolution area mapping at the catalyst is desired to confirm the crystal phase of catalyst. Besides, the Area mapping at the nanowire can provide the information of the polarity of nanowire at the interface (refer to

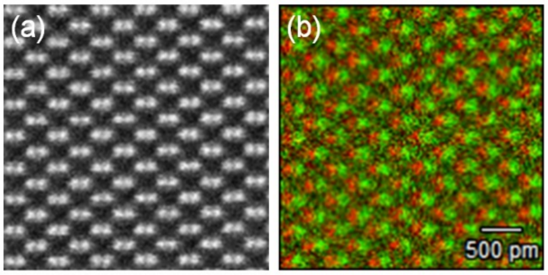

Fig.2. (a) HAADF STEM image of GaAs showing the dumbbells of Ga-As, and the corresponding (b) elemental mapping. Red and green balls represent Ga and As atom positions.

Fig. 2b). This result can enhance the understanding of growth mechanism Ni catalyst induced nanowires.

Outcome 3: Develop additional skills as a researcher

I gained invaluable experience in using the state-of-art Cs-corrected STEM facilities. This experimental skill Enriches my research experience. Besides. This overseas research travel enhanced my networking skills, especially with the researchers in Kyushu University. The conversation and also knowledge exchanging with them deepen my knowledge in TEM operation and analysis.

Outcome 4: Enhance the quality of research publication

- The results I obtained during this trip deepen my understanding on my current research findings, and hence enhance the quality of a paper that I am writing. These results will be very significant in making strong contributions to the III-V nanowires research field.

Summary

This overseas travel provided me the opportunities to learn transferrable experimental skills, develop networking skills which enriched my research experience and will help me in navigating my future career.

Acknowledgements

I would like to acknowledge the funding support from Overseas Travel Fellowship (OTF) provided by Australian Nanotechnology Network (ANN), which enabling me to extend my skills and gain valuable experience during final stage of my PhD research. Besides, I am grateful to Professor Syo Matsumura's group at Kyushu University for hosting me, and Professor Jin Zou and Associate Professor Kazuhiro Nogita from The University of Queensland for providing the information of the research facilities. This is part of the UQ-KU Project which has been established to increase practical collaboration between The University of Queensland and Kyushu University.

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OVERSEAS TRAVEL FELLOWSHIPS

MS LARISSA HUSTON FROM THE AUSTRALIAN NATIONAL UNIVERSITY VISIT TO THE OAK RIDGE NATIONAL LABORATORIES, TENNESSEE, USA.

Larissa Huston- ANN Overseas Travel Fellowship Report

Temperature and decompression rate dependence on the phase transformations of Si nanowires

Summary

The ANN overseas travel fellowship funded an extended visit to work at the High Pressure Collaborative Access Team (HPCAT) at the Carnegie Institute of Washington, Argonne National Laboratory, Argonne, IL, USA from mid June 2017 to late September 2017. The project was supervised by the HPCAT director, Dr Gouyin Shen, and focused on the high pressure behaviour of Si nanowires. As part of this project, transmission electron microscopy was conducted with Dr David Cullen at Oak Ridge National Laboratory (ORNL). As part of this visit, I was invited to give a presentation to the group on "Pressure induced phase transformations in Si and Ge – Temperature and Size effects".

Motivation and Background

Most silicon, has a diamond cubic crystal structure under ambient conditions. However, on the application of ~11 GPa of pressure, silicon will change to a metallic (β-Sn) structure.1 When the pressure is released, β-Sn-Si will further transform into one of many metastable phases of Si such as r8-Si, bc8-Si, hd-Si and a-Si.2 These forms of Si have been predicted and measured to have useful electronic and optical properties. For example, bc8-Si has a narrow bandgap3 and hd-Si was predicted to have a direct bandgap when strained 4%.4

At the nanoscale, the phase transformation behaviour is different to bulk. Phase transformations of 90-150 nm Si nanowires are suppressed and do not transform until later than expected and a-Si is the favoured final phase and only a small amount of bc8-Si forms. This behaviour has similarities to cold diamond anvil cell decompression where decompression of bulk Si at low temperatures leads to the formation of a-Si and bc8-Si at room temperature.5 There are also similarities to nanoindentation where fast unloading leads to a-Si and slow unloading leads to bc8/r8-Si.6 Given that both low temperatures and fast unloading leads to a-Si, it would seem possible that increasing the temperature and/or unloading at a slow rate would favour the formation of bc8-Si over a-Si.

In this report, the influence of both unloading rate and temperature on the phase transformation behaviour of 80-150 nm Si nanowires.

The goals of this project were:

- • To understand the effect of temperature on the nanowires- can we use it to encourage bc8-Si to form and amorphous not to form?
- • To understand how unloading rate can affect the outcome.
- • To optimise the conditions for forming bc8-Si

Experimental Section

Techniques acquired from visit

At HPCAT, several techniques were accessed including:

Gas membrane system: This is a method for remotely controlling pressure in a DAC involving pushing the cell by inflating gas membranes to force the diamonds together (or apart) and thus increasing (or decreasing) pressure. A double membrane system was used allowing for both compression and decompression to be controlled.

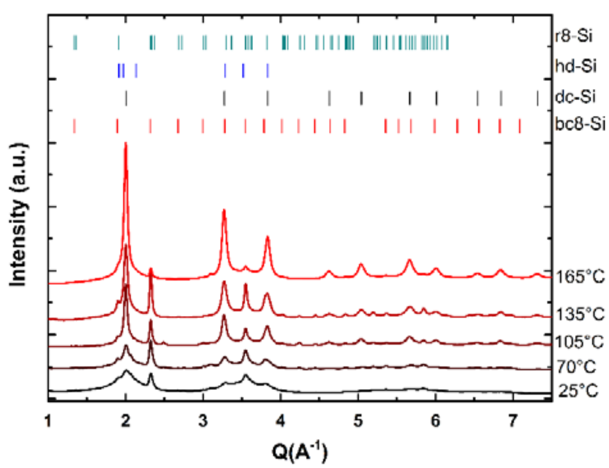
Alignment of diamonds
Running a synchrotron beamline: 3 nights of beamtime of 16-IDB were accessed. Here *ex-situ XRD* measurements, *in-situ* measurements and x-ray mapping were erformed.
Laser drilling: HPCAT has a laser drilling system that is used for drilling small holes.
In-situ heating: A resistive heater was used to heat samples to 70-165°C
rotoDAC: HPCAT recently designed a cell that is capable of rotating one or both diamond anvil cells. The cell was loaded and an experiment which rotated ne diamond was performed.

Experimental details

80-150 nm diameter Si nanowires grown in the <111> direction which had their gold removed were loaded into a DAC. Samples were heated to 25°C, 70°C, 105°C, 135°C and 165°C and loaded to 20-22GPa. The samples were then decompressed to ~8 GPa and then from 8 GPa to ~2-3 GPa, the samples were decompressed at a rate of ~2 GPa/hr. To investigate the effect of unloading rate, new samples were loaded at the same temperatures but the unloading rate was changed to ~15 GPa/hr. Two higher unloading rates were also completed for 105°C. In order to differentiate the effects of the nanowires from bulk-Si, single crystal bulk-Si was loaded at 105°C and 165°C and unloaded under similar conditions at ~2 GPa/hr. These samples were all cooled and removed from the DAC before being placed into a 31 keV x-ray beam with a 4x6 µm spot size. Powder diffraction patterns were collected on a Pilatus 1M-F detector and integrated using the Dioptas software package. Data taken whilst under pressure was also collected for a sample that was loaded at 105°C.
Transmission electron microscopy was conducted at Oak Ridge National Laboratory with the assistance of Dr David Cullen. Samples were removed from the gasket and ultrasonicated in isopropanol. Using a micropipette, the isopropanol and nanowires was deposited onto a lacey carbon grid. A 300 kV Hitachi HF3300 TEM was used on conventional mode to take images and diffraction patterns of the nanowires. EDS was performed on a few nanowires to look for impurities.

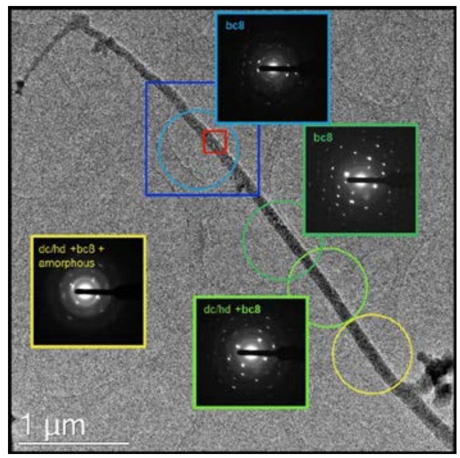
Results

XRD patterns of the recovered Si nanowires samples when heated to 25-165°C and then decompressed at a rate of ~2 GPa/hr are shown in fig.1. At 25°C, a number of weak sharp peaks superimposed over two broad peaks (between Q=1.5 and Q=4). These broad peaks are indicative of that the nanowires were predominately a-Si whilst the sharper peaks indicate that there is a trace amount of the crystalline phases: bc8-Si and dc-Si. Increasing the temperature to 70°C had the effect of increasing the proportion of crystalline phases, however, some a-Si was still present. Further increasing the temperature to 105°C and 135°C resulted in a further increase in the proportion of crystalline phases. When temperature was further increased to 165°C, the ratio of bc8-Si to dc-Si changed and the portion of dc-Si increased. This behaviour is in contrast with bulk-Si where only bc8-Si (no dc-Si) is observed when bulk Si is subjected to similar unloading conditions at 105°C and hd-Si forms at 165°C. It was found the higher unloading rates had the same effect as lowering the temperature. For example, unloading from 10 GPa to 0 GPa in ~1-2 s at 105°C resulted in predominately a-Si nanowires.



The *in-situ* XRD data at 105°C gave some insight on how the different phases formed. It was found that when decreasing pressure, β-Sn-Si started to transform to dc-Si at higher pressures than bc8-Si. All the β-Sn-Si had converted to dc-Si or bc8-Si by ~6 GPa.

Whilst the phases in the recovered nanowires could be identified using XRD there is no information on how the phases are distributed. TEM was used to look at the morphology as well as the how phases distributed within a nanowire in order to find out if nanowires were of a single phase or contained multiple phases. Figure 2 contains an image of a Si nanowire which has been heated to 105°C and unloaded at ~15 GPa/hr. A series of selected area diffraction patterns (SAPD) taken from the encircled regions were the colour of the border of the SADP corresponds to colour of the circled region. The SADPs indicate that the nanowire is predominately bc8-Si with trace amounts of a-Si and dc-Si. It was also found that regardless of temperature, most nanowires have an ~10 nm thick amorphous layer. It is suspected this is due to the oxide layer.



Conclusions

The influence of unloading rate and temperature of the pressure induced phase transformations of Si nanowires was investigated. It was found that a-Si was the dominant phase at room temperature, as temperature was increased crystalline phases such as bc8-Si and dc-Si formed and further increasing the temperature resulted in a higher proportion of dc-Si. TEM results suggested that the recovered nanowires were mostly single phase and contained traces of other phases in them. Further TEM will be required to confirm this.

Acknowledgements.

I would like to thank Guoyin Shen for hosting me at HPCAT and his supervision of my project during my visit. My gratitude goes to Ross Hrubiak, Jesse Smith, Curtis Kenney-Benson and Changyong Park for their training and assistance on various equipment at HPCAT. I would also like to thank all the members of HPCAT for making me feel welcome during my visit.

The transmission electron microscopy component of research was conducted at the Center for Nanophase Materials Sciences, which is a DOE Office of Science User Facility. I would like to thank David Cullen for his assistance with TEM and also for making me feel welcome. I'd also like to thank Shawn Reeves for accommodating me in the sample preparation lab, and Donovan Leonard and Dorothy Coffey for their assistance with the focused ion beam. Finally, I would like the thank Bianca Haberl for her insightful discussion of my project and for also making me feel welcome at ORNL.

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OVERSEAS TRAVEL FELLOWSHIPS

DR. MARKUS MUELLNER, SCHOOL OF CHEMISTRY, UNIVERSITY OF SYDNEY VISIT TO AALTO UNIVERSITY, FINLAND.

Dr Markus Müllner Lecturer in Polymer and Physical Chemistry

Report for the Overseas Travel Fellowship – Dr Markus Muellner

Project: Research visit to Department of Applied Physics, Aalto University, Finland (Professor Olli Ikkala, Molecular Materials group, part of the Academy of Finland´s Centre of Excellence in Molecular Engineering of Biosynthetic Hybrid Materials research)

Project aims: 1) Cellulose sourcing and processing; 2) cellulose nanocrystal (CNC) preparation, modification and polymer grafting; 3) CNC characterisation; and 4) Cryo-ET of CNC-based nanoparticles.
Summary and findings: This project focussed on the investigation of rod-like CNC-based polymer nanoparticles and their application as templates for hybrid materials production. We modified CNC (produced from filter paper) with initiation sites for polymerisation, and grafted the CNC with a shell layer of a polyelectrolyte using controlled radical polymerisation. The produced core-shell templates have then been used to enable a thin coating of an inorganic component onto the CNC surface. Our methodology overcomes several difficulties associated with sol-gel coatings of rod-shaped cellulose nanomaterials. Our approach also speeds up the process and avoids organic solvents. Several follow-up studies are currently on-going, looking at the use of our nanomaterials for battery electrodes.
Aside the research component, I have used the time in Finland to teach students about polymeric nanomedicine. This was achieved via a departmental seminar, as well as one-on-one discussions with students and staff.

Budget spending: Funding was requested to support the research stay (8.7-18.8.2017) at Aalto University and sought to contribute to travel and accommodation costs.

Communication of results: M. Morits, V. Hynninen, Nonappa, A. Niederberger, O. Ikkala, A.H. Gröschel, M. Müllner* 'Polymer brush guided templating on well-defined rod-like cellulose nanocrystals' *Polymer Chemistry* **2017**, DOI:10.1039/c7py01814b.
Invited conference/seminar contributions (where the results were communicated):
European Polymer Congress (Lyon, France), Soft Matter Materials Symposium (QUT, Australia), HYBER seminar at School of Applied Physics (Aalto University, Finland), Physical Chemistry colloquium (University of Duisburg-Essen, Germany), School of Chemistry Seminar (UNSW Australia)

Acknowledgments
I am very grateful for the support through the ANN/ANU which has allowed me to utilise world-class facilities at the Nanomicroscopy Center at Aalto University. More importantly, I am convinced this award and its outcomes has increased my competitiveness in obtaining future funding, and as surely benefited my successful ARC DECRA application.

