Australian Nanotechnology Network

Annual Report 2011

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MISSION STATEMENT AND OBJECTIVES

Mission Statement

The Mission statement of the Australian Nanotechnology Network (formerly ARCNN) is to enhance Australia's Research in Nanotechnology and related areas, by effectively promoting and drawing together collaborations in this field.

The ARC funding came to an end in 2010. ANN has received funding from the Department of Innovation, Industry, Science and Research towards the continuation of network operations for the next three years.

This innovative network was created by four seed funding networks joining together in order to cover the broader areas and to create a larger more effective network.

As from this year the following institutions will also be contributed to the funding of the network operations.

Australian National University, CSIRO, DSTO, 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 (formerly ARCNN) 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

2011 in Review

The work in 2011 was focused on enhancing the funding of programs and events related to Nanotechnology around the country. Preparations were also underway for the next International Conference on Nanoscience and Nanotechnology to be held in Perth in February 2012.

Membership of 1313, participants including 800 post graduate students and Early Career Researchers. More than 265 research groups are participating in the Network.

Over 3,500,000 Website hits

Held the ANN Early Career Researcher Workshop

1 Long Term Visit

2 Short Term Visits

10 Overseas Travel Fellowships

6 Events Sponsored by ANN

Published two Editions of the NanoQ (Nano Quest Magazine)

Structure and Management

The Australian Nanotechnology Network is managed by a Management Committee which met twice during 2011. The meetings were held in May at the University of New South Wales and in October at the University of Melbourne.

This 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 ARC 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 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 publicise 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.*

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. The MC has representatives from ANSTO, CSIRO, DSTO and industry.

Chairman – Emeritus Professor Erich Weigold – Australian National University

Convenor- Prof Chennupati Jagadish - Australian National University

Events Working Group

Prof. Laurie Faraone	**the University of Western Australia**
Prof. Paul Mulvaney	**the University of Melbourne**
Dr Alan Wilson	**Defence Science and Technology Organisation**
Prof. Peter Majewski	**University of South Australia**
Prof Michael James	**Australian Nuclear Science and Technology Organisation**

Visits Working Group

Dr Adam Micolich	**University of New South Wales**
Prof. Deb Kane	**Macquarie University**
Prof Gordon Wallace	**University of Wollongong**

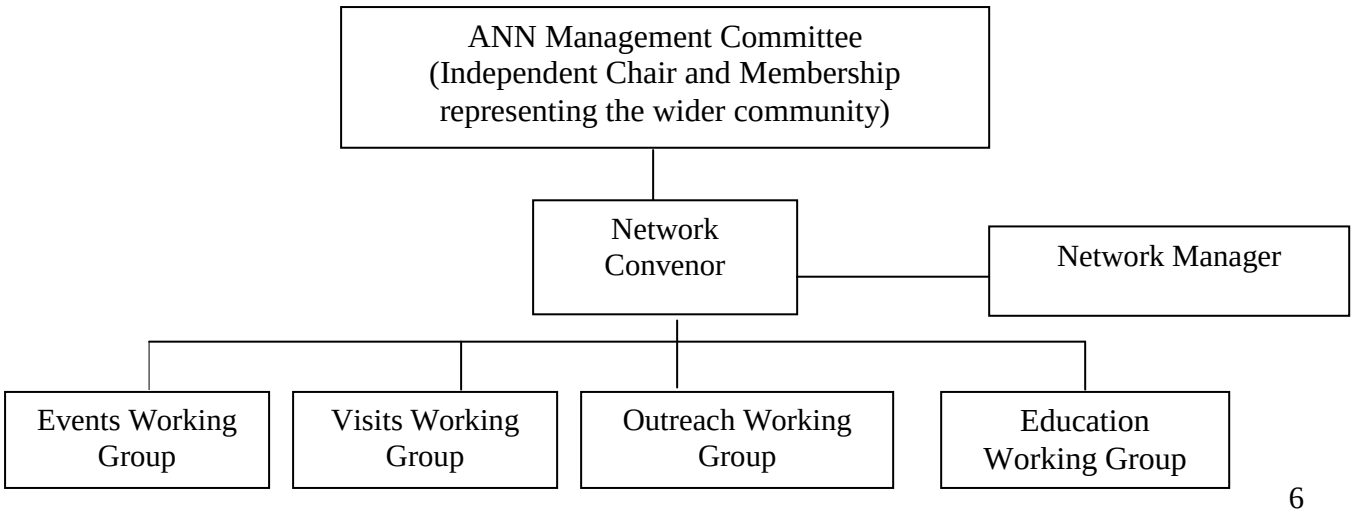
Outreach Working Group

Dr Adam Micolich	**University of New South Wales**
Prof. Deb Kane	**Macquarie University**
Mr Jaret Lee	**Australian National University**

Education Working Group

Prof. Max Lu	**University of Queensland**
Dr Terry Turney	**Micronisers Pty Ltd and Monash University**
Dr Steve Duvall	**Silanna Ltd**
Dr Calum Drummond	**Commonwealth Scientific and Industrial Research Organisation**
A/Prof Paul Wright	**RMIT-University, convenor of NanoSafe Australia**
Ms Liz Micallef	**Network Manager**

ANN Structure



ACTIVITIES UNDERTAKEN BY ANN

List of Activities funded / organized by ANN

- ANN Early Career Researcher Workshop - 21-22nd November 2011

Long Term Visits

Miss Rhiannon Creasey (Flinders University) visit to Curtin University in Western Australia

Short Term Visits

- Dr Withawat Withayachumnankul (Uni Adelaide) visit to RMIT
- Mr Benjamin Gully (UWA) to visit the CSIRO C3 protein crystallisation facility in Melbourne.
- Mr Zhou Deng from the University of Queensland - visit to Research School of Chemistry at the Australian National University

Overseas Travel Fellowships

- Mr Matthew Barr from the University of Newcastle visit to Cambridge University for a period of three months
- Miss Yeoh LaReine from the University of New South Wales visit to Cambridge University for a period of 6 weeks.
- Dr Natasha Sciortino from Sydney University visit to the Institute de chimie de la matière condensée de Bordeaux (ICMCB) in Bordeaux France for a period of 4-7 weeks
- Dr Tracey Clarke from the University of Wollongong visit to the University of Groningen, Netherlands for a period of eight weeks
- Mr Jing Ren from the University of Melbourne visit to Nagoya University in Japan for a period of 4 months
- Mr Rama Vasudevan from the University of New South Wales visit to the Oak Ridge National Laboratories in the USA
- Ms Xia Wu from the University of Queensland visit to the Ecole Polytechnique Federale de Lausanne (Switzerland) for a period of 3 months
- Dr Javad Faroughi from the University of Wollongong visit to the Nantech Institute at the University of Texas (USA) for a period of 8 weeks

- Mr Jason Chen from the University of New South Wales visit to the University of Nebraska (USA) for a period of 3 months
- Dr Angel Tan from the University of South Australia visit to the University of Copenhagen (Denmark) for a period of four weeks
- Dr Peter Metaxas from the University of Western Australia visit to the Georgia Institute of Technology (USA) for a period of 6 months

Asia Nano Camp

- Participants sent to the 4th Asia Nanotech Camp (ANC) 2011 which took take place on Aug. 15th through Aug. 28th 2011 in Korea.

Workshops and Events Sponsored by ANN

- Trilateral Nanophotonics Workshop, February 2011, McLaren Vale
- Australian and New Zealand Micro- and Nano-fluidics Symposium
- Nanostructures for Sensors, Electronics, Energy and Environment
- NanoS-E3 Kingscliff (NSW) 12-16 September 2011
- 2nd International NanoMedicine Conference Coogee Beach Sydney, 14-16th July
- Materials and Complexity V111 Workshop, 13-16th December 2011- Kioloa Campus (NSW coast)

ANN Early Career Researcher Workshop - 21-22nd November 2011

Australian Nanotechnology Network Early Career Symposium
Macquarie Park Conference Centre
Macquarie Park, NSW

The ANN ECR workshop was held at the Macquarie Conference Centre in Sydney on the 21st and 22nd of November 2011.