OVERSEAS TRAVEL FELLOWSHIPS

DR HOANG PHUONG PHAN FROM GRIFFITH UNIVERSITY VISIT TO STANFORD UNIVERSITY, USA FOR A PERIOD OF EIGHT WEEKS.

ANN Overseas Travel Fellowship Report – H.-.P. Phan (Travel to USA, wide band gap materials-base MEMS/NEMS for harsh environment applications)

PURPOSE OF THE VISIT

The aim of this collaborative project between QMNC, Griffith University and Prof. D.G. Senesky at Stanford University is to investigate into the physical properties of wide band gap materials and their applications for harsh environments, especially for space exploration (in collaboration with NASA).

During this visit, Dr. Phan brought his expertise in strain engineering in semiconductors to characterize strain effect in silicon carbide nanowires and AlGaN/GaN 2-dimensional electron gas (2DEG) to further the development of mechanical sensors including pressure and strain sensors. Professor Senesky's group at Stanford University (Extreme-Laboratory or XLab) contribute device-fabrication facilities, and test-bed at low and high temperatures.

RESEARCH BACKGROUND

Why silicon carbide? There is a great demand on the development of transducers which can withstand harsh conditions with high temperature, high pressure, strong electric fields as well as aggressive chemicals. These sensors can be applied to a wide range of industries, including automobile, mining, space exploration, and power generation to enhance the system performance, and minimize failures. Current technologies utilizing silicon (Si) do not meet these requirements since Si is not suitable for electronic devices at high temperatures above 200°C due to its small band gap. Silicon Carbide (SiC) can solve this bottleneck thanks to its excellent mechanical strength, chemical inertness, thermal durability, and electrical stability. **Queensland Micro and Nanotechnology Centre (QMNC)** is one of the world leading research institutes in the growth of large scale SiC wafers. To date, QMNC has developed SiC wafers with diameters up to 300 mm with controllable crystalline orientation and carrier concentration. The centre has also been working toward SiC electronics such as Schottky diode and transistors for high power devices. My role at the centre, as an earlier carrier researcher is to investigate sensing mechanisms of SiC such as the piezoresistive, thermoresistive, thermoelectric, Hall effects, and residual stress for MEMS/NEMS transducers. Recently, we have found several interesting properties including the large piezoresistive effect, Hall-effect in SiC thin film. Nevertheless, sensing effects at cryogenic temperatures of SiC thin films as well as the feasibility of SiC nanowires as a new platform for MEMS sensors have not been explored.

Why Stanford University? To investigate the piezoresistive effect in semiconductors, the bulging test where a diaphragm is subjected to a mechanical load has been widely employed. Nevertheless, when it comes to SiC, this is not an easy approach. Firstly, it is due to the chemical inertness of SiC making it challenging to form SiC diaphragm from a thick SiC bulk wafer. Secondly, there is a need for simultaneously controlling temperatures along with pressure level during the bulging test. The Xlab led by Prof. Senesky has the expertise and facilities to solve these problems. The group has developed a simple technique to rapidly remove thick SiC substrate, allowing the formation of SiC diaphragm using laser engraves (20 um/min) and ICP etching (1 um/min). In addition, Xlab has also developed a test bed which enable the characterization of electrical properties in semiconductor at high and low temperatures. By combining our expertise in strain engineering and Xlab's MEMS/NEMS fabrication and characterization technologies, my visit to Stanford will make the investigation into the strain effect in SiC nanowires a promising possibility.

RESEARCH FINDING AND ACTIVITIES

(i) SiC nanowires pressure sensors:

The aim of this part is to develop for the first time SiC nanowire based pressure sensors. Our approach was based on nanowires locally fabricated on free standing structures with a high stress concentration. This stress concentration phenomenon amplified the strain induced into nano-scaled sensing elements while the bulk materials are still at small strain regime, therefore enhancing the sensitivity of the sensors. For proof of concept, we utilized SiC nanowire fabricated using focused ion beam from an epitaxially grown thin film.

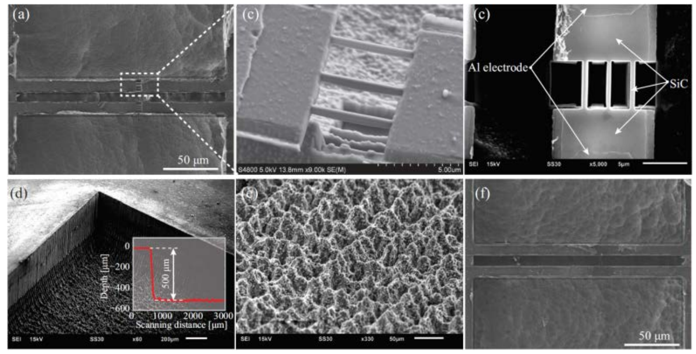


Figure 1. Photograph of fabricated devices. (a) SiC nanowires fabricated at the center of a suspended bridge; (b)(c) SEM images of an SiC nanowires from side view and top view (d)(e) SEM image of back side Si membrane;(f) A pressure sensor with suspended SiC micro-resistors fabricated on a Si membrane for comparison to nanowire based sensor.

Work done at Griffith: Fabrication of SiC nanowire on top of Si, and metallization

Work done at Stanford: Fabrication of Si membrane using UV laser engraving, and the characterization of SiC nanowire sensor employing UV laser engraving. Acknowledging that I only had two months at Stanford, I quickly finished all safety inductions for the lab in the first two days. From the third day, I was trained for the UV laser and the fume cup (for device cleaning). The preliminary experimental result was obtained in my first week at Stanford thanks to the help from PhD students and postdoc at the Xlab. My quick progress was also resulted from my experience in the previous overseas visits at Hyogo University, and The National Institute of Advanced Industrial Science and Technology (AIST), Japan, from where I learned how to deploy my research project in a timely-manner and how to effectively utilize the facilities available at the visiting institutes.

Figure 1 shows photograph of the fabricated SiC nanowires, and the engraved Si membranes. By thinning down the Si membrane using the UV laser at Stanford, it was possible to induce strain into the as-fabricated in SiC nanowires by deflecting the membrane using external compressed gas (Ar). Figure 2 shows the experimental results of SiC nanowire pressure sensors in comparison to conventional thin film piezoresistive sensors. Experimental results show significant 3-fold enhancement in the sensitivity in comparison to conventional structures, which is in good agreement with analytical model and numerical simulation. The proposed design shows potential for the development of miniaturized highly sensitive but robust nano mechanical-sensors. *This work has been published in Materials and Design (IF. 4.304)* 10.1016/j.matdes.2018.06.031

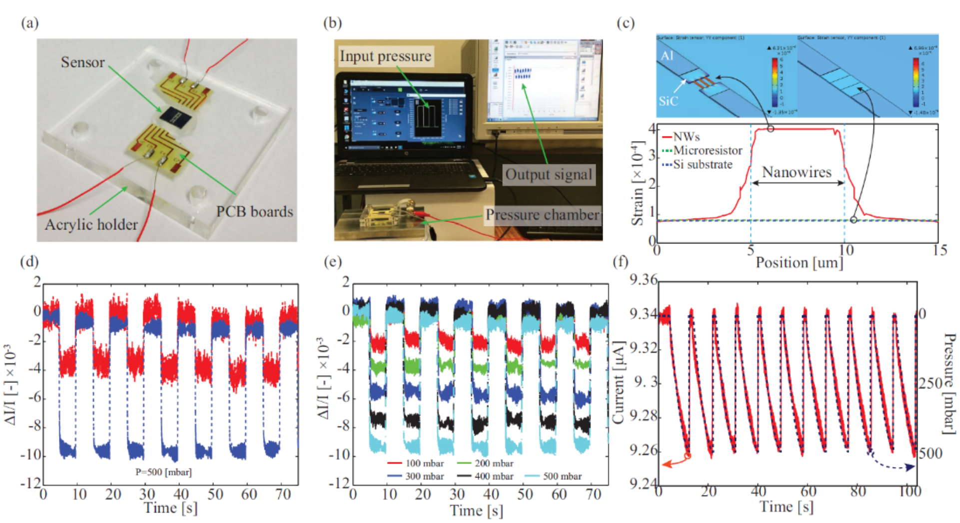


Figure 2. Characterization of SiC pressure sensors. (a)(b) Experimental setup of SiC nanowire pressure sensors; (c) Simulation of strain induced into the nanowires and micro-scaled frames; (d) A 3-fold increase in the sensitivity of nanowire sensors (blue) in comparison to SiC micro-resistors (red); (e) The output of SiC nanowire sensor under different input-pressures. (f) Response of the nanowire pressure sensors under ramp-up pressures from 0 to 500 mbar.

(ii) Characterization of the piezoresistive effect in SiC at cryogenic temperatures

This part investigates the piezoresistive effect in p-type 3C-SiC thin film mechanical sensing at cryogenic conditions. Nanothin 3C-SiC films with a carrier concentration of 2×10^{19}cm^{-3} was epitaxially grown on a Si substrate using LPCVD process, followed by photolithography and UV laser engraving processes to form SiC-on-Si pressure sensors. The magnitude of the piezoresistive effect was measured by monitoring the change of the SiC conductance subjected to pressurizing/depressurizing cycles at different temperatures.

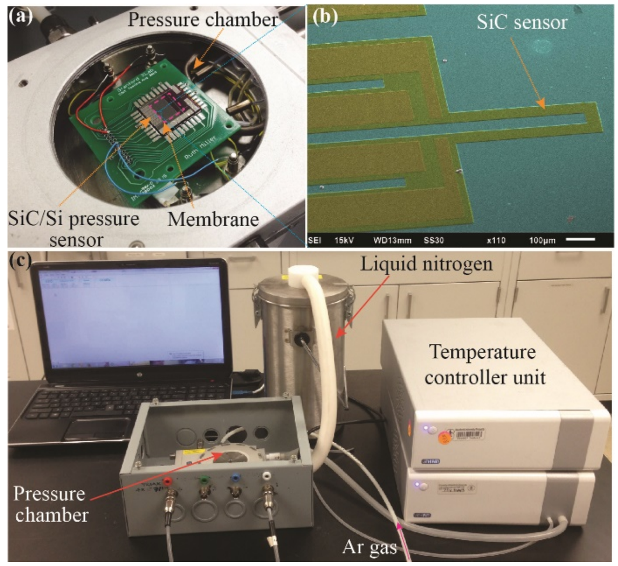


Figure 3. (a) SiC on Si pressure sensor mounted on a PCB board; (b) SEM image of a SiC resistor (c) Experimental setup for characterization of the piezoresistive effect in 3C-SiC at cryogenic temperature.

Work done at Griffith: Micro fabrication of SiC U-shape resistors and metallization were conducted at the ANFF-Q cleanroom at QMNC, Griffith University.

Work done at Stanford: Si membranes under the SiC piezoresistors were fabricated using the UV laser at Stanford University. The SiC devices were then mounted on a home-built circuitry-board, and tested at cryogenic temperatures using a Linkam™ temperature and pressure controller.

Figure 3 shows the photograph of the fabricated SiC-on-Si pressure sensors, and the experimental setup at cryogenic temperatures. The resolution of the Linkam temperature controller was 0.1 K, while the temperature on the surface of the chip could be reduced down to 150K. External pressure was applied to the chip by pressurizing/de-pressurizing Ar gas into the Linkam chamber.

The I-V curve of the resistance at 150K shows that good Ohmic contact between metal (Al) and p-type SiC was maintained at low temperatures. Furthermore, the current leakage to the substrate at low temperatures was significantly lower than the current passing through the SiC resistors as plotted in Fig. 3(a). This is due to the discontinuity between the valance bands of SiC and Si as well as the reduction of the charge carriers in Si substrate, resulting in less hole tunnelling through the potential barrier between SiC and Si at low temperature. The piezoresistive effect of the SiC pressure sensors at cryogenic temperature was then investigated by pressurizing the chamber using Ar gas as described above. Figure 3(b) shows the relationship between the gauge factors and temperature. It is evident that, there was a small change in the piezoresistive effect in the p-type 3C-SiC at low

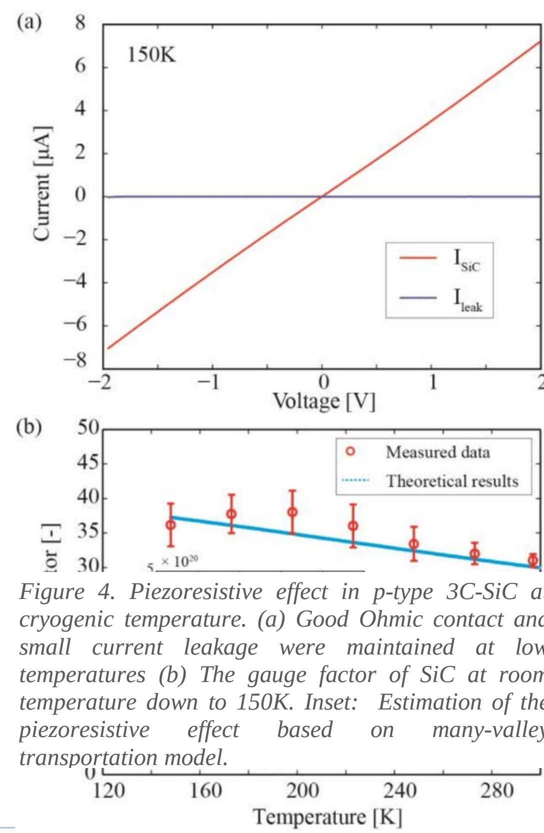


Figure 4. Piezoresistive effect in p-type 3C-SiC at cryogenic temperature. (a) Good Ohmic contact and small current leakage were maintained at low temperatures (b) The gauge factor of SiC at room temperature down to 150K. Inset: Estimation of the piezoresistive effect based on many-valley transportation model.

temperature; the gauge factor increased from 30 at 300K to 36 at150K. The data was also in good agreement with theoretical analysis obtained based on the charge transfer phenomenon, Fig 3(b) Inset. This finding demonstrates the potential of 3C-SiCfor MEMS sensors used in a large range of temperatures from cryogenic to high temperatures. *This work has been submitted to Adv. Eng. Mater. (Under review).*

VISIT OUTCOMES

The collaborative work between Griffith University and Stanford University has furthered the understanding in the physical properties of SiC material for MEMS applications. There are at least three journal papers resulted from this visit (on the SiC nanowire pressure sensors, the characterization of the piezoresistive effect in SiC nanowires, and characterization of AlGaN/GaN 2DEG under tensile strain at elevated temperatures).