This workshop was co-chaired by Prof Deb Kane (Macquarie University), A/Prof Adam Micolich (University of New South Wales) and Mr Jaret Lee (Australian National University)

There were 55 attendees, 30 of whom werePhD students presenting their talks at the workshop.

Participants at the workshop

Invited speakers included high profile scientists both from Academia and Industry. These were Prof Keith Nugent (University of Melbourne) who gave a talk titled Science, Industry and Synchrotrons, Dr James Chon (Swinburne University) who gave a talk on Surface plasmon resonance, and Dr Petar Atanackovic and Dr Chris Escott from Silanna who gave a talk on Perspectives on research and development: the long and short of it.

Dr Chris Escott from Silanna and Prof Keith Nugent from the University of Melbourne presenting their talks at the workshop

Participation of Industry speakers gave participants a broader perspective on starting companies and developing technologies. Overall it was a successful workshop.

LONG TERM VISITS

LONG TERM VISITS

ANN supports the nanotechnology community by making funding support available to **postgraduate students** and **early career researchers** (within 5 years of award of PhD degree) for travel and accommodation expenses associated with Long Term Visits to research Institutions within Australia. Up to $2,000 are provided for a maximum of three months for travel and accommodation to a location(s) within Australia.

Miss Rhiannon Creasey (Flinders University) visit to Curtin University in Western Australia

Details of long term visit: –May 2011

The purpose of this series of laboratory visits has been to analyse Pseudoexfoliation syndrome (PEX) deposits on diseased tissue using AFM-based antibody recognition, known as 'picoTREC', compared to control tissue samples taken from cataract patients.

In the first month, the protein detected by picoTREC was LOXL1, as it has been implicated by genetics and proteomics as involved in the pathophysiology of PEX. It was found that LOXL1 was present on the surface of both normal and diseased tissue samples; however it was more abundant in diseased tissue samples. Furthermore, it appeared to be associated with the small cross-linked fibres found on diseased tissue. As LOXL1 is essential for the crosslinking of elastin, it was hypothesised that instead of dissociating from the elastin protein after fibre formation, it was remaining bound. Hence, for the second month's visit, elastin was detected using picoTREC. This protein has been detected on both normal and diseased tissue samples in approximately equal portions, but is not specifically associated with fibres and instead appears in amorphous regions. This may be due to the use of an antibody that is detecting the tropoelastin monomers instead of full-length elastin fibres. It is also possible that the elastin is forming in layers or other formations, indistinguishable from the surrounding matrices. This data is still being analysed. Collagen I has also briefly been investigated, as this is a protein known to be present in normal extracellular matrices, however this data has not yet been analysed.

It should be noted that the original timeline envisioned for this work was to be finished by now. However, early in the year, there were multiple equipment malfunctions so that visitations had to be delayed. Also, in the most recent visit, there has been a problem with the probes used for picoTREC. We are currently in contact with Agilent to rectify the issue, but until it is sorted further experiments can not be carried out. Hence the final month visitation will be postponed until July or August, depending on both Agilent's responses and on possible conference attendance in July.

The data from these visits thus far is being integrated with proteomic data such as MALDI-MS-imaging and immunohistochemistry to provide a more complete understanding of the pathophysiology of PEX. In the final month of visitation, we hope to investigate the protein haemoglobin, newly discovered to be an integral component of PEX deposits, as well as other extracellular matrices components as we identify them by MS.

Details of how the Long Term Visit has enhanced career development:

Thus far, the lab visit has enhanced career development by providing networking opportunities with industry and academic leaders based in WA. Furthermore, the data we are obtaining is very high quality and is being drafted for publication in a high impact journal.

Details of how the Long Term Visit has enhanced skills development: As the only researcher in Australia with experience using the picoTREC technique (to the best of our knowledge), having access to the equipment ensures maintenance of this valuable skillset. Furthermore, there has

been opportunity to teach the technique to another PhD student based at Curtin University, therefore developing skills in demonstrating and teaching a complex technique.

Characterisation of pathological deposits in Pseudoexfoliation Syndrome by means of antibody recognition imaging via atomic force microscopy. – Rhiannon Creasy

The purpose of this series of laboratory visits has been to analyse Pseudoexfoliation syndrome (PEX)1 deposits on diseased tissue using AFM-based antibody recognition, known as 'picoTREC'2, compared to control tissue samples taken from cataract patients.
In the first month, the protein detected by picoTREC was LOXL1, as it has been implicated by genetics and proteomics as involved in the pathophysiology of PEX. LOXL1 is an extracellular enzyme with a copper-dependent amine oxidase function, catalysing the first step in the formation of crosslinks in collagens and elastin - an integral part of the basement membrane forming the lens capsule3. According to the literature, LOXL1 is also involved in developmental regulation, senescence, tumour suppression, cell growth control, and chemotaxis, indicating that it has multiple physiological roles3-6. Given the fibrillar nature of PEX pathology, it is the fibre formation function of LOXL1 that is relevant here. Although LOXL1 is produced as a 417-amino acid pro-protein, post-translational modification cleaves the N-terminus, leaving a 249-amino acid active enzyme7. Before cleavage, the N-terminus is glycosylated and the protein is folded to contain at least three disulfide bonds8, along with incorporation of copper9 and lysyltyrosine quinone10. Finally, the pro-protein is secreted, and the glycosylated N-terminus is cleaved once the extracellular matrix is detected to reveal the mature enzymatically active LOXL1 protein 3, 11,12.

The lysine residues in the C-terminal region of elastin monomers (tropoelastin) are de-aminated by the mature LOXL1 enzyme, resulting in aldehyde groups capable of forming covalent cross-linkages with adjacent aldehydes or peptidyl lysines. LOXL1 also binds with fibulin-5, assisting in the regulation of growth and deposition of tropoelastin onto extracellular matrix scaffolds for elastic fibre homeostasis4. LOXL1 mRNA expression in ocular tissues is increased in the early stages of PEX, then significantly decreased in advanced PEX13 with reference to control tissue expression.

Two coding single nucleotide polymorphisms in the LOXL1 gene confer higher susceptibility to PEX14-16, and LOXL1 has been shown to be present in PEX deposits using both MS and IHC17. It is clear, therefore, that LOXL1 has a role in the pathophysiology of PEX. LOXL1 has been shown to be localised to mature PEX fibres using immunofluorescence and EM immunogold labelling on PEX-affected capsule sections13, however the lateral distribution of LOXL1 is unknown. Due to resolution limitations of the above techniques, the localisation of LOXL1 on aggregates is not understood at a level relevant to individual PEX fibres. Hence, TREC was applied utilising an anti-LOXL1 functionalised probe on lens capsule samples.