During the visit at Stanford I also learned Stanford's research on AlGaN/GaN 2DEG, another wide band gap systems which can be used for sensing and energy harvesting in harsh environment. I contributed my expertise in strain engineering to investigate the electrical conductance of AlGaN/GaN 2DEG under mechanical stresses, employing the bending beam method. Experimental results showed the temperature dependent transient behaviour in the 2DEG which was caused by two types of traps in the AlGaN/GaN heterostructure at 0.62 eV and 0.87 eV. Our results were later on presented at the Hilton Head Meeting by Dr. C. A. Chapin.

The visit to Stanford also gave me opportunities to join other projects at the XLAB, including collaborations with NASA (e.g. with Prof. M. Rai-Zadeh) on the development of sensors and computing systems for space explorations. The new network with Stanford and NASA will open up opportunities for collaboration on SiC nanowires sensors for space explorations, where our devices could be tested at NASA in the future.

DR PEI PEI JIA FROM THE UNIVERSITY OF ADELAIDE VISIT TO THE MEDICAL RESEARCH COUNCIL (MRC)-LABORATORY OF MOLECULAR BIOLOGY (LMB), CAMBRIDGE, UK, FOR A PERIOD OF TWO MONTHS.

ANN Overseas Travel Fellowship Report

With ANN Overseas Travel Fellowship, I visited the MRC Laboratory of Molecule Biology (LMB) in Cambridge UK from Jun 12 to July 28. On my visit, I first helped to setup a high vacuum thermal evaporation system for copper and gold deposition in order to get high quality nanomembranes. I also solved the issue in the releasing process of gold nanomembrane from the template, such as splitting and wrinkles, and developed a method to release multiple membranes in one single process. Meanwhile, the transfer (to TEM grids) process was improved to stretch gold membrane on grids. This tension is important to prevent sample motion during electron irritation in cryoEM. After several iterations, we purchased new templates of nanohole arrays with various hole size and periods. With these templates, I made three batches (4 for each template) of samples, which would be enough for the following stability test to get statistics data.

The initial SEM and TEM demonstrated high structural and crystalline quality, which we believe meet the requirement for cryoEM sample support. They are now in the process of stability test with nanoparticles. This will give us the preliminary result of sample motion inhibition. After this, we will proceed to the biological sample test and get more data for publication. We also developed a mechanical elastic theory to analyse the behind physics. When all the data are ready, we will publish them on high impact journals.

Indeed, MRC-LMB has an unsurpassed environment for both young with state-of-the-art facilities, sufficient funding and a unique scientific culture. I had attended their cryoEM courses for researchers, which introduced me to the most advanced cryo-EM technique for protein imaging and structure determination.

Ongoing

This project will certainly create interest in this gold membrane which will enable us to leverage funding or private investment. Actually, with the help from ANN Overseas Travel Funding, I am applying the University of Adelaide Research Fellowship. My industry partner also agreed to jointly apply for the Global Connection Funding Bridging Grant, which would enable us to reach our next milestone.

Project Public Statement

In biology, precise determination of the structure of biomolecules is fundamental to realizing how they assemble into molecular complex and how they function in cells. All of these are essential for understanding biological processes from the cell metabolism to the human brain operation. We are developing a gold nanomembrane as ultrastable sample support for biomolecule imaging with electron microscopy. In comparison to commercial carbon support, gold substrates are more stable. This would allow for imaging even smaller and more dynamic proteins at even higher resolution than before. Meanwhile our gold nanomembrane will maintain the same cost level as carbon substrates thanks to our novel and cost-effective fabrication method. This will enable routinely structure determination for many macromoleculars to be practical. With precise structure knowledge, biologists can fully investigate biomolecule complexes in various functional states, thereby gaining more biological insight. Pharmaceutical companies can also utilize the structure information to help to predict behaviours of biomolecules involved in disease, which might be targeted with drugs.

MR LIAM SCARRATT FROM THE UNIVERSITY OF SYDNEY VISIT TO THE MAX PLANCK INSTITUTE FOR POLYMER RESEARCH, MAINZ, GERMANY FOR A PERIOD OF TWELVE WEEKS.

ANN Travel Report – Liam Scarratt (Visiting the Max Planck Institute for Polymer Research, Mainz, Germany, working with Professor Doris Vollmer).

Purpose of my visit:

The objective of my research stay at the Max Planck Institute for Polymer Research was to investigate lubricant infused surfaces, which have practical use in self-cleaning, anti-icing/anti-fouling and drag reduction applications. These surfaces are made by infusing nano- and micro-structured materials with a chemically compatible lubricant that is immiscible with the liquid to be repelled, mimicking the Pitcher Plant found in nature. Current research on these materials has focused on reporting methods for their production, with little discussion of how they behave when exposed to conditions common in their practical use, i.e. how the lubricant layer is retained under flow and after placement or impact of liquid droplets.

The Vollmer group's expertise in using laser scanning confocal microscopy to visualise the interface of the solid/lubricant/liquid was the catalyst for my research during the 3-month stay. This technique uses a laser with multiple finite emission wavelengths and a piezo sample stage, illuminating a transparent sample from beneath and collecting reflected and emitted light in several detectors with customisable wavelength ranges. This technique's unique importance stems from its ability to control the z-axis focal plane within 350 nm step sizes, and the detection of fluorescence from dyed liquids and reflected light from interfaces with low curvature. Using these features, one can observe changes in the lubricant coverage of the structured substrate when in contact with the liquid to be repelled in 3D via XYZ scans, with additional imaging methods including XY cross-sections with the option of merging images for larger scan areas, and XZ cross sections with faster data collection rates for faster dynamics. The scan dimensions typically available for standard measurements are 400 x 400 µm with Z axis ranges of 60 µm, with the smallest time step between images being 530 milliseconds.

Experimental plan:

Experiments were conducted on photolithography patterned surfaces using SU-8 polymer on glass coverslips, which produced transparent regular arrays of square pillars of 10 µm in height and with varying widths and spacing. The sizes studied my experiments were pillars with 100 µm widths and 100 µm spacing, and 50 µm widths and 50 µm spacing. The surface chemistry of these pillars was modified via chemical vapour deposition (CVD) with hydrophobic silanes, and solution based self-assembly of PDMS brush layers, which was performed to vary their affinity for PDMS lubricant in the presence of water. Confocal experiments were conducted as follows: PDMS lubricant with either 10000 cSt or 100 cSt viscosity was deposited on the pillar surfaces and its thickness was controlled to be either ≈ 30 µm above pillar tops, or just covering the pillar tops, characterised as excess or starved respectively (Figure 1). A 5 µl droplet of water stained with a fluorescent dye was placed onto the lubricant infused pillars and confocal images were taken to measure the changes in the lubricant between and covering pillars over time, with the evaporation of the water droplet controlled via placement of a small cap over the system.

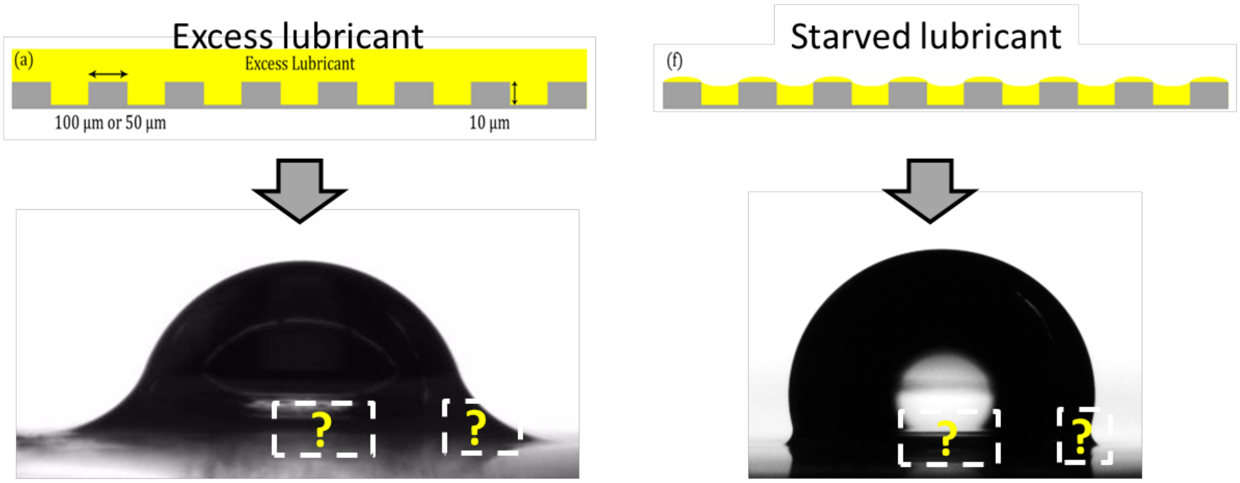


Figure 1. Images of 5 µl water droplets on structured lubricant infused surfaces taken via goniometry. LHS shows an excess lubricant configuration prior to droplet placement, while RHS shows a starved one. In each case, lubricant on the surface forms a wetting ridge around the water droplet/substrate contact line, the size of which is influenced by the volume of lubricant available.

Main findings:

When a water droplet is placed onto lubricant covered pillars with ≈ 30 µm thickness at either viscosity, the water droplet deforms around the lubricant in its central area of contact, thinning the lubricant at the outer edges of its circumference, eventually contacting the pillar surfaces. The lubricant that remains in excess under the centre of the water droplet slowly thins over time. Depending on the surface chemistry of the pillars, the water droplet can collapse between pillars in isolated areas displacing the lubricant at its outer circumference leading to the trapping of the lubricant in its centre, or can collapse completely between the pillars displacing large amounts of lubricant and strongly adhering to the substrate. This effect is accelerated with less lubricant prior to droplet placement and reduction of lubricant viscosity. A summary of observations is shown in Figure 2. This work has revealed that there are more complex dynamics occurring during the deposition of water droplets on lubricant infused surfaces than has previously been discussed in literature. I am in the process of finalising a paper draft with Professor Vollmer after having recently returned to the Max Planck Institute for Polymer Research for 3 weeks between May and June 2018 to finish off some experiments, after giving a talk at IACIS 2018 Rotterdam in late May.

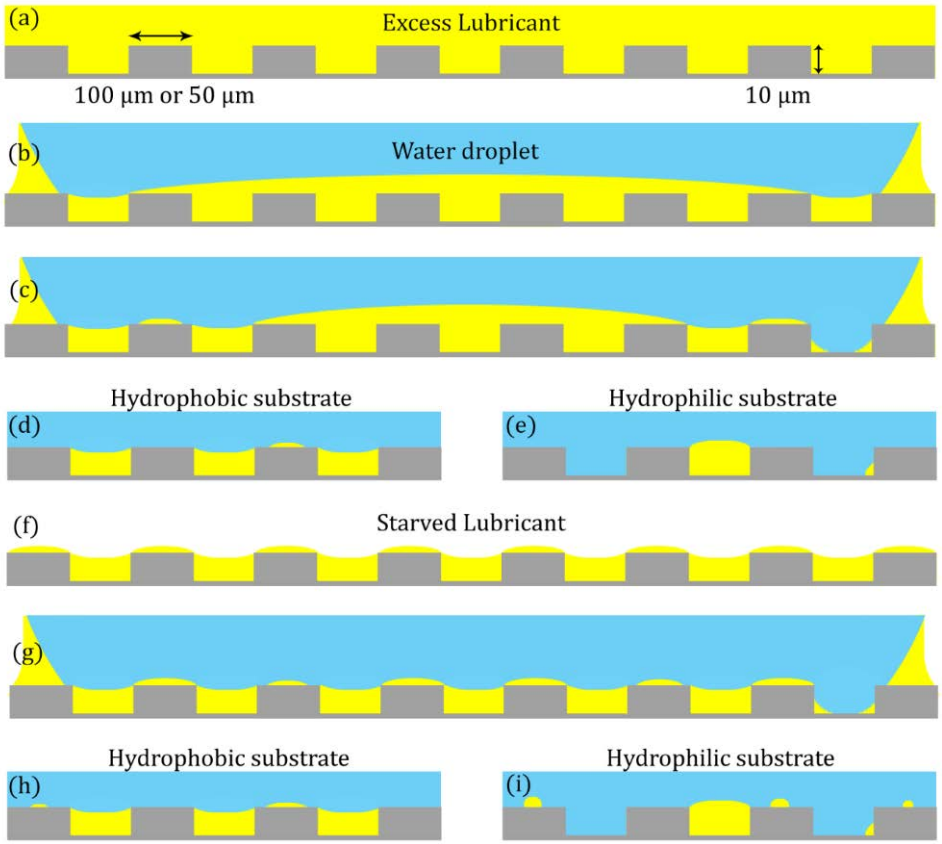


Figure 2. Wetting configurations on PDMS lubricant (10000 cSt) on square SU-8 pillars with different chemical surface treatment. (a) Excess lubricant approx. 25 µm in height over the pillar tops. (b) Addition of water droplet (5 µl), lubricant is thinned at outer edges contact. (c) Lubricant thinning continues at outer edges as central lubricant mass decreases. Potential scenarios are shown including Cassie-state between pillars, lubricant pockets on pillar tops, and collapse of the lubricant towards wetting ridge into Wenzel-state. (d) and (e) Final configuration depending on surface chemistry of the pillars. For Hydrophobic substrates, a Cassie-state is dominant with some lubricant pockets on pillar tops. On Hydrophilic substrates, the Wenzel-state is dominant with some trapped lubricant between pillars and at their bases. (f) Starved lubricant with slight inward curvature between pillars and over their tops. (g) Addition of water droplet (5 µl). Potential scenarios are shown including Cassie-state between pillars, lubricant pockets on pillar tops, and collapse of the lubricant towards wetting ridge into Wenzel-state. (h) and (i) Final configuration depending on surface chemistry of the pillars. For Hydrophobic substrates, a Cassie-state is dominant with lubricant pockets on pillar tops. On Hydrophilic substrates, the Wenzel-state is dominant with some trapped lubricant between pillars and at their bases and lubricant droplets on pillar tops.

MS JEESON KIM FROM RMIT UNIVERSITY VISIT TO THE KOREAN INSTITUTE OF SCIENCE AND TECHNOLOGY (KIST) IN SOUTH KOREA FOR A PERIOD OF SIX WEEKS

ANN Overseas Travel Fellowship 2017 - Award Outcomes Report

SUMMARY

The report is a summary of the research visit performed at Korea Institute of Science and Technology (KIST) in South Korea and a presentation at 2017 International Conference on Solid State Devices and Materials (SSDM) in Japan supported by the Australian Nanotechnology Network and KIST.

The aim of this visit was primarily to expand that already established collaboration and build an unclonable function that harness randomness and chaos not only at nano-domain but also at architectural level. Dr. Jeong's research lab activities are strategically aligned with the research topic of my PhD. The lab director, Dr. Doo Seok Jeong, has a long history of serving as a senior scientist at KIST.

Further, I aimed to communicate my current research results via the conference which was held 19-22 September 2017 in Sendai, Japan. The interest of SSDM is well-aligned with my PhD research focusing on emerging technologies and applications, and therefore this conference is the most suitable venue for presenting my results.

RESEARCH BACKGROUND

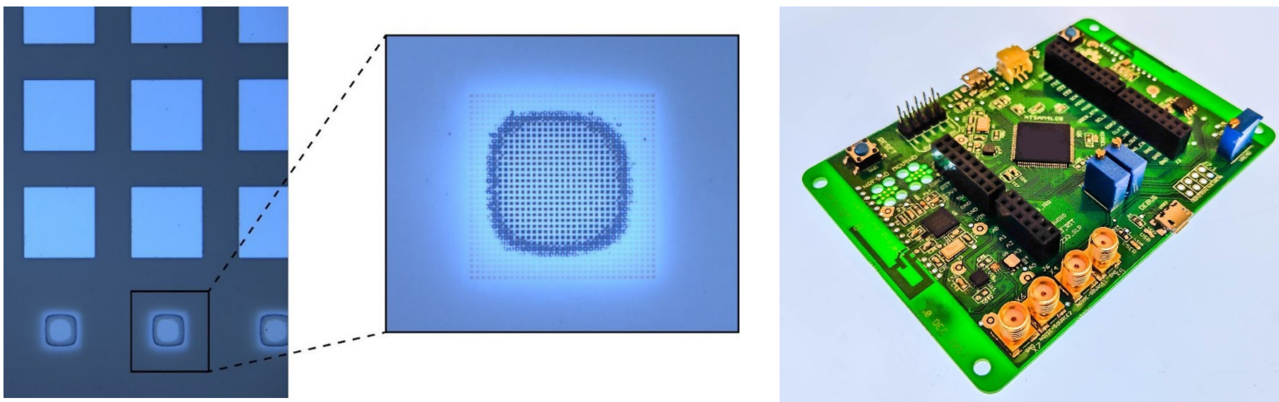
Nano-intrinsic security primitives has driven high demands as one of the promising next-generation solutions for cyber-physical applications like Internet of Things (IoT), industrial IoT (IIoT), or wireless sensor networks. This is significant because these signatures can be used for preventing fraud and counterfeiting, protecting sensitive data and securing communications.

Physical unclonable functions (PUFs) are innovative physical security primitives which produce unclonable and inherent instance-specific measurements of physical objects. The PUF in my research is simple, fast, tiny, energy efficient and highly secure as a result of the abundant nano-fabrication variation. At the core of my research resistive switching memories (redox-based valance change memory) have been extensively investigated. So far I have shown that none of the existing technologies is capable of producing recyclable secure characteristics meaning that if a security primitive is cloned a soft-reconfiguration (like application of different readout voltage) could guarantee security with producing streams that have low inter-correlation with previously generated data streams. This emerging topic is significant and interesting as it uses otherwise disadvantageous phenomena like noise and variation in favour of a practical and beneficial outcome for an important application. It does this with tremendous energy efficiency that makes it applicable to resource restricted applications like IoT or any portable entity. Stochastic characteristic of ReRAMs is multidimensional and rich.

It exists not only in geometrical terms (special process variation) but also in temporal behaviour like programming cycle-to-cycle variation, something that is not profound in transistor technology. They also provide a rich current-voltage dynamics, presenting a clear opportunity for ultra-low-power security primitives.

VISIT OUTCOMES

An improved nanoscale ReRAMs were fabricated and below are the microscopic images of the fabricated ReRAMs (Fig. 1(a)). Variation feature which is traditionally considered as disadvantageous can be used for lightweight hardware-based security application such as true random number generator. In this project, a true random number generator prototype was developed (Fig. 1(b)) and the fabricated PCB can generate random numbers based on ReRAMs' device-to-device variation as well as random telegraph noise within them.



(a) (b)

Figure 1: Prototype developtment. (a) Microscope image of ReRAM crossbar. The inset shows the bottom electrode. (b) The fabricated application prototype PCB.

Further beneficial outcomes from this research trip were the collaboration projects with the two seperate groups with constructive discussions and feedback on previous works, and the opportunity to learn the experimental process of nano-scale ReRAM fabrications and measurement.

My visit to Korea coincided with 2017 International Conference on Solid State Devices and Materials (SSDM) in Japan, and I was able to attend and deliver oral presentation titled “Predictive analysis of randomness in ReRAM-based cyber-physical systems.”

CONCLUSION

The overseas travel to Japan and South Korea for 3 months has brought significant benefits to my PhD research developments because I have experience the state-of-art techniques and explicit discussions and feedbacks at one of the most prestigious institution, KIST. In addition to that, visit to KIST and attend to the conference have built up my network through working with the field-leading experts, which will be definitely beneficial for my future research career. I would also like to express my appreciation to Australian Nanotechnology Network, RMIT university and KIST for supports.

OVERSEAS TRAVEL FELLOWSHIPS

MR JUN PENG FROM THE AUSTRALIAN NATIONAL UNIVERSITY VISIT TO THE KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KAUST) SOLAR CENTER IN SAUDI ARABIA, FOR A PERIOD OF SIX MONTHS

Dear ANN Team,

In the spirit of the ANN Overseas Travel Fellowship, I submit the following statement reporting on my recent overseas research travel. This statement summarises the benefits of my travel and collates the details the activities undertaken through the research travel.

Yours sincerely,

Jun Peng

Statement of Purpose

(1) One of the major purpose of this short-term (six months) visiting KAUST (King Abdullah University of Science and Technology) is to synthesize novel p-type nanomaterials (NiO and its dopants, CuGaOx) to instead of Spiro-OMeTAD and PTAA as hole transporting layers for high-performance and stable perovskite solar cells and perovskite/silicon tandem solar cells. In general, Spiro-OMeTAD and PTAA have been widely used as hole transporting layers normally need bis(trifluoromethane)sulfonimide lithium salt (Li-TFSI) doping and oxidizing to enhance its conductivity. However, the Lithium ions from Li-TFSI source can easily diffusion into the perovskite layer and act as trap states/defects to ruin the performance and stability of the perovskite solar cells during the condition of long-term work. What's worse is that the mismatched optical index of Spiro-OMeTAD and PTAA are not good candidates for two-terminal perovskite/silicon tandem solar cells based on our optical modeling. To solve those problems, NiO and its dopants have been regarded as the best candidates to meet the optical index requirement and other criteria (good conductivity and suitable work function) which can effectively reduce the optical loss and increase the current for perovskite/silicon tandems, and enhance the stability of perovskite/silicon tandems. In this research proposal, I am going to synthesize NiO and its dopants nanoparticles (d=5~10 nm) by low temperature wet-chemistry methods or by hot-injection synthetic technology. After washing and collecting the final products, those nanoparticles might be suspended in organic solvents (such as Et-OH, IPA, Chlorobenzene or Chloroform). Then, a small amount of stabilizer will be added into the final solution and stored in cool condition before use. Furthermore, I will use XPS/UPS to systematically estimate the stoichiometry, work function and valance band of those nanoparticles. High-resolution TEM will be performed to examine the size of those nanoparticles. XRD and TEM will be utilized to study the crystal structure of those nanoparticles. SEM and AFM will be used to check the formability and surface morphology of thin films deposited by spin coating nanoparticles' solution. KPFM, C-V and Hall-Effect measurements will be conducted to help us to understand some physical properties of those nanoparticles' thin films. Once the NiO and its dopants nanoparticles meet the criteria (good conductivity and suitable work function), they will be systematically investigated as hole transporting layers for perovskite solar cells and perovskite/silicon tandems.

(2) Based on the KAUST's first-class characterization facilities, ultra-fast transient spectroscopy (such as TA and TR-PL) and NMR measurements will be performed to reveal the passivation mechanism of PMMA in perovskite solar cells, and to investigate the correlation between surface recombination and operating voltage for perovskite solar cells.

(3) Inverted perovskite solar cells based on novel functionalized ZnO nanomaterials.

(4) Besides, the other main purpose is to attend the PSCO conference which was held at University of Oxford in 18th-20th Sep. 2107.

Key Outcomes and Findings

(1) I successfully finished the perovskite surface recombination project entitled "Double-Side Passivation for High Open-Circuit Voltage in Perovskite Solar Cells: Role of Carbonyl Groups in Poly(methyl methacrylate)". For this work, the results are very impressive; the manuscript is now under preparation. And I will submit it to a Nature family journal-*Nature Energy*.

(2) I also successfully finished the project of highly efficient inverted perovskite solar cells based on novel ZnO nanomaterials. For this project, the manuscript is now under preparation, and will be submitted to a high impact-factor journal (targeting at *Advanced Energy Materials*).

(3) For the novel hole transporting materials project, as the NiOx nanomaterials are very trick, it was challenge to finish this project in such a short-term visiting. But, good news is that I successfully obtained the NiOx nanomaterials, some preliminary characterization works also have been done for investigating and understanding those home-made NiOx nanomaterials, which will provide a very useful guideline to further optimizing the doped NiOx nanomaterials. Again, more works are required for this NiOx hole transporting materials project.

(4) I presented a poster at PSCO conference which was held at University of Oxford in 18th-20th Sep. 2017.

Other Outcomes and Findings

(1) During the short-term (six months) visiting KAUST, I built a high-performance (efficiency~20%) perovskite solar cells baseline in Prof. Stefaan De Wolf's laboratory at KAUST Solar Center, King Abdullah University of Science and Technology (KAUST), Kingdom of Saudi Arabia.

(2) Built an informal link and collaboration between ANU and KAUST.

Detailed Itinerary Schedule

1 July 2017 - 2 July 2017- *Flew from Sydney to Dubai, in transient.* 2 July 2017 Flew *from Dubai to Jeddah, in transient.*

2 July 2017- *Met with Prof. Stefaan De Wolf in KAUST Solar Centre, and registered in KAUST Solar Centre*

3 July 2017- *Met with Prof. Stefaan De Wolf's group members, and gave a 60 min talk on the topic "High-Efficiency and Stable Perovskite Solar cells with Negligible Hysteresis via Interface Engineering" in KAUST Solar Centre. Briefly introduced the work I've done in ANU during the past two years' research, and chatted with the other group members and got familiar with their research areas and interests.*

14 November 2017 - *Gave a 30 min seminar in KAUST Solar Centre on the topic 'Efficient Indium-Doped TiOx Electron Transport Layers for High-Performance Perovskite Solar Cells and Perovskite-Silicon Tandems'. Had a very good discussion with the audiences from KAUST Solar Centre.*

4 July 2017 - 16 September 2017- *Mainly focused on:*

(1) Characterizing and investigating the correlation between surface recombination and operating voltage for perovskite solar cells using ultra-fast transient spectroscopy measurements, TA and TR-PL.

(2) Investigating the bulk defects within multi-crystal perovskite films by using GIWAXS, PDS, FTPS, TA, TR-PL, XRD and

(3) Synthesizing and characterizing the NiOx nanoparticles.

(4) Setting up the high-efficiency perovskite solar cells baseline in KAUST Solar Centre.

17 September 2017- *Flew from Jeddah to London, in transient.*

18 September 2017 - *Participated in the conference and, gave a poster presentation.*

18 September 2017 - 20 September 2017- *Participated in the conference.*

21 September 2017 - 23 September 2017- *Visited Prof. Henning Sirringhaus' Lab (from Cavendish Laboratory, University of Cambridge); met/discussed with three post-docs from his group.*

24 September 2017 - 25 September 2017 - *Flight from London to Jeddah, in transient.*

25 September 2017 - 22 December 2017- *Continued to work at KAUST Solar Center.*

23 December 2017- *Flew from Jeddah to Dubai, in transient.*

24 December 2017 - 25 December 2017 *Flight from Dubai to Sydney, and back to ANU.*

Conclusion

This is a fruitful short-term (six months) overseas visiting based on the following seven main achievements:

1. Successfully finished the perovskite surface recombination project entitled "Double-Side Passivation for High Open-Circuit Voltage in Perovskite Solar Cells: Role of Carbonyl Groups in Poly(methyl methacrylate)". This work is now under preparation, and will be submitted to *Nature Energy*.

2. Successfully finished the project of highly efficient inverted perovskite solar cells based on novel ZnO nanomaterials. For this project, the manuscript is now under preparation, and will be submitted to a high impact-factor journal (targeting at *Advanced Energy Materials*).

3. Did a lot of preliminary works on the optimization of synthesizing the NiO nanomaterials and some related characterizations, which will provide a very useful guideline to further optimize the doped NiOx nanomaterials.

4. Built a high-performance (efficiency~20%) perovskite solar cells baseline in Prof. Stefaan De Wolf's laboratory (from KAUST Solar Centre).