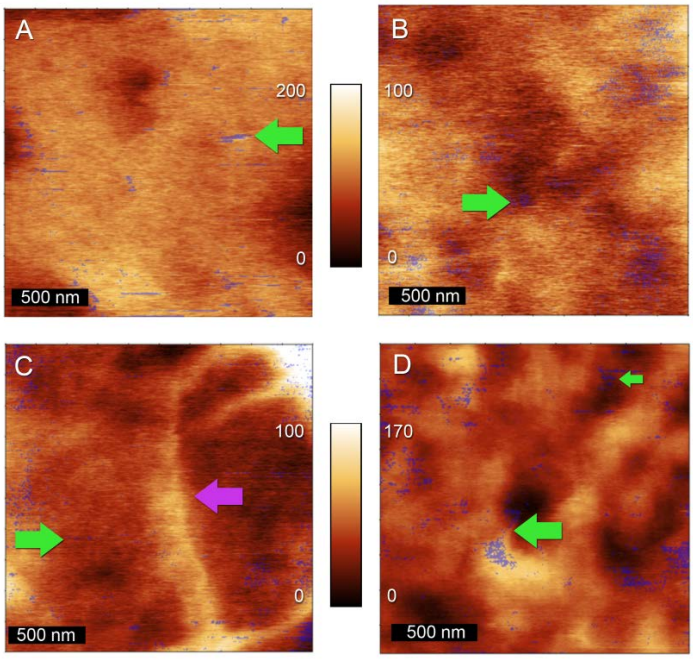


Figure 1 - AFM topography images of (A, B) control and (C, D) PEX-affected lens capsules acquired using an anti-LOXL1 antibody functionalized tip,

masked with TREC recognition in blue. Green arrows denote recognition of (A) a small fibre, (B) the edge of a pit, (C) a small fibre, and (D) a small fibre (large arrow) and the edge of a pit (small arrow). The purple arrow in (C) denotes a large fibre showing no recognition.

As seen in Figure 1, LOXL1 was detected on both control and PEX-affected lens capsules. It was most commonly associated with small (<50 nm width) fibres and the edges of pits, regardless of disease status, as shown by the green arrows in figure 1. LOXL1 was also detected on large (>50 nm width) spots and fibres on PEX-affected lens capsules. Very little inter-sample variation was seen with respect to recognition features on PEX-affected lens capsules, whilst recognition on or beside pits (figure 1A, D) on control capsules did not follow any trends, even on the same sample. There was comparatively less association with topographical features in the control capsules, with more recognition spots not being clearly associated with topographical features. Given its involvement in extracellular matrix turnover, the detection of minimal LOXL1 in control capsules is expected.

For the second month's visit, elastin was detected using TREC. As collagen has not been identified as a major component of PEX, and elastin epitopes have been detected in PEX material, elastin is therefore the most likely candidate for LOXL1 cross-linking in PEX. Hence, elastin was detected on PEX-affected lens capsules using TREC to investigate potential associations between LOXL1 and elastin in PEX deposits.

As discussed in the previous section, LOXL1 is responsible for cross-linking tropoelastin monomers into fibrous arrays. Tropoelastin is an 830 amino acid protein with alternating hydrophobic and lysine-rich domains18. This monomer is water soluble, however the deamination of the lysine residues leading to cross-linking changes the structure such that some of the hydrophobic residues are available, hence the cross-linked protein becomes insoluble. Elastin forms the core of elastic fibres in connective and supportive tissues and is a major component of the extracellular matrix and PEX19,20, along with fibrillin21 .

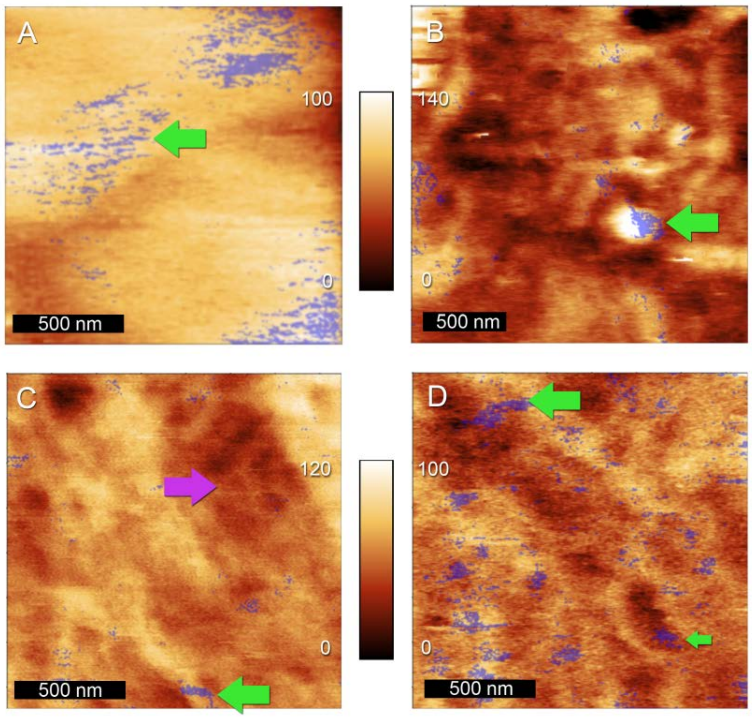


Figure 2 - AFM topography images of (A) control and (B - D) PEX-affected lens capsules acquired using an anti-elastin antibody functionalized tip, masked with TREC recognition. Green arrows denote recognition of (A) no specific topographical features, (B) the side of a large spot, (C) a large fibre, and (D) a large fibre (large arrow) and the edge of a pit (small arrow). The purple arrow in (C) denotes a small fibre showing no recognition.

Only one control capsule was imaged using the anti-elastin modified probe, in which no fibres were observed (Figure 2A). More samples were planned; however, equipment and probe issues caused us to run out of time. The presence of elastin in extracellular matrices such as the lens

capsule is well established18,22-24, and it is the comparison of elastin to LOXL1 in PEX-affected tissue that is of interest in this case: Hence, only two images were acquired on one control capsule.
In PEX-affected lens capsules, elastin was most commonly associated not with the small (<50 nm width) fibres as seen with LOXL1, but with large (>50 nm width) fibres and spots instead, as seen in Figure 1B – D. There is also a large amount of recognition observed without association to specific topographical features. This may be detection of lamellar elastin, or the pre-crosslinked monomer, tropoelastin. As seen with LOXL1 recognition on normal capsules, detection of elastin on or beside pits is not consistent either between samples or on the same sample. Interestingly, detection on the sides of large spots (Figure 1B) was observed primarily on one sample, while the other PEX-affected capsule showed detection on top of large spots. A larger sample size would be required to further investigate this pattern of recognition.

Table 1 - Comparison of recognition spot sizes between control and PEX-affected lens capsules seen for elastin and LOXL1 proteins. The % recognition describes the amount of pixels due to recognition with respect to the total number of pixels imaged. The P value describes the statistical significance of spot size comparisons between normal and PEX data for each antibody (where P > 0.05 indicates no statistical difference). Note that the small image area of controls for elastin makes this calculation insignificant.

Clusterin	Spot size (nm^2)	Spot count	Total image area (μm^2)	% Recognition	P(T<=t) two-tail
LOXL1					
PEX	88.8 ± 8.1	3793	20.24	1.66	0.0031
control	56.4 ± 7.4	2918	20.5	0.80	
Elastin					
PEX	47.0 ± 2.4	5492	17.25	1.49	0.6809
control	51.2 ± 10.0	1437	5.5	1.34	

As seen in Table 1, LOXL1 detection shows more spots of larger area on PEX-affected (88.8 ± 8.1 nm, n = 3793) compared to control capsules (56.4 ± 7.4 nm, n = 2918). The increased detection of LOXL1 in PEX-affected capsules may indicate an increased presence, as expected from IHC results31, on diseased capsules. However, TREC is not a quantitative technique, and solubility and homogenisation issues inhibit confirmation via a proteomic technique.
Given that the recognition spots for LOXL1 were observed associated with small fibres in TREC images on the PEX-affected lens capsule, it is conceivable that the LOXL1 protein is becoming trapped or embedded in the fibres it enables to crosslink, or is unable to dissociate from the ECM substrate. This may be a result of the sequence variant detected in the genetic associations with PEX, as these variants occur in the enzymatically active portion of LOXL1: However, the LOXL1 genotypes of the patients from whom these samples were acquired are unknown, and so determination of this potential hypothesis is not possible with this data. If it is true that LOXL1 is becoming trapped with elastin, it follows that the elastin detected in PEX-affected capsules should chart a similar trend of recognition to LOXL1 as evidence of co-localisation. As only a small area of control capsule was investigated using an anti-elastin antibody modified probe, no significance can be attributed to the comparison between control and PEX-affected capsules. However, the percentage of recognition between PEX-affected capsules of elastin and LOXL1 are comparable, yet a smaller spot size (47.0 ± 2.4 nm) and increased spot count (n = 5492) is seen for elastin on PEX-affected capsules in Table 1.

These results suggest that elastin and LOXL1 do not co-localise as hypothesised, as elastin is not significantly observed on the smaller fibres of PEX. It is worth noting that due to a limitation of

the TREC technique, the ligand epitopes must be available at the surface of the material to be detected. As elastin has been observed as the central core of elastic fibres with a fibrillin coating96, it is not surprising that the epitopes may not be available for TREC detection. Furthermore, mature PEX fibres may in fact be composed of multiple proteins, or may be oriented so that the elastin binding epitope becomes hidden during PEX fibre formation. It is also possible that epitopes for the protein may not be detectable with the utilised antibody. However, all antibodies used were confirmed to detect their respective proteins in control capsules using Western Blotting31,38 (Sarah Martin, unpublished data). Admittedly, the number of PEX-affected lens capsules investigated using the anti-elastin antibody functionalised probes is half that investigated for LOXL1; however, there is no indication of co-localisation even in this small sample number. Due to the rarity and expense of reagents and samples, further investigations into elastin were not pursued as no new insights were becoming apparent.

LOXL1 has been shown to co-localise with elastin in PEX deposits using IHC and immunogold TEM32,93, however these techniques require extensive sample preparation which would alter the native state of PEX fibres. Furthermore, the tissue is sectioned, hence laterally-oriented fibres would not be visible as fibres, and may become indistinguishable due to the resolution limitation of EM. Therefore it is not entirely logical to compare these methodologies.
The use of TREC in PEX investigations allows for analysis of the tissue surface in a physiological environment. Further, it offers a higher resolution than other immuno-based techniques utilising EM or optical/fluorescence microscopy. However, TREC has some drawbacks as a technique for investigations of protein aggregation disease:

- Time; the time to acquire images is limited by the kinetics of antibody binding as the probe approaches and withdraws from the surface. Further time is taken to acquire each image multiple times at different probe oscillation amplitudes as a proof. Hence, the total area investigated can be severely limited by overall time of acquisition.
- Sample choice; the sample size is limited by the confines of the equipment, and the sample roughness must be minimised to avoid topography and recognition crosstalk. The sample also must be immobilised to prevent movement.
- Immunorecognition; TREC operation relies upon the protein epitopes naturally being accessible at the tissue surface.

Nonetheless, it has been shown to be a desirable technique for analysis of PEX deposits on disease lens capsule samples. Further studies investigating the effects of tissue preparation to expose protein epitopes or utilising of alternate antibodies for probe functionalisation are recommended before future studies to identify and localise more proteins on the tissue surface involved in PEX.

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Short Term Visits

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 Withawat Withayachumnankul (Uni Adelaide) visit to RMIT

Research interest: terahertz spectroscopy; microwave/terahertz metamaterial; plasmonics; biosensing

Details of proposed short term visit : Microplatforms Research Group, School of Electrical and Computer Engineering, RMIT University in Melbourne during July 21-22, 2011 for discussion on various research topics. The schedule has been prepared for these two days, with peer participants from the University of Adelaide specialising in terahertz spectroscopy and metamaterials (myself and Omid Kaveh) and RMIT specialising in nanotechnology (Dr Sharath Sriram, Dr Madhu Bhaskaran, and Charan Manish Shah).

The participants will discuss final designs of new kinds of microwave/terahertz metamaterials. For this particular project the proof-of-concept simulation, together with the measurement on individual components, has already been carried out with promising results. It is necessary to discuss in details the materials and fabrication processes to ensure the functionalities of the fabricated structures. It is expected that this discussion will occupy the whole day, since it involves two complicated structures.

The first project involves multiple designs of terahertz metamaterials, which are now being fabricated at RMIT. Problems and potential extensions will be brought into discussion. These novel structures will be used to enhance the capabilities of terahertz technology in many diverse applications, e.g. biomedicine, quality control, and security. The next project involves terahertz plasmonic biosensors initiated by RMIT. Since the project is in the initial stage, possibilities and directions are mainly focused in the discussion. This project will potentially create high-performance biosensors.

Report on Outcomes

1. Hybrid terahertz metamaterials – Both UoA and RMIT researchers agree on the preliminary design of this hybrid structure. However, the design needs some adjustment, which is currently being carried out by Withawat & Omid.
2. Terahertz metamaterials – The samples are already fabricated by RMIT researchers. At the moment, the experiment is being set up at UoA. The first measurement can be expected by the end of August 2011. The manuscript on this particular structure is expected to be submitted to a journal by the end of 2011.
3. Tunable terahertz metamaterials – The designs are ready for fabrication. However, both UoA and RMIT researchers agree that we wait until the structures in #2 are validated by the experiment.
4. Terahertz plasmonic surfaces – RMIT researchers are after an effective approach to fabricating this structure. The fabricated samples are expected by the end of 2011.
5. Mechanical sensors – Five designs of multiple mechanical sensors, by a PhD student at UoA, have been approved by RMIT researchers. The fabrication is being carried out in RMIT at the moment. The student is designing the testing platform. We expect the first experiment in September 2011. The abstract is submitted to a sensor conference in Adelaide (ISSNIP2011) for consideration.
6. Reflectarrays – Preliminary designs of reflectarrays are feasible in terms of fabrication, according to RMIT researchers. A PhD student at UoA is currently designing the final version, which is expected to finish by the end of 2011. After that, the fabrication can be carried out at RMIT immediately

Mr Benjamin Gully (UWA) visit to the CSIRO C3 protein crystallisation facility in Melbourne.

ANN written report following a Short Term Visit to the CSIRO C3 protein crystallisation facility in Melbourne.

The short term visit to the *CSIRO C3 protein crystallisation facility took place in December 2011 and* allowed preliminary crystallisation testing, use of modern crystallisation facilities and a chance to initiate a collaboration.

Work is undertaken at the interface of structural biology and nano-material science, specifically in attempt to improve the methodology of protein crystallisation destined for x-ray diffraction. Generation of diffracting crystals is a major bottle neck in the process of macromolecular structural analysis. Nano-materials applied here have the potential to aid the crystallisation of proteins, aid favourable nucleation and improve the diffraction quality of crystals generated. This work has the potential to yield macromolecular crystal structures that may be currently difficult or impossible with available technologies and techniques.

Experiments undertaken include:

‣ Differential Scanning Fluorimetry analysis of complexation effects of phosphonated-calix[4]arene, calix[5]arene, calix[6]arene and calix[8]arene and on the thermal stability of 4 test proteins in multiple buffers.

‣ Differential Scanning Fluorimetry analysis of complexation effects of Cyclobis (paraquat-*p*-phenylene) (Blue Box) and 1,1'-[1,4-phenylenebis(methylene)]bis(4,4'-bipyridinium) (Horseshoe) and on the thermal stability of 4 test proteins in multiple buffers .

‣ Co-crystallisation attempts of the above 8 cavitands with Lysozyme, totaling 800 individual experiments. These will be monitored 13 times over a month from set-up with X-ray diffraction analysis to be undertaken on any crystals generated looking for co-crystallisation.