5. Built an informal link and collaboration between ANU and KAUST.

6. Presented a poster at PSCO conference which was held at University of Oxford in 18^{th}-20^{th} Sep. 2017.

7. At least two collaborative journal papers will be published in high impact factor journals.

OVERSEAS TRAVEL FELLOWSHIPS

DR YICHAO ZOU FROM THE UNIVERSITY OF QUEENSLAND VISIT TO THE ULTRAMICROSCOPY RESEARCH CENTRE AT KYUSHU UNIVERSITY FOR A PERIOD OF ONE MONTH

Australian Nanotechnology Network Overseas Travel Fellowship Outcome

Yi-Chao Zou

School of Mechanical and Mining Engineering, The University of Queensland (UQ), QLD 4072

Travel dates: 1st-30th July 2017

Host supervisor: Prof. Syo Matsumura, The Ultramicroscopy Research Centre, Kyushu University

Phase engineering through chemical modification can significantly alter the properties of transition-metal dichalcogenides (TMDs), and allow the design of many novel electronic, photonic and optoelectronics devices.1 The atomic-scale mechanism underlying such phase engineering is still intensively investigated but elusive.1 TMDs crystallize in many types of crystal symmetry, including the hexagonal 2H, monoclinic T' and orthorhombic Td. For MoTe2, the room-temperature stable phase is 2H. Energetic calculation indicated that the substitution of Mo by W in monolayer Mo1-xWxTe2 reverses the phase stability between 2H and T', and thereby stabilize T'. This was also demonstrated in bulk Mo1-xWxTe2, where experiments shows that W alloying leads to the phase transition from 2H to T' or Td. Previous phase determination of Mo1-xWxTe2 was mostly based on Raman spectroscopy and X-ray diffraction, which gives structural information at mesoscopic scale. On the other hand, aberration-corrected scanning transmission electron microscopy (STEM) provides the capability to directly resolve the local atomic structure, which is critical for a precise understanding on the phase engineering of ternary TMDs and a precise prediction/interpretation of their properties.1

In this project, the growth of Mo1-xWxTe2 samples (nanoplates, nanobelts) was conducted in UQ, using chemical vapour deposition method. Nanostructures with a series of compositions (x values, e.g. x=0, 0.1, 0.5, 0.8, 1) were grown to investigate the phase evolution resulted from W alloying. The as-grown nanostructures were then detail characterized through my visit to Japan, using the aberration-corrected STEM (JEOL ARM200CF) located in the Ultramicroscopy Research Centre of Kyushu University. The high-angle annular dark-field imaging technique in STEM was used as it gives an atomic-number (Z) dependent contrast of the atomic columns, which directly reflect the substitution of W (Zw=74) for Mo (ZMo=42) in Mo1-xWxTe2 and helps resolve local chemical environment. During the visit, the academic and technical staff in Prof. Matsumura's group offered me assistances in operation of STEM imaging, specimen preparation using focused ion beam, as well as advices in experimental design and image analysis.

The imaging results from this visit show interesting phenomena: Mo1-xWxTe2 nanostructures with low W concentrations ($0<x\leq10$ at.%) are found as single-phase T', whereas highly W-concentrated ($10<x\leq80$ at.%) nanostructures exhibit a mixed phase composed of T', Td and a newly uncovered orthorhombic phase Td'. Td' preserves the centrosymmetry of T'. We proposed that Td' provides the possible phase transition path for T'→Td with a low energy state, which was confirmed by the energetic calculation contributed by our other collaborators.1 The visit to Japan culminated in the publication of a paper "Atomic insights into phase evolution in ternary transition-metal dichalcogenides nanostructures" in the journal Small.1 Further research results will be presented as a mini oral plus poster in 19th International Microscopy Congress, to be held at September 2018 in Sydney.

1Yi-Chao, Z.; Zhi-Gang, C.; Shijian, L.; Kohei, A.; Chenxi, Z.; Fantai, K.; Min, H.; Syo, M.; Kyeongjae, C.; Jin, Z., Atomic Insights into Phase Evolution in Ternary Transition-Metal Dichalcogenides Nanostructures. *Small* **2018,** *14* (22), 1800780.

DR ROEY ELNATHAN FROM THE UNIVERSITY OF SOUTH AUSTRALIA VISIT TO THE MAX PLANCK INSTITUTE FOR MEDICAL RESEARCH, STUTTGART, GERMANY.

Dr Elnathan "ANN Overseas Travel Fellowship Scheme"

The **overarching aim** was to develop vertically aligned-nanowire electrode arrays (VA-NEAs) as a mean to increase the efficiency of intracellular electrical measurements. The hypothesis was that pre-programmed VA-NEAs with adaptable architecture and surface chemistry can be used for direct, real-time electrical readouts of cellular biological systems; this was the basis for addressing three aims.

The ANN project had **three specific aims**:
Aim 1: The design and manufacturing of novel VA-NEA array:
Aim 2: Developing NW–cell electrical coupling interfaces:
Aim 3: Establishing proof-of-concept for electrophysiological measurements:
Key results are:
Aim 1:
(i) We created a library of VA-NEA array via the use of combinatorial fabrications routes.

(ii) These novel combinatorial nanofabrication routes were translated into a powerful new VA-NEA-mediated transduction technology, allowing large-scale, precise, and independent control of SiNW-based nanoelectrode location, element spacing, diameter, length, and shape.

Aim 2:
(i) Each SiNW-based nanoelectrode in this powerful VA-NEA technology was comprised of predesigned vertical SiNW architecture, followed by NW metallisation with Au/Ti, and encapsulation with polycarbonate insulating shells.
(ii) We identified inputs, including impedance, gain, noise, bandwidth, and bias stability. These optimal conditions were the key to improving long-term in-vitro signal stability, increase signal-to-noise ratio, minimised crosstalk,and read out intracellular biological information.

Aim 3:
(i) Together with collaborators in the Max-Planck Institute for Medical Research in Stuttgart/Heidelberg, we overcome issues with fabrication and electronic interface, to enable a new generation of cell–NW electrophysiological studies through mechanical SiNW-based nanoelectrode penetration. We have gained direct access to the interiors of electrogenic cell types by forming tight electrical junctions with local cell membranes.
(ii) Our preliminary experiments on the influence of VA-NEA-based platform geometry, using novel ways of producing intracellular recordings to achieve proof of concept for the ANN project. Our preliminary results indicate that research is required into the optimisation of (i) key parameters affecting the architecture of the VA-NEA, and (ii) the high-resolution electrical interface. This ultimately will allow us to efficiently form and measure cell–electrode junctions, and to sample noise-free signals from which we can process and interpret critical intracellular information.
Overall, the German–Australian team made fundamental advances in materials science and cell biology by designing and fabricating novel topographical parametric combinations of VA-NEA arrays, never before created coupled to the NW surface functionalisation for proof-of-concept applications in – intracellular recording. This research was a key stepping stone in our progress towards a range of life science applications, including VA-NEA-mediated transduction technology

OVERSEAS TRAVEL FELLOWSHIPS

MS WEIJIE LI FROM THE UNIVERSITY OF WOLLONGONG VISIT TO DONGGUK UNIVERSITY IN SEOUL, KOREA.

Weijie Li will be taking up the fellowship in 2018

DR TANVEER HUSSAIN FROM THE UNIVERSITY OF QUEENSLAND VISIT TO THE UNIVERSITY OF TEXAS, USA.

Tanveer will be taking up the fellowship in 2018

MISS YANYAN JIANG FROM THE UNIVERSITY OF NEW SOUTH WALES VISIT TO THE UNIVERSITY OF COLORADO, BOULDER, USA

Yanyan will not be taking up this Fellowship

DR PHILIPP REINECK FROM RMIT VISIT TO THE MOCHALIN LAB AT MISSOURI UNIVERSITY OF SCIENCE & TECHNOLOGY, USA FOR A PERIOD OF EIGHT WEEKS.

Phillipp will be taking up the fellowship in 2018

DR TRISTAN CLEMONS FROM THE UNIVERSITY OF WESTERN AUSTRALIA VISIT TO THE STUPP LABORATORY AT THE NORTHWESTERN UNIVERSITY, CHICAGO, USA FOR A PERIOD OF THREE MONTHS

Tristan will be taking up the fellowship in 2018

DR MOHSEN RAHMANI FROM THE AUSTRALIAN NATIONAL UNIVERSITY VISIT TO THE LASER ZENTRUM, HANNOVER, GERMANY FOR A PERIOD OF FIVE WEEKS

Mohsen will be taking up the fellowship in 2018

MISS YUAN WANG FROM THE UNIVERSITY OF NEW SOUTH WALES VISIT TO THE FRITZ-HABER INSTITUTE, MAX PLANCK SOCIETY, BERLIN, GERMANY FOR A PERIOD OF THREE MONTHS

Yuan will be taking up the fellowship in 2018

MR DEEPAK DWIVEDI FROM CURTIN UNIVERSITY VISIT TO CAMBRIDGE UNIVERSITY FOR A PERIOD OF EIGHT WEEKS.

Deepak will be taking up the fellowship in 2018

Workshops, Conferences and Events

8TH BIENNIAL AUSTRALASIAN COLLOID AND INTERFACE SYMPOSIUM.

29/01/2017 - 02/02/2017 - COFFS HARBOUR

Introduction

ACIS 2017 was held at Opal Cove Resort, Coffs Harbour, from 29 January to 2 February 2017. The symposium programme offered four days of stimulating and thought provoking sessions and showcasing speakers. The conference commenced with registration at 2.30pm on Sunday 29 January, and the Welcome Reception was held outside on the Pool Terrace of the hotel that evening. The 2017 ACIS sessions commenced on Monday 30 January at 8.30am. The programme format consisted of plenary & concurrent sessions, trade displays, a poster session and social functions.

Delegate Testimonials:

"Excellent programme and location, very good networking opportunities, excellent organization. I was particularly impressed by the strong commitment to equality and diversity, strengthened by two dedicated sessions outside of the scientific programme and the good gender balance in speakers."

"good scientific presentations, networking, catching up with colleagues, enough time to discuss, excellent program"

"ACIS was by far the most congenial conference/symposium I have been to and this is largely down to the friendly and approachable nature of the senior delegates. The field is very collegiate, resulting in a constructive environment for discussion/debate and it would be great to see this atmosphere maintained into the future as the next generation become senior delegates."

"The well-organized conference I have attended. The best was that everything was on time so I could attend all the sessions I wanted to. The venue was also great as well. Thanks so much for putting it together. Also thank you for not printing the abstracts. I really feel that it is not necessary and it wastes resources."

Venues

The symposium was held at Opal Cove Resort, Opal Boulevard, and Coffs Harbour NSW. Plenary sessions were held in the Ballroom. Breakout sessions were held in Osprey, Currawong and Shearwater (the Ballroom split into 3rds).

The registration desk, exhibition and poster boards were in the Foyer area of the hotel, with lunch being held in the exhibition area and the Opals Room. Morning and afternoon tea was served throughout the exhibition area.

The Welcome Reception was held outside on the Pool Terrace at Opal Cove. The conference Dinner was held at Aanuka Beach Resort, 11 Firman Drive, Coffs Harbour, NSW, a 5 minute coach transfer from Opal Cove. Some delegates stayed at Aanuka Beach Resort. The Kingfisher was used as the conference secretariat room.

Organising Committee

Prof. Gunther Andersson (Chair), Flinders University
Dr. Bryn Coad (Co-Chair), The University of Adelaide
Prof. Vincent Craig (Treasurer), Australian National University
Dr. Rico Tabor (Social Program Coordinator), Monash University

Aminreza Khodabandeh (Committee), University of Tasmania
Jane Yeaman & Sarah Robinson (Conference Secretariat), Tulips Meetings Management

Theme Chairs

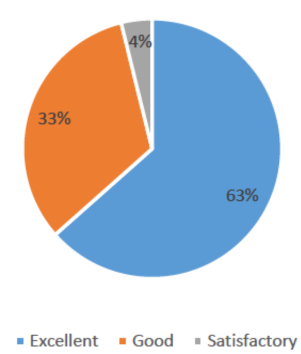
1. Thin Liquid Films and Surface Coatings Theme Chairs: A/Prof. Chiara Neto and Dr. Tim Davey
2. Hierarchical Assembly of Nanomaterials Theme Chairs: Prof. K. Swaminathan Iyer and A/Prof. Zhi Ping (Xu
3. Biointerfaces Theme Chairs: Dr. Bryan Coad, Dr. Laurence Meagher, Dr. Ingo Koeper and Prof. Gunther Andersson
4. Nanobubbles Theme Chairs: Prof. Vincent Craig and A/Prof. Xuehua Zhang
5. Controlled Release of Bioactives Theme Chairs: Dr. Wye-Khay Fong and Dr. Nicky Thomas
6. Scattering and Self-Assembly Theme Chairs: Dr Charlotte Conn and Dr. Rico Tabor
7. Frontiers in Colloid and Interface Science Theme Chairs: Prof. Raymond Dagastine and Dr. Alison Tasker

Attendee Data

201 participants attended the conference.
State / Country No. of Delegates % of delegates
Australian Capital Territory 6 3%, New South Wales 39 19%, Queensland 14 7%, South Australia 10 5% Tasmania 1 0%, Victoria 52 26%, Western Australia 4 2%, Canada 21%, China 5 2%, Czech Republic 1 0%, Denmark 1 0%, France 1 0%, Germany 14 7%, Ireland 10%, Japan 12 6%, Netherlands 21%, New Zealand 10 5%, Saudi Arabia 2 1%, Singapore 4 2%, South Korea 1 0%, Taiwan 2 1%, United Kingdom 9 4%, USA 8 4%
TOTAL Delegates 201 100%

The conference received very positive feedback from delegates on a number of measures including the overall content of the scientific program.

Overall Content of the Program



Support from the Australian Nanotechnology Network.
The following delegates had their conference fees covered from the ANN bursaries

Ritchie Cameron Student , Blauth Christian Student , Barker Emily Student, Robinson Kye Student Jehannin Marie ECR , Wickham Shelley ECR , Daughtry Jesse Student , Du Joanne student.

Presentations by supported delegates
Delgate Presentation
Cameron Ritchie - A Low Temperature, Water-Based Synthesis of Non-Toxic, Single Crystal CZTS Nanoparticles for Photovoltaics
Christian Blauth Can nanoparticles be the new efficient light emitting material for blue ?
Emily Barker - Formation of Proline Calix[4]arene Hydrogel Imaged by In Situ Atomic Force Microscopy
Kye Robinson- Investigation of Modified Organosilica Core-shell Nanoparticles for Stable pH Sensing in Biological Environments
Marie Jehannin - Nano bubbles in Mixtures of Water and Non-Aqueous Solvents
Shelley Wickham DNA Barrels: Cylindrical NanoPegboards Assembled from DNA
Jesse Daughtry - Pulsed vapour deposition of ligand supported, chemically-synthesised clusters onto defect-rich TiO2

Joanne Du - Stimuli Responsive Phospholipid-based Nanomaterials for On-demand Drug Delivery

The organising committee of ACIS 2017 are very grateful for the support of the Australian nanotechnology Network in providing support for these bursaries that enable PhD students and Early Career Researchers to attend our meeting and contribute in a very significant way to the scientific discourse.