‣ Preliminary trials to utilise and employ nano-tablets of nacre as a nucleating agent in protein crystallsation trials.

The visit to the *CSIRO C3 protein crystallisation facility* gave me a comprehensive understanding of modern crystallisation techniques, the underlying principles of crystallisation and additive testing highlighted where improvements could be made in the methodology on the whole.

This visit has provided a vast amount of information which will benefit me through the remainder of my candidature whilst additionally allowing collaboration between the University of Western Australia and the detailed facility, now high throughput testing of additives can be conducted in the future, allowing rigorous testing of novel nano-materials.

Mr Zhou Deng from the University of Queensland - visit to Research School of Chemistry at the Australian National University

REPORT

Background

X-ray reflectometry measures the reflection of X-rays off an interface produced at the boundary of two media that differ in their refractive indices. X-ray reflectometry can be used to study the interaction of nanoparticle-protein quantitatively on the nanoscale at the air-water interface, and allows monitoring the structural changes in real time1.

Many biological and industrial processes occur at the air-water interface. For example, pulmonary surfactant proteins are responsible for lowering the surface tension at the air-liquid interface thereby preventing alveolar collapse at the end of expiration2,3. Industrially, protein additives are used as emulsion stabilizing agents. The study of nanoparticle-protein interaction at the air-water interface can potentially indentify the molecular interactions of the nanoparticles in the biological system, such in the lungs.

Fibrinogen, the third most abundant protein in the blood with physiological concentration ranging between 2-5 mg/ml, is a versatile protein and is involved in both haemostatic and inflammation processes4,5. The protein is a rod-shaped glycoprotein of 340 kD and is 45 nm in length and 5 nm in diameter (Figure 1). It consists of three pairs of polypeptide chains, namely alpha, beta and gamma chains, respectively. The protein can be presented as three globular domains joined by two flexible helical domains6. The protein has pI of 5.5 and it is overall negatively charged at physiological pH. Fibrinogen is well known to bind onto different nanomaterials7-12. The physicochemical characteristics of fibrinogen is summarised in table 1.

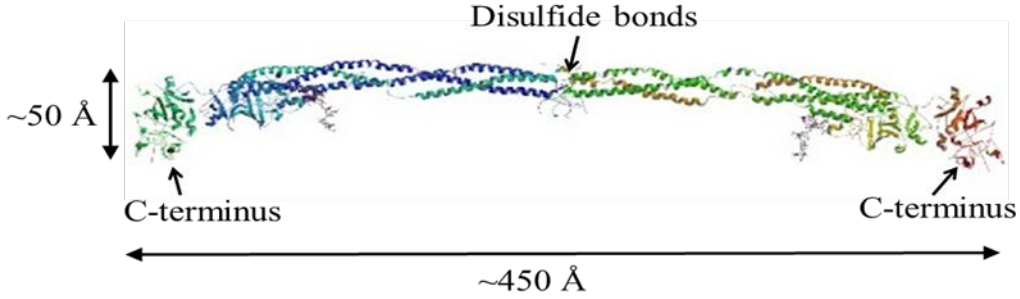

Figure 1 crystal structure of fibrinogen 13.

Table 1 physicochemical characteristics of fibrinogen14

Molecular mass	340,000
Molecular volume	3.7×10^3 nm^3
Sedimentation coefficient ($S_{20,w}$)	7.8×10^{-13} s
Translational diffusion coefficient ($D_{20,w}$)	1.9×10^{-7}
Rotary diffusion coefficient ($O_{20,w}$)	40,000 s^{-1}
Frictional ratio (f/f_0)	2.34
Partial specific volume	0.72 cm^3/g
Extinction coefficient ($A_{280,\ 1\%}$)	15.1
Intrinsic viscosity (η)	0.25 dl/g
Degree of hydration (g/g of protein)	6
α-helix content	33%
Isoelectric point	5.5

The aim of the study was firstly to identify the structural characteristics of fibrinogen at the air-water interface, followed by examining the effects of nanoparticles on the structural organisation. Different sample preparation methods were compared. The X-ray reflectivity of

fibrinogen at different concentrations was determined. The X-ray reflectivity of fibrinogen in the presence of silica nanoparticles or clay-derived nanoparticles was examined. Nanoparticle-only samples were also examined as controls.

Experimental

Purified fibrinogen was purchased from Sigma-Aldrich and prepared into 50 mM phosphate buffer, pH 7.2 at stock concentration of 1 mg/ml. The sample was stored at 4oC until use.

8-nm spherical silica nanoparticles, Ludox® SM-30 at 30% w/v were procured from Sigma-Aldrich1. The molar concentration was calculated by the size and density of the nanoparticles.

Clay-derived hectorite nanoparticles were obtained from a commercial source and prepared using established procedure in the lab. The molar concentration of hectorite was calculated based on its average sizes (25 nm in diameter and 2 nm in depth) and density (2.5 g/cm3).

X-ray reflectometry was performed according to the established procedures1, using an in-house angle-dispersive X-ray reflectometer at the Australian National University. The measurements were carried out at ambient temperature.

Preliminary results

Equilibrium of fibrinogen at air-water interface

Two different sample preparation procedures were used to obtain the initial data from fibrinogen itself at the air-water interface. Firstly, the sample was prepared by a spreading method according to the reported procedure 1. Briefly, 500 µl of 1 mg/ml fibrinogen was deposited onto the surface of 25 ml buffer in the Teflon trough. The X-ray reflectivity profile was measured over 24 hours. The electron density profile showed a protein layer at the air-water interface with a thickness of approximately 70 Å (Figure 2). The surface reached equilibrium within the first hour of measurement. This suggested a fast surface adsorption process, and it was possibly due to the high surface concentration initially generated by the surface spreading. The thickness of the layer at 70 Å potentially suggested that the protein was adsorbed with a side-on configuration at the interface. Multiple fringes were observed in the electron density profile, suggesting the presence of multiple domains at the air-water interface. This corresponds to the nodular structure of the fibrinogen protein. A 20-Å thick layer immediately below the surface possibly represented the coiled-coil region of fibrinogen. The coiled-coil region is rich in α-helix and displays surfactant-like properties by having hydrophobic cores and hydrophilic surfaces. This possibly explains its preferential adsorption at the air-water interface.

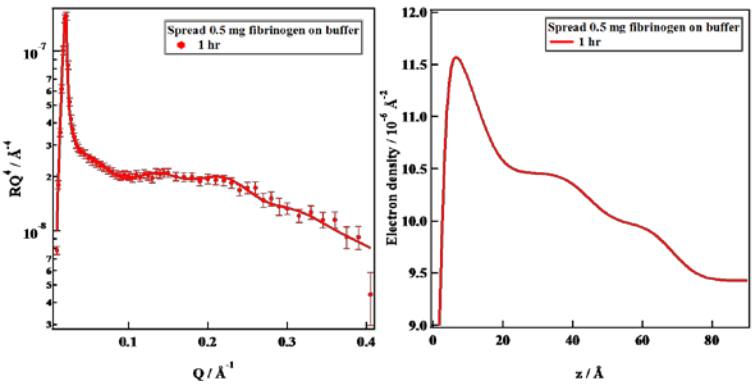

Figure 2 Spread 0.5 mg fibrinogen on buffer. Raw data (left panel) and electron density profile (right panel).

Secondly, the protein solution was prepared in bulk solution at 4 µg/ml or 0.8 µg/ml, and approximately 25 ml of the solution was transferred onto the trough for reflectivity measurements. At the higher concentration of 4 µg/ml, an overall increase of the electron

density at the surface was observed over 26 hours (Figure 3). This suggested fibrinogen was gradually adsorbed onto the interface. At the first hour of incubation, it appeared that the layer was only at 20 Å in thickness. This was probably due to that the surface fibrinogen was at low amount and could not provide sufficient contrast for the protein domains that were positioned deeper under the surface. At incubation of 26 hours, the thickness of the layers reached approximately 60 Å, suggesting the increase concentration of fibrinogen adsorbed to the surface. The profile was similar to the one in the "spreading" method shown above in Figure 2.

At the lower concentration of 0.8 µg/ml, the thickness of the layer was at 20 Å over the course of experiment. No further increase of layer thickness was observed. This was probably due to the low concentration of fibrinogen in the solution.

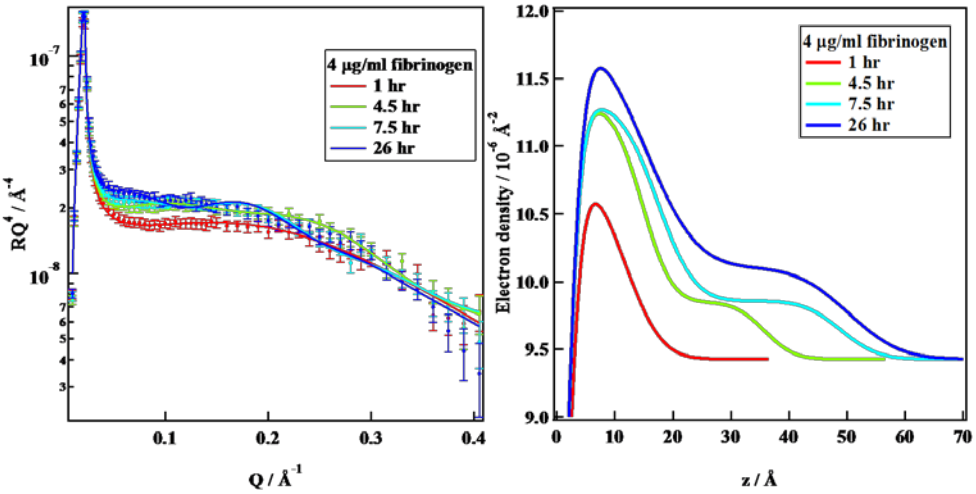

Figure 3 Bulk mixture of fibrinogen at 4 µg/ml over 24 hours. Raw data (left panel) and electron density profile (right panel).

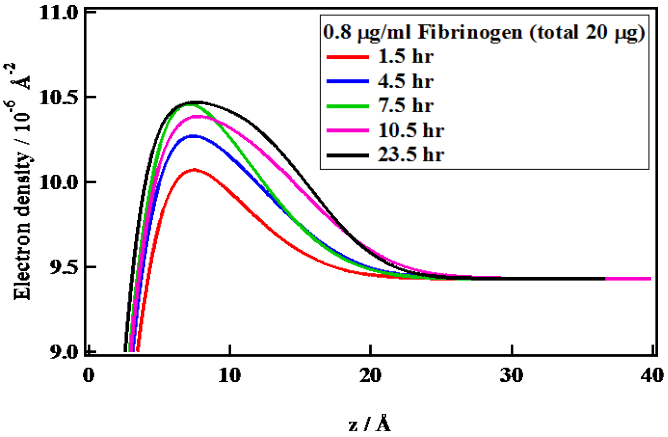

Figure 4 Bulk mixture of fibrinogen at 0.8µg/ml over 24 hours. Electron density profile.

Interaction of hectorite and fibrinogen at air-water interface

The experiment was carried out by mixing of 0.8 µg/ml fibrinogen with 0.5 mg hectorite in 25 ml of the buffer. This gave a molar ratio of 1:10 for fibrinogen and the nanoparticles. The measurement was carried out over 7 hours. In the presence of the nanoparticles, the thickness of the surface layer increased to 30 Å. The thickness of the hectorite nanoparticles is estimated to be 1-2 nm. The increase of the layer thickness could be potentially due to the binding of the nanoparticles to fibrinogen via a side-on configuration. Fibrinogen titrations are required to obtain further information and the kinetics of the interaction.

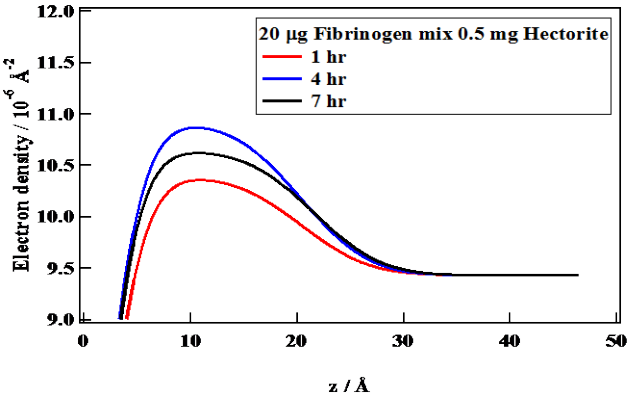

Figure 5 Electron density profile of 20 µg fibrinogen mixed with 0.5 mg hectorite in 25 ml buffer. Measurement over 7 hours.

Interaction of silica nanoparticle and fibrinogen at air-water interface

The experiment was carried out by mixing fibrinogen and the silica nanoparticles at a molar ratio of 1:10 in 25 ml of the buffer. The Ludox silica nanoparticles are 8-nm spherical nanoparticles. In the presence of the nanoparticles, the thickness of the surface layer was at apprximately 100 Å at equilibrium. The increase of the layer thickness could be potentially due to the binding of the nanoparticles to fibrinogen. Fibrinogen titrations are required to obtain further information and the kinetics of the interaction.

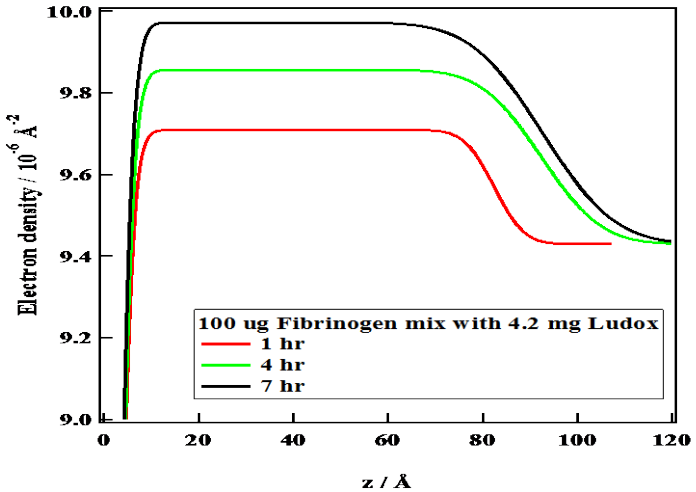

Figure 6 Electron density profile of 100 µg fibrinogen mixed with 4.2 mg of the Lodox® in 25 ml buffer. Measurement over 7 hours.

Outcomes and future plans

During the trip, the fibrinogen protein and its interaction with different types of nanoparticles at the air-water interface were investigated using the angle-dispersive X-ray reflectometer at the Australian National University. The electron density profile of fibrinogen at the air-water interface was generated. The binding of fibrinogen to nanoparticles at the air-water interface was evident. The preliminary studies established a feasible experimental procedure, which allows follow-up studies. Future studies will examine the interactions by adding increasing concentrations of fibrinogen in the bulk mixture. This will be able to provide novel information on the structural organisation and the kinetics of the fibrinogen-nanoparticle interactions.

There are other possible protein and nanoparticle candidatures that can be studied using the X-ray reflectometry. For example, examining the proteins present at the air-water interface of lungs would provide relevant information in the nanotoxicology. Moreover, clay-derived nanoparticles (e.g. hectorite) have been extensively used in the industry and exposed to the

humans. Future studies on the interaction of clay nanoparticles and proteins can provide information to better understand the biological effects of these nanoparticles.