WORKSHOPS, CONFERENCES AND EVENTS

11TH CONFERENCE ON NEW DIAMOND AND NANO CARBONS.
28/05/2017 - 01/06/2017 - SHANGRI-LA, CAIRNS

NDNC
CAIRNS AUSTRALIA
28 May - 1 June 2017

The New Diamond and Nano Carbons conference was held in Cairns 28/5 – 1/6 2017. This is one of the largest diamond meetings globally and the largest in the Asia/Pacific meeting.

The conference spans wide research topics from fundamental physical and chemical concepts to applied technologically driven applications with carbon based materials. Those include, but not limited to single crystal diamond, nanodiamonds, carbon nanotubes, graphene and other carbon nanostructures. This conference received more than 200 abstracts from 22 countries that resulted in 86 oral talks, 104 posters. More than 50% of the attendees were PhDs/ECRs

Conference Topics included

- Carbon materials in Energy
- Color centers in diamond
- Diamond and Carbon in biology
- Novel carbon materials
- Nanodiamonds for sensing
- Diamond growth and doping
- Surfaces and interfaces of carbon materials
- Theoretical modelling of carbon materials
- Electronic, spintronic and optical properties of diamond
- Device Structures
- Graphene and other 2D materials
- MEMs
- Electrochemistry of diamond and nanocarbon materials
- Diamond-like carbon and amorphous carbon
- Hybrid carbon materials

WORKSHOPS, CONFERENCES AND EVENTS

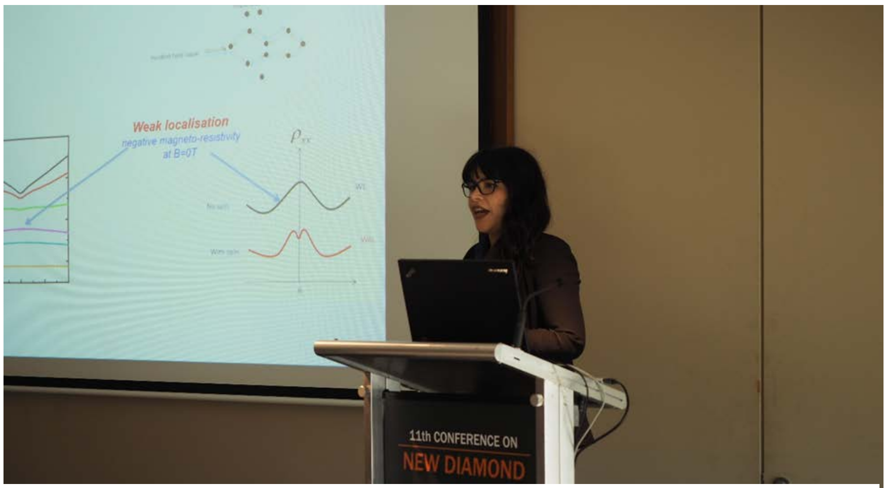
List of Invited speakers below

Title	Name	University / Institution
Prof	Amir Yacoby	Harvard University, USA
Prof	Mark Newton	Warwick University, UK
Prof	Kian Ping Loh	National University of Singapore, SINGAPORE
Invited Speakers		
Title	**Name**	**University / Institution**
Prof	Dean Ho	University of California Los Angeles, USA
Dr	Hiromitsu Kato	National Institute of Advanced Industrial Science and Technology, JAPAN
Prof	Shery Chang	Arizona State University, USA
Prof	Ryong Ryoo	Korea Advanced Institute of Science and Technology, KOREA
Dr	Alastair Stacey	University of Melbourne, AUS
Prof	Bingqing Wei	University of Delaware, USA
Prof	Chrsitian Degan	E.T.H Zurich, SWITZERLAND
Prof	Mutsuko Hatano	Tokyo Institution of Technology, JAPAN
Prof	Peter Cigler	Czech Academy of Science, Czech Republic
Prof	Wolfram Pernice	University of Munster, GERMANY
Prof	Nicolas Rouger	Grenoble Institute of Technology, FRANCE
Prof	Li-Chyong	National Taiwan University, TAIWAN
Prof	Anyuan Cao	Peking University, CHINA
Prof	Hua Zhang	Nanyang Technological University, SINGAPORE

The following students and ECRs received a fee waiver for their registration (~ 500$ value) from ANN. We aimed to achieve geographical as well as gender balance while maintaining highest quality.

Student name and institution	Topic
1. Kerem Bray (UTS)	Diamond and Carbon in biology
2. Shaikh Nayeem Faisal (USYD)	Hybrid carbon materials
3. Md. Monirul Islam (UoW)	Graphene and other 2D materials
4. Golrokh Akhgar (LaTrobe)	spintronic and optical properties of diamond
5. Sidra Waheed (UTas)	MEMs
6. Julia McCoey (UoM)	Diamond and Carbon in biology

7. Jan Jeske (UoM)	Spintronic and optical properties of diamond
8. Nicole Cordina (MQ)	Diamond and Carbon in biology
9. Tak Kim (Griffith)	Novel carbon materials
10. Wei Tong (UoM)	Diamond and Carbon in biology



Golrokh Akhgar (ANN bursary recipient presenting her talk

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WORKSHOPS, CONFERENCES AND EVENTS

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NDNC Delegates

WORKSHOPS, CONFERENCES AND EVENTS

7TH INTERNATIONAL CONFERENCE ON NANOMATERIALS BY SEVERE PLASTIC DEFORMATION. 02/07/2017 - 07/07/2017 – SYDNEY

POST EVENT REPORT TO ANN

Conference Summary:

The conference was successfully held in the University of Sydney, Australia on 2–7 July 2017. There were over 200 conference delegates from 24 countries, including Australia, Austria, China, France, Germany, India, Iran, Japan, Russia, South Korea, UK, and USA. During the conference, 8 keynote presentations, 158 invited and contributed oral presentations, and 21 poster presentations were offered covering the areas of processing, microstructures and deformation mechanisms, mechanical properties, modelling, and innovations in SPD processes. The Pro Vice-Chancellor (Strategic Collaborations & Partnerships) in the University of Sydney provided the opening remarks for the conference. This was followed by the traditional introductory lecture given by Prof. Ruslan Valiev and Prof. Terence Langdon, including the report of the International NanoSPD Steering Committee on the related activities over the past three years.

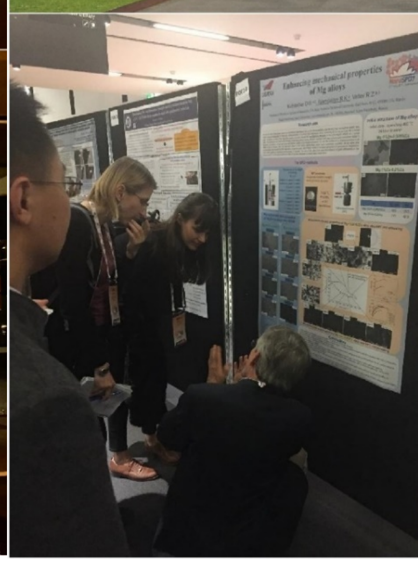
To encourage excellent young NanoSPD researchers, the conference ran four dedicated Young Researcher sessions on Tuesday for 21 postdocs and research students. Four oral presentations (one from each session) were selected for the best oral presentation awards. Two best posters were also chosen during the poster reception on Tuesday night. All presenters were commended for their high standard of work.

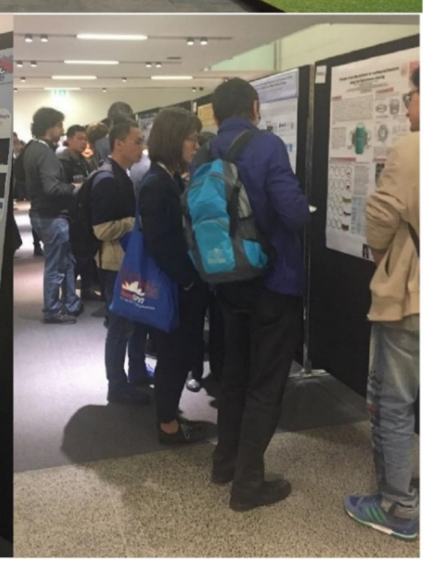
Participant Numbers: 226 (34 Australian / 192 International)

Details of Funding Recipients: Fund were used to support their participation at the conference.

NAME	AFFILIATION	RESEARCH TOPIC
Dr. Ahmad Zafari	University of Melbourne	Grain refinement in a severely deformed beta titanium alloy at different strains and strain rates
Mr. Prathap Chandran	University of Melbourne	Processing and characterization of Al-Al3Nb prepared by mechanical alloying and equal channel angular pressing
Dr. Xianghai An	University of Sydney	Microstructural evolution and phase transformation in twinning-induced plasticity steel induced by high-pressure torsion

Mr. Yu Liu	University of Wollongong	Effect of sample orientation on the dynamic recrystallization of an AZ31 Mg alloy during high strain- rate deformation
Dr. Qingyun Lin	University of Sydney	Dynamic strain aging precipitation of Mg17Al12 Phase in AZ80 magnesium alloy||during multi-directional forging process
Dr. Jiaqi Duan	University of New South Wales	Thermal behaviour and texture of commercial purity nickel sheets by accumulative roll bonding
Mr. Md Nazmul Hasan	University of Sydney	Evolution of Heterogeneous Nano Structure in 316LN Austenitic Stainless Steel by Heavily Cold-Rolling
Mr Dongzhi Luo	University of Wollongong	Microstructures and hardness of stir zone for friction stir processed and post-processed heat treatment 7B04-O aluminium alloy





WORKSHOPS, CONFERENCES AND EVENTS

8TH INTERNATIONAL NANOMEDICINE CONFERENCE
03/07/2017 - 05/07/2017 - CROWNE PLAZA, COOGGEE BEACH, SYDNEY, NSW

The organising committee of the 8th International Nanomedicine Conference, and our co-hosts the Australian Centre for NanoMedicine (ACN) and the ARC Centre of Excellence for Convergent Bio-Nano Science and Technology (CBNS) would like to thank the Australian Nanotechnology Network (ANN) for their sponsorship and for providing funds to assist students and ECRs in attending the conference.

CONFERENCE ATTENDEES

The conference attracted more than 215 delegates from around Australia and internationally (103 delegates from NSW, 73 from interstate, 39 international) to discuss key themes in the field of nanomedicine: Drug Delivery; Sensors and Imaging; Bioactive Materials; Bio-Nano Interactions & Nano Toxicology; Social Aspects & Regulatory; Industry Session; Microfluidic and Clinical Challenges. Over the course of 3 days, 5 plenary, 11 Keynote, 22 invited, and 50 oral presentations (from submitted abstracts) were given along with 58 posters. Of the 215 delegates, 98 were university students and there were an additional 5 high school science students from St Aloysius College (Kirribilli, NSW) who participated as judges of the poster competition. In addition, 14 delegates from industry and government research institutes attended the conference.

NSW Health Minister Brad Hazzard attended and officially opened the 8th International Nanomedicine Conference.

The Minister delivered an opening speech entitled: *Inspiring insights: nanoparticles/ targeted drug delivery*

https://twitter.com/BradHazzard/status/881664824324702208

WORKSHOPS, CONFERENCES AND EVENTS

Through the funding provided by the ANN, the conference was able to provide support for 17 students and ECRs from 5 different research institutions (see table below).

#	Name	Company
1	Dr Maria Alba-Martin	Monash University
2	Dr Anna Cifuentes-Rius	Monash University
3	Ms Upulie Divisekera	Monash University
4	Ms Tara Alvarez	Monash University
5	Ms Anna Gemmell	The University of Queensland
6	Dr Zach Houston	The University of Queensland
7	Ms Imanda Jayawardena	The University of Queensland
8	Mr Kevin Koo	The University of Queensland
9	Ms Bei Li	University of Queensland
10	Ms Jing Wang	The University of Queensland
11	Ms Yilun Wu	The University of Queensland
12	Mr Md Nurul Karim	RMIT University
13	Dr Yi Ju	The University of Melbourne
14	Dr Mattias Björnmalm	The University of Melbourne
15	Miss Tahlia Meola	University of South Australia
16	Ms Hayley Schultz	University of South Australia
17	Ms Leah Wright	University of South Australia

The ANN's sponsorship was acknowledged throughout the proceedings including verbally during the conference opening and closing ceremonies, and on slides in all conference rooms between sessions. In addition, the ANN logo was displayed on the conference website and 1-page foldout. ANN company descriptor and contact information was printed in the conference program booklet.

On behalf of the Conference Organising Committee, thank you again for your support.

Professors Maria Kavallaris, Richard Tilley and Nico Voelcker

Co-Chairs of the 8th International Nanomedicine Conference

WORKSHOPS, CONFERENCES AND EVENTS

NANOTECHNOLOGY ENTREPRENEURSHIP WORKSHOP FOR EARLY CAREER RESEARCHERS. 12/07/2017 - 13/07/2017 - FUTURE INDUSTRIES INSTITUTE, MAWSON LAKES CAMPUS, UNIVERSITY OF SOUTH AUSTRALIA

The aim of this symposium was to provide a forum for early career researchers (ECRs) and postgraduate students working on nanotechnology research to interact with industry leaders and learn about how to commercialise Nanotechnology.

This workshop was chaired by Prof.Peter Majewski from the University of South Australia, and co-chaired by Miss Gayathri Rajeev also from the University of South Australia.

There was a total of 60 attendees, 10 of which were Early Career Researchers and 57 PhD and masters student, with wide representation from the major Universities all over Australia.

Seven speakers were invited to speak about and share their knowledge and experience in the area of innovation and entrepreneurship.

These speakers were

Dr Anita Hill, Executive Director, Future Industries, CSIRO - Future Trends for Future Industries

Dr Matthew Lay, FB Rice - Why, what and when of patents

Ms Nehal Jain, Microsoft Innovations Centre - Innovate on the cloud with the Microsoft Innovation Centre

Ms Rosie Hicks, Australian National Fabrication Facility- Introduction to the Australian National Fabrication Facility

Ms Rebecca O'Dell, Business South Australia - Bringing your Business Idea to Life

Dr Stephen Rodda, UniSA Ventures Pty Ltd - Supporting entrepreneurship from a University environment

Ms Jo Schneider, DVE Business Solutions - Transferring engineering skills into business results

Prof Benjamin Thierry, University of South Australia - Ferronova: from a PhD project to a VC-backed spin-off company

Dr Shruti Sardeshmukh, University of South Australia- Pitch-perfect: Making a business case

The workshop was run in three main sections:

Invited Speakers presentations

Each of the invited speakers presented talks on a wide variety of topics which emphasised on their own experience in their own ground-breaking research (from a cancer diagnostic company to setting up and transferring skills into business results. Following each session there was a direct discussion with each of the presenters.

Poster Session

The poster session was run after the talks on the first day. The students and ECRs presented their own research through poster presentations. There was a lot of discussion with the Invited speakers during this session. The best posters were awarded a cash prize at the end of the workshop.

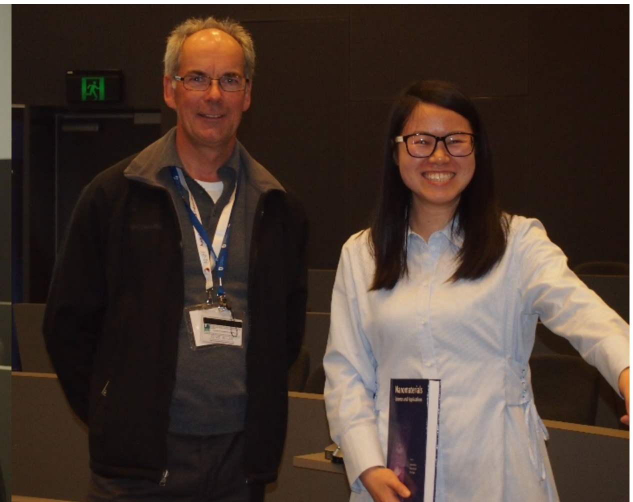
Enhancement of Catalytic Activity and Stability of Hexapod Mesostructured Perovskite for Methane Combustion, Yuan (Helena) Wang et al.

Grain Boundary Chemistry of Dual Main Pahse Nd-Ce-Fe-B as Sintered Magnets Revealed by Atom Probe Tomography, Hengshen Chen et al.

Group work and pitching sessions

After Dr Sardeshmukh's talk on making a business case pitch perfect on the second day the delegates were divided into three groups and were asked to work on preparing a business case to pitch to a panel which consisted of some of the invited speakers. Each group was also mentored by one of the invited speakers. The pitching session took place after lunch and each group was given 10 minutes with another 5 minutes of question time from the panel. Although reluctant and with very little time to prepare for their pitch, the three groups were very enthusiastic in their presentations. At the end of the pitching sessions, all three groups were awarded cash prizes in order of best business pitch.

WORKSHOPS, CONFERENCES AND EVENTS



The workshop was very well received by all attendees present judging by the casual oral feedback from invited speakers and delegates.

WORKSHOPS, CONFERENCES AND EVENTS

INTERNATIONAL SYMPOSIUM ON ENERGY CONVERSION AND STORAGE MATERIALS 31/07/2017 - 03/08/2017 - BRISBANE

Re: **ANN sponsorship funding**

Symposium Summary

As global population growth and economic development continue to ramp up, sustainable energy supply is emerging among the top issues and challenges for humanity. In addressing this challenging issue, innovative materials are essential enablers for efficient energy conversion and energy storage systems. As a satellite meeting of the Centenary RACI, IChemE and Carbon Conference on 23-28th July in Melbourne, the 2017 International Symposium on Energy Conversion and Storage Materials (ISECSM-2017) was held on 31st July – 3rd August 2017 in Brisbane, Australia. This ISECSM-2017 symposium brought together over 200 researchers from various countries to discuss the latest advances in functional materials for sustainable energy conversion and storage technologies. The symposium promoted international cooperation and partnership between world leaders in the fields of nanomaterials and nanotechnology for clean energy applications.

We received around 190 abstracts with a long list of outstanding plenary/keynote/invited speakers to present at the symposium. Day one and two of the symposium began with plenary sessions. Presentations were given by leading scientists on the topics of a rich collection of functional nanomaterials, innovative devices and their application in energy conversion and storage fields. We had three parallel sessions on different topics, including catalysis, energy storage, solar cells, and functional nanomaterials. To complement the oral presentations, a poster session was held on Tuesday 1st Aug. In the third day (3rd Aug), a special Early Career Researcher (ECR) session was held at UQ for young scientists and students to present their research.

ORGANISING COMMITTEE

Chair: Prof. Lianzhou Wang, The University of Queensland
Co-Chair: Prof. Alan Rowan, AIBN director, The University of Queensland
Co-Chair: Prof. Dan Wang, Institute of Process Engineering, Chinese Academy of Sciences
Co-Chair: Prof. Gang Liu, Institute of Metal Research, Chinese Academy of Sciences
Prof. Debra Bernhardt, The University of Queensland
Prof. Ian Gentle, The University of Queensland
Prof. Chris Greig, the University of Queensland
Prof. Yue Zhang, University of Science and Technology, Beijing
Ms. Cheryl Berquist, The University of Queensland
Dr. Yang Bai, The University of Queensland
Dr. Delai Ye, The University of Queensland
Dr. Bin Luo, The University of Queensland
Dr. Muxina Konarova, The University of Queensland
Dr. Ruth Knibbe, The University of Queensland
Dr. Yun Hau Ng, The University of New South Wales

SYMPOSIUM ORGANISATION

Nanomaterials Centre- Australian Institute for Bioengineering and Nanotechnology (AIBN)
Faculty of Engineering, Architecture, and Information Technology (EAIT), The University of Queensland

Details of expenditure

The funding was used to support the registration of the following 5 postdocs and 4 phd students and 2 poster or oral presentation awards. The detailed information of the recipients are listed below.

Student/ECR name	institution	research topic
Dr. Yan Jiao	The University of Adelaide	Evaluation of Graphene Materials for Electrochemical Energy Conversion Reactions
Dr. Mega Kar	Monash University	ETHER-FUNCTIONAL IONIC LIQUIDS FOR MAGNESIUM BATTERIES
Dr. Wei Li	Monash University	Microstructure characterizations for photoactive perovskite materials-CH3NH3PbI3 and CsPbIBr2
Dr. Hui-Ling Tan	The University of New South Wales	Understanding the Crystal-Facet-Dependent Interfacial Charge Interactions between BiVO4 and Reduced Graphene Oxide
Dr. Jinbao Zhang	Monash University	Developing Efficient Triphenylamine-based Hole Transport Materials for Perovskite Solar Cells
Ms. Shi-Nee Lou	The University of New South Wales	An Operando Synchrotron X-Ray Diffraction Visualisation of the Light-Induced Intercalation Reactions in MoO3 Solar Batteries
Mr. Cho-Fai-Jonathan Lau	University of New South Wales	Highly Efficient Strontium Doped CsPbI2Br Perovskite Solar Cells
Mr. Da-Seul Lee	University of New South Wales	Grain size engineering for organic metal halide perovskites using mixed anti-solvents
Mr. Mohammad-Ziaur Rahman	The University of Adelaide	Enhancing Visible-Light Photocatalytic Hydrogen Production on Melem
Mr. Wenxin Mao	Monash University	Controlled Growth of Monocrystalline Organo-Lead Halide Perovskite and Its Application in Photonic Devices (**ANN Poster Award**)
Dr. Yan Jiao	The University of Adelaide	Evaluation of Graphene Materials for Electrochemical Energy Conversion Reactions (**ANN Oral Award**)

Symposium Photo

WORKSHOPS, CONFERENCES AND EVENTS

INTERNATIONAL CONFERENCE ON BIONANO INNOVATION
24/09/2017 - 28/09/2017 - UNIVERSITY OF QUEENSLAND

Report on International Conference on BioNano Innovation (ICBNI 2017)

Prepared by Andrew Whittaker, Co-Chair of ICBNI 2017

Overview of Conference

The International Conference on Bio-Nano Innovation (ICBNI 2017) was held on The University of Queensland campus in September 2017. The conference presented the latest advances in the most exciting and commercially-promising area of science and engineering, i.e. the interface between the biological and physical sciences at the nanoscale. Science and technology at the Bio-Nano Interface is delivering not only new understanding of our world, but is being translated into valuable products in a vast array of areas, such as microelectronics, biologics and other therapeutics, stem cell therapies, new vehicles and approaches to delivering drugs, advanced diagnostics tools, nanocomposites, etc., etc.

The ICBNI brought to Brisbane world leaders in the BioNano fields to discuss their latest results and the latest advances in their field. Plenary speakers were Professor Elizabeth Blackburn, Director of the Salk Institute, and Nobel Laureate in Physiology or Medicine in 2009, Professor Alan Mackay-Sim, Emeritus Professor, Griffith University and 2017 Australian of the Year, Professor Ian Frazer, The University of Queensland and 2006 Australian of the Year, Professor Heather Maynard, UCLA, Professor Melissa Little, Murdoch Childrens Research Institute, Professor Geraldine Richmond, University of Oregon, Professor Sam Stupp, Northwestern University, Professor Wilhelm Huck, Radboud University Nijmegen and Professor Johan Hofkens, KULeuven. There were a total of 42 Keynote speakers, 150 contributed talks and 60 poster presentations. Overall a total of 418 delegates attended the conference.

The ICBNI gratefully acknowledges the support of the Australian Nanotechnology Network. The following students and ECRs were supported by granting of complementary registrations. All are members of ANN.

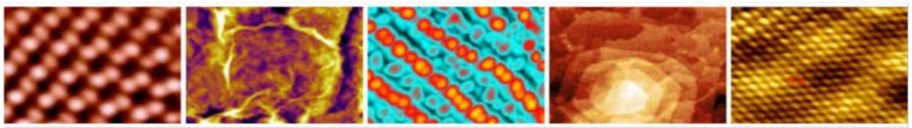
Surname	First Name	Status	Email	Affiliation
Li	Peng	Student	p.li3@uq.edu.au	AIBN
Hassanain	Waleed	Postdoctor	w.hassanain@qut.edu.au	QUT
Liu	Michelle	Postdoctor	Michelle.Liu@qimrberghofer.edu.au	QIMR
Tavallaie	Roya	Postdoctor	tavallaieroya@gmail.com	UNSW
Jiang	Edward	Student	e.jiang@uq.edu.au	AIBN
Pujara	Naisarg	Student	n.pujara@uq.edu.au	AIBN
Kumeria	Tushar	Postdoctor	t.kumeria@uq.edu.au	Adelaide
McDonough	Rowan	Student	mcdo0353@flinders.edu.au	Flinders
Jayawardena	Imanda	Student	c.jayawardena@uq.net.au	Monash

Hassan	Marwa	Student	m.hassan@imb.uq.edu.au	AMMRF
Popat	Amirali	Postdoctor	a.popat@uq.edu.au	AIBN
Tjandra	Kristel	Student	kristel.cahyadi@hotmail.com	UNSW
Sina	Abu	Student	a.sina@uq.edu.au	AIBN
Zadeh	Fatemeh	Postdoctor	f.mirnajafizadeh@unsw.edu.au	Sydney

Some of the Invited speakers at ICBNI

WORKSHOPS, CONFERENCES AND EVENTS

NANOSTRUCTURES FOR SENSORS, ELECTRONICS, ENERGY AND ENVIRONMENT
26/09/2017 - 29/09/2017 - QUEENSLAND UNIVERSITY OF TECHNOLOGY



NanoS-E3 2017 Brisbane

26-29 September 2017

QUT Gardens Point Campus - Brisbane, Australia

Conference Chair: Prof. Nunzio Motta

Conference Co-Chairs: Prof Antonio Tricoli, Dr Jennifer MacLeod, Dr Mahnaz Shafiei

Following the successful NanoS-E3 schools and workshops in 2007, 2008, 2011, 2013, and 2015 the 7th conference broadened the topics to 2D materials, batteries, supercapacitors and superconductors with a 2-day school proceeded by a 3-day workshop. The international meeting fostered knowledge exchanges, especially between international leaders and young scientists in the field of nanotechnology, focusing on sensors, electronics, energy and environment, whilst establishing fruitful collaborations in the area of material science, chemistry, physics and engineering.

This rapidly emerging field focussed on design, fabrication, and characterisation of functional objects having dimensions at the nanometer length scale. The new advances in this field are expected to have long-range implications in a wide variety of different scientific and engineering disciplines.

HIGHLIGHTS

Participant Numbers

Lecturers 9, Keynote Speakers 11, Invited Speakers 31, Students 30

WORKSHOPS, CONFERENCES AND EVENTS

Conference Chairs

Name	Affiliation
Prof Nunzio Motta	Queensland University of Technology (QUT), Brisbane
Prof Antonio Tricoli	Australian National University (ANU), Canberra
Dr Jennifer MacLeod	Queensland University of Technology (QUT), Brisbane
Dr Mahnaz Shafiei	Swinburne University of Technology (SUT), Melbourne & Vice Chancellor's Senior Research Fellow IFE, Queensland University of Technology (QUT), Brisbane

Organising Committee

Name	Affiliation
Prof Nunzio Motta	Queensland University of Technology (QUT), Brisbane
Dr Jennifer MacLeod	Queensland University of Technology (QUT), Brisbane
Dr Josh Lipton- Duffin	Queensland University of Technology (QUT), Brisbane
A/Prof Anthony O'Mullane	Queensland University of Technology (QUT), Brisbane
Prof YuanTon Gu	Queensland University of Technology (QUT), Brisbane
Prof John Bell	Queensland University of Technology (QUT), Brisbane

SPONSORS

In addition to ANN sponsorship, the event was supported and sponsored by:

Scitek, Institute for Future Environment, QUT, AXT, ARC Centre of Excellence in Future Low-Energy Electronics Technologies (FLEET), ATA Scientific Instruments, Office of Naval Research, Science and Technology, Australian Institute of Physics

SCHOOL

2 day school. Lectures were exciting and interactive, delivered by outstanding scientists in the field.