About the trip

During the trip, I worked with Prof. John White and his colleague Mr Joo Ang at the Research School of Chemistry, Australian National University, Canberra. I spent 4 days in Prof. White's laboratory from 16th to 19th, May. I learnt to use the in-house x-ray reflectometer and performed some initial experiments. Future studies and collaborations have been discussed. In addition, we have followed up the progress of our proposed work on small-angle neutron scattering

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OVERSEAS TRAVEL FELLOWSHIPS

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.

Mr Matthew Barr from the University of Newcastle visit to Cambridge University

ANN Overseas Travel Fellowship Report
Development of a Scanning Helium Microscope (SHeM)

Priority Research Centre for Organic Electronics, School of Mathematical and Physical Sciences
University of Newcastle, Australia
Visit to the Cavendish Laboratories, University of Cambridge, UK
30/9/2011 - 13/12/2011

I would like to extend the sincerest thanks to the Australian Nanotechnology Network for their generous funding. Without the ANN funding, this highly successful collaboration would not have been possible.

Background

The purpose of any microscope is to allow the investigation of small-scale structures and phenomena. Microscopes have given unparalleled insight into the nature of many surface structures and processes down to the nanoscale and beyond, simply because they make them big enough to see with our own eyes. For the microscopy techniques employing probing particles, the particle wavelength sets the best-possible resolution of the instrument. For all particles (including photons) a reduction in wavelength leads to a corresponding increase in energy. For the electrons in a scanning electron microscope, a resolution in the nanometre range requires energies around 10 keV. Since chemical bonds are of the order eV and the energies of physisorption far lower than that, substantial sample degradation and damage can occur.

If we substitute the electrons with neutral helium atoms, resolutions in the nanometre range would require energies of a few meV. This low interaction energy means that a scanning helium microscope (SHeM) will allow even delicate structures (such as thin films and physisorbed particles) to be investigated. Another benefit of this low interaction energy is that the helium atoms are unable to penetrate surfaces at all. Being neutral, charging effects are eliminated and charged, or magnetic surfaces can be investigated. Helium atoms are therefore a uniquely non-destructive probe particle that offers unambiguous surface sensitivity [1].

Since we are dealing with neutral helium atoms, focusing is exceptionally difficult, although both reflection [2] and diffraction [3] techniques have been demonstrated. The collaboration project between the Universities of Cambridge and Newcastle was to build a prototype SHeM

utilising pinhole 'optics'. A pinhole microscope does away with the requirement of focusing; however any improvement in resolution has a corresponding reduction in signal intensity. A pinhole microscope thus requires a highly intense source of neutral helium atoms, and even then the best-possible resolution (for practical scan times) of such an instrument is of the order 500 nm to a few microns. The prototype SHeM was therefore constructed to demonstrate proof of concept of helium atom microscopy and will serve as a test bed for future developments of the technique.

The collaboration project involved working within the Surfaces, Microstructure and Fracture (SMF) group with my supervisor Prof. Paul Dastoor (Newcastle), Adam Fahy (Newcastle, PhD student), Dr. Andrew Jardine (Cambridge) and Dr. William Allison (Cambridge). The project required the design, fabrication and construction of a new beamline, including a high intensity supersonic free-jet nozzle beam source, sample and detector stages. After the pinhole SHeM was constructed, some samples were imaged to demonstrate the use of the technique.

Research Outcomes

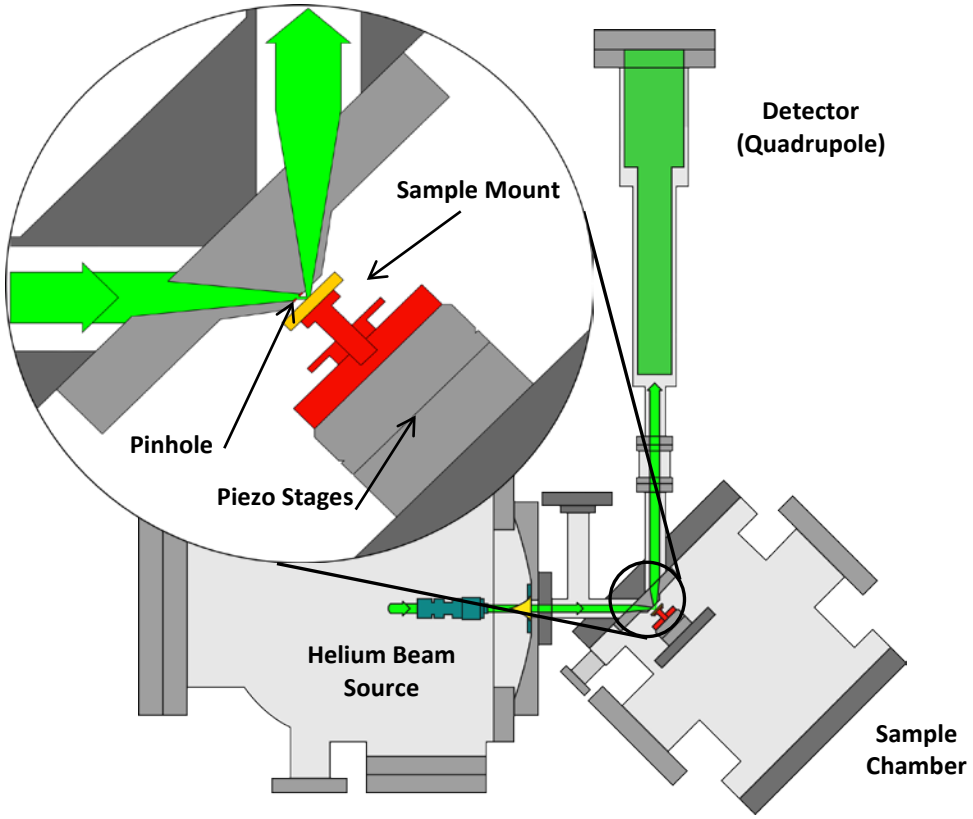


Fig.1. Schematic diagram of the pinhole SHeM design. The inset shows the details of the beam, pinhole, sample and detector geometry.