Lecturers

Name	Affiliation	Topic
Prof Dimitri Goldberg	QUT	New Possibilities of Transmission Electron Microscopy: in situ Studies
Prof Chennupati Jagadish	ANU	Growth and Characterization of Semiconductor Nanowires

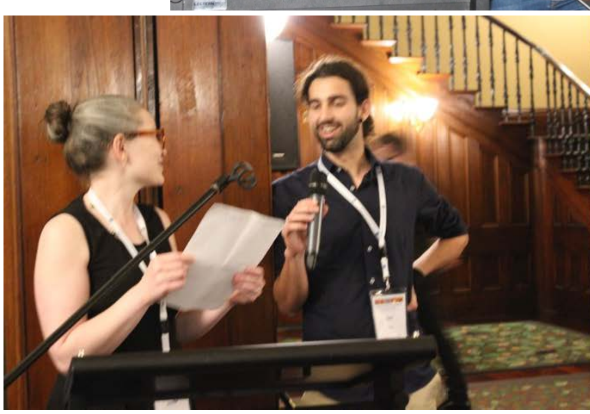
Prof Antonio Tricoli	ANU	Multi-Scale Engineering of Nanostructures and Devices by Flame Synthesis
Dr Josh Lipton-Duffin	QUT	Photoelectron Spectroscopy
Dr Jennifer MacLeod	QUT	Measuring the Electronic Gap
Prof Federico Rosei	Univ. du Québec	Survival Skills for Scientists
A/Prof Prashant Sonar	QUT	Conjugated Polymers for Flexible and Stretchable Electronics
Prof Peter Talbot	QUT	Lithium Batteries and Supercapacitors
A/Prof Aijun Du	QUT	Materials Design from Electronic Structure Engineering

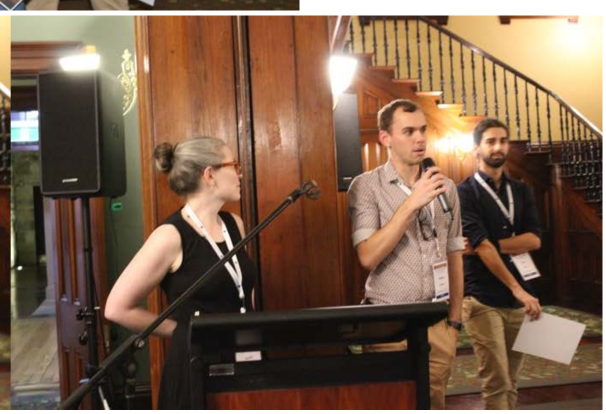
Poster Session

At the end of the 2-day school workshop, a poster session allowed students to present their work. As the poster session continued in a welcome cocktail and barbecue starting the workshop, all participants to the workshops attended the poster session.

A prize of gift cards (1 x $100 and 2 x $50) and an award certificate for the best poster was granted to: Qianhui Zhang from Monash University, Australia. 2nd prize to Zelio Fusco (ANU). 3rd prize to Jonathan Bradford (QUT).

1ST Prize





2nd (Zelio Fusco,ANU) and 3rd (Jonathan Bradford, QUT) Poster prize

WORKSHOPS, CONFERENCES AND EVENTS

Students funded by ANN

	Name	Institution
1	Marina Castelli	Monash University
2	Hamid Ilbeygi	University of South Australia (UniSA)
3	Zelio Fusco	Australian National University (ANU)
4	Yunyi Yang	Swinburne University of Technology
5	Sam Peppou-Chapman	University of Sydney
6	Teng Wang	Queensland University of Technology (QUT)
7	Maryam Abyazisani	Queensland University of Technology (QUT)
8	Danielle Holmes	University of Melbourne
9	Jonathan Bradford	Queensland University of Technology (QUT)
10	Arixin Bo	Queensland University of Technology (QUT)
11	Yang Wang	Monash University

WORKSHOP

The three-day workshop focused on the following topics:

Materials	Applications
Semiconductor Nanostructures	Quantum Computing
2D and Layered Materials	Nanoelectronic devices
Graphene/carbon nanostructures	Optoelectronics
Metal-oxide Nanostructures	Solar Cells
Conducting Polymers	Chemical Sensors
Organic Molecules	Water Purification
Phase Changing Materials	Nanofabrication Tools and Techniques
Magnetic Materials	Plasma Etching and Deposition
	Batteries, Supercapacitors and Superconductors

Keynote Speakers

Name	Affiliation	Topic
Dr Christopher Barner-Kowollik	QUT	Macromolecular Nanostructure
Dr Amanda Barnard	CSIRO	Molecular and Materials Modelling
Dr Dmitri Golberg	QUT	In-situ Electron Microscopy for Nanomaterials

Prof Veena Sahajwalla	RMIT	Transforming E-waste into value- added materials for energy storage applications
Prof Zhiwei Shan	Xi'an Jiaotong University	Nanomechanics
Prof Rudra Pratap	Indian Institute of Science	MEMS for Sensing
Prof Michael Fuhrer	Monash University	2D Materials - STM
Dr Meinan Liu	SINANO	Nanomaterials for Energy Storage
Prof Justin Gooding	UNSW	Chemical Sensors
Prof David Jamieson	Melbourne University	Quantum Computing
Prof Bronwyn Fox	Swinburne University	Carbonization of polymericprecursors

Invited Speakers

Name	Affiliation	Topic
Prof Chennupati Jagadish	ANU	Semiconductor Nanowires for Optoelectronics and Neuroscience Applications
Dr Agustin Schriffin	Monash University	Electronic Control at the Nanoscale: Towards Solid Interfaces with Enhanced Electronic and Optoelectronic Functionalities
Dr Federico Rosei	University. Du Québec	Surface Self assembly and polymerisation
Dr Meinan Liu	SINANO	Nanomaterials for batteries and supercapacitors
Prof Ian Mackinnon	QUT	Superconductors: Powering the Future
Prof Joe Shapter	Flinders University	Use of Nanomaterials in Solar Cells
Dr Paul Shaw	QUT	Fluorescence-based detection of explosive vapours
A/Prof Kylie Catchpole	ANU	Perovskite solar cells for high efficiency electricity generation and water splitting
Prof Jose Alarco	QUT	Identification of superconductivity mechanisms and prediction of new superconducting materials using DFT calculations
Prof Ajayan Vinu	UNISA	Nanoporous Carbon and Nitride Based Materials and their Applications
Prof Ken (Kostya) Ostrikov	QUT	Synergies in plasma-nano-catalysis
Prof Hongxia Wang	QUT	Effect of Chlorine on the Properties of MAPbI3 Perovskite Film Beyond Morphology
A/Prof Yeng Ming	NanYang Technological University	Hybrid perovskite materials for light emission application
A/Prof Aijun Du	QUT	Computational Discovery of Dirac Materials

Dr Rakesh Joshi	UNSW	Application of graphene and graphene oxide
Prof Baohua Jia	Swinburne University	Light interaction with 2D materials at a nanometer scale
Prof Cheng Yang	QUT	Failure behaviour of electrode materials
Dr Jarryd Pla	UNSW	Spin resonance at the quantum limit using superconducting microwave resonators
A/Prof Sharath Sriram	RMIT	Nanoscale effects in oxides for multi- state electronic memories
Prof Ken (Kostya) Ostrikov	QUT	Synergies in plasma-nano-catalysis
Prof Hongxia Wang	QUT	Effect of Chlorine on the Properties of APbI3 Perovskite Film Beyond Morphology
A/Prof Yeng Ming	NanYang Technological University	Hybrid perovskite materials for light emission application
A/Prof Aijun Du	QUT	Computational Discovery of Dirac Materials
Dr Rakesh Joshi	UNSW	Application of graphene and graphene oxide
Prof Baohua Jia	Swinburne University	Light interaction with 2D materials at a nanometer scale
Prof Cheng Yang	QUT	Failure behaviour of electrode materials
Dr Jarryd Pla	UNSW	Spin resonance at the quantum limit using superconducting microwave resonators
A/Prof Sharath Sriram	RMIT	Nanoscale effects in oxides for multi- state electronic memories

All presentations were of the highest measure, creating extensive debates and discussions which ensued during free time and breaks.

WORKSHOPS, CONFERENCES AND EVENTS

EMERGING POLYMER TECHNOLOGIES SUMMIT 22/11/2017 - 24/11/2017 - RMIT UNIVERSITY

The second Emerging Polymer Technologies Summit 2017 (EPTS'17) was held at RMIT University, Melbourne, Australia on 22–24 November 2017. The meeting was devoted to the scientific and technological aspects of polymer sciences. It aimed to give participants a warm and friendly environment in which to exchange ideas, discover novel opportunities, re-acquaint with colleagues, make new friends, and showcase their latest and exciting innovations in polymer science, engineering and technology, including applications in the areas of health, personal care, advanced materials and sustainability, etc.

We were very pleased to have four distinguished overseas and local plenary speakers at this Summit, including Professor Kristi Anseth of University of Colorado, Boulder (USA); Professor Katharina Landfester of Max Planck Institute for Polymer Research (Germany); Professor Bin Liu of National University of Singapore (Singapore); and Professor San Thang of Monash University (Australia). In addition, the Summit included many eminent keynote and invited speakers, as well as a raft of young and early career scientists' contributions, all of whom formed an integral part of the EPTS'17 scientific program. During the EPTS'17, we specially organised an Outreach Session', where secondary school science teachers and students were invited to participate free-of-charge and to hear about recent advances in polymer technologies. Also, a session on translational research and a session on academia–industry collaboration were organised allowing academics and industry representatives to share their success stories from different perspectives.

EPTS'17 attracted 174 attendees, including 59 female attendees, from 19 different countries. The Outreach Session had 59 teachers and students from 9 schools registered. 9 bursaries were offered to students and early career researchers, as shown in the Table below.

Title	First name	Last name	Institution	Country	Bursary sponsor
Mrs.	Nesibe A	Dogan	KAIST	Korea	EPTS'17
Dr.	Ros	Ramli	Universiti Malaysia Pahang	Malaysia	EPTS'17
Mr.	Joshua	Holloway	Ghant University	Belgium	EPTS'17
Dr.	Vinh	Truong	Monash University	Australia	EPTS'17
Mr.	Kamyar	Shirvanimoghaddam	Deakin University	Australia	ANN
Ms.	Melinda	Jue	Georgia Institute of Technology	USA	EPTS'17

Dr.	Junqiao	Lee	Curtin University	Australia	ANN
Dr.	Pree	Johnston	CSIRO	Australia	ANN
Ms.	Xiangyu	Pan	Monash University	Australia	EPTS’17

EPTS’17 gratefully acknowledges the support and sponsorship of RMIT University School of Engineering, Australian Nanotechnology Network, FB Rice, Boron Molecular, BASF, Davies Collison Caves, Polymer International journal, ATA Scientific, Polymers journal and the International Academy of Innovative Business.

WEBSITE

Website

http://www.ausnano.net

The ANN Website is a very popular website and as at the end of 2017 it received more than 12,532,000 hits to the site, and it is believed that a significant amount of these are from Australia, and there is also interest from a number of other countries.

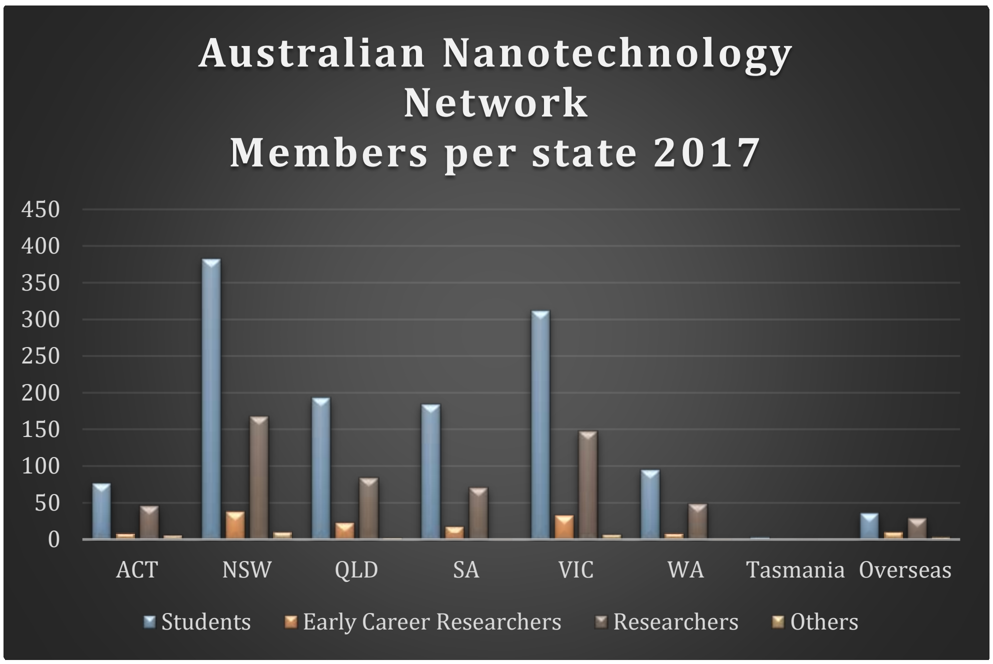
Website contains among other things:

- the lists of members and Research Groups affiliated with the network,
- online applications for members
- Online applications for grants
- Nanotechnology Facilities and Capabilities Register
- Reports from Young Nano Ambassadors
- Employment Opportunities
- Links to other websites and events

The website is continually being maintained and updated and there are links to various sites including various surveys, other networks and related activities.

MEMBERSHIP

The ANN membership consists of established researchers, Early Career Researchers, PhD students whose research field is in the area of Nanotechnology. It also consists of members from Government departments and industry.



State	Students	Early Career Researchers	Researchers	Others	Total
ACT	77	8	46	6	137
NSW	383	38	168	10	599
QLD	193	23	84	2	302
SA	185	18	71	1	275
VIC	312	33	148	7	500
WA	95	8	49	1	153
Tasmania	3		1		4
Overseas	36	10	29	3	78
TOTAL	1284	138	596	30	**2048**

Planned 2018 Activities

- **International Conference on Nanoscience and Nanotechnology (ICONN2018)** *29/01/2018 - 02/02/2018* - **Wollongong University , NSW**
- **Membrane Society of Australasia 5th Early Career Researcher Symposium.** *04/02/2018 - 06/02/2018* **- Macquarie University**
- **Energy Future Conference 2018** *05/02/2018 - 07/02/2018* **- University of New South Wales**
- **26th Annual Conference of the Australasian Society for Biomaterials and Tissue Engineering.** *03/04/2018 - 05/04/2018* **- Fremantle, Western Australia**
- **9th International Nanomedicine Conference** *25/06/2018 - 27/06/2018* **- Coogee, Sydney, NSW, Australia**
- **World Polymer Congress MACRO 2018** *01/07/2018 - 05/07/2018* **- Cairns Convention Centre**
- **Frontiers in Bio Nano Science** *27/09/2018* **- Monash University**