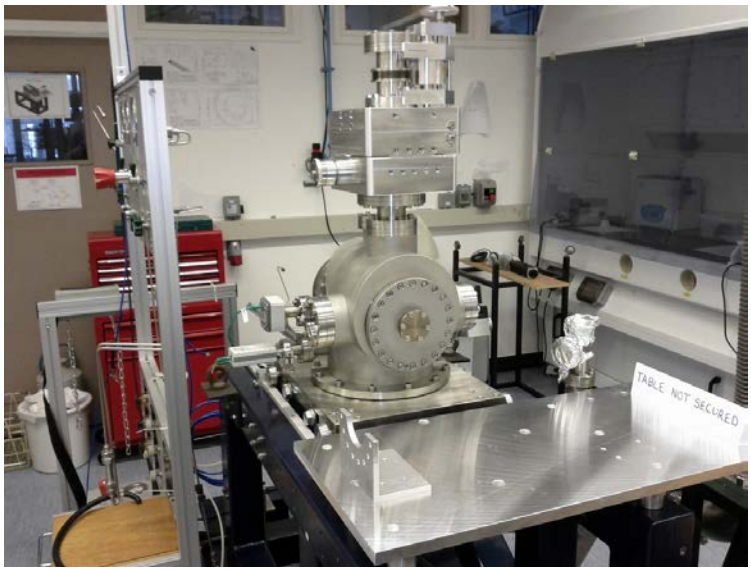
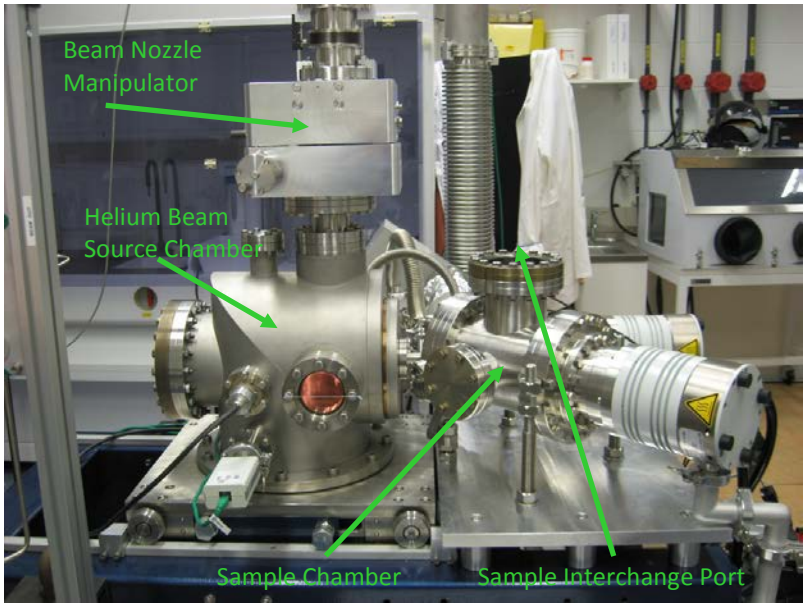


Fig. 2. A photograph of the SHeM beamline during the early stages of construction.



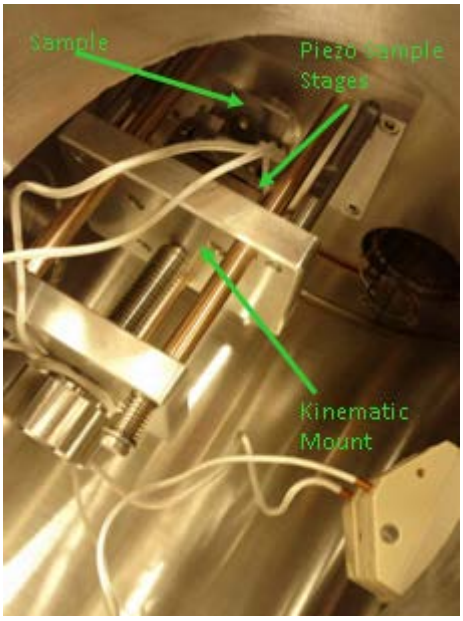


Fig. 3. (Left) completed SHeM beam line; (right) sample mounting assembly.

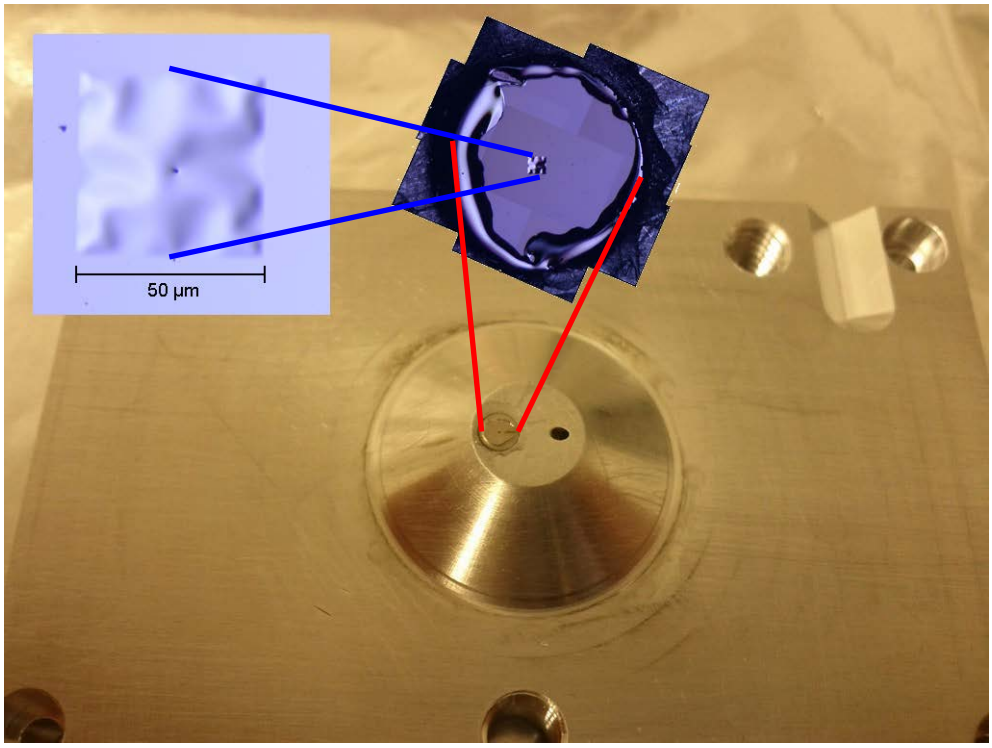


Fig. 4. Photograph of the pinhole assembly. The insets are of optical microscopy images of the silicon nitride disc, through which a 5 micron diameter pinhole was produced using focused ion beam (FIB) milling. The milling of pinholes down to 300 nm diameter was demonstrated, however all of the images shown in this report were made with the 5 micron pinhole.

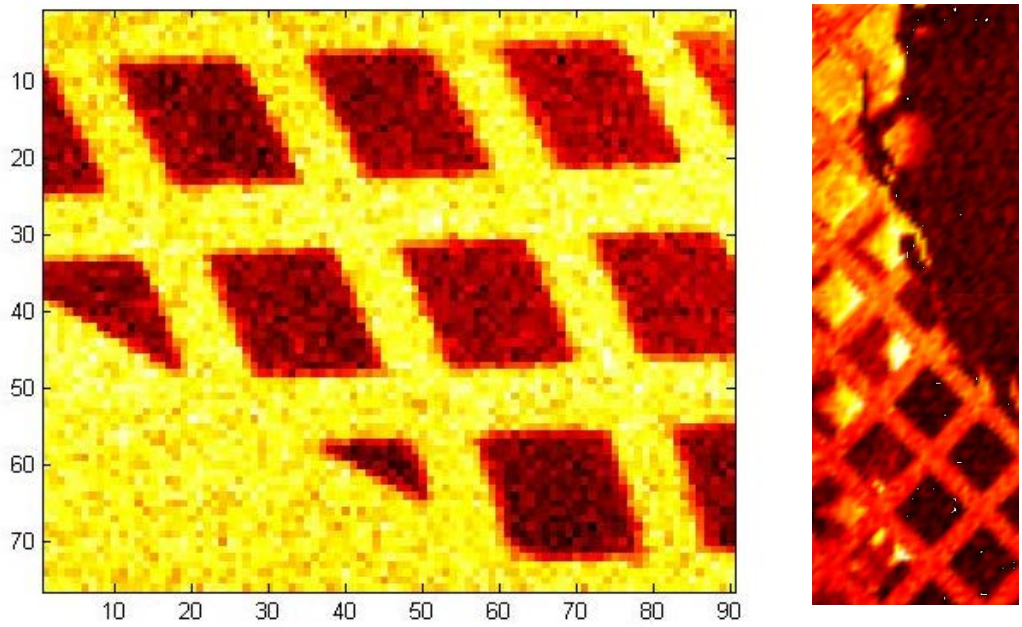


Fig. 5. (Left) SHeM image of TEM grid on stainless steel, axis units are in microns. (Right) Image of the same grid looking at a damaged section.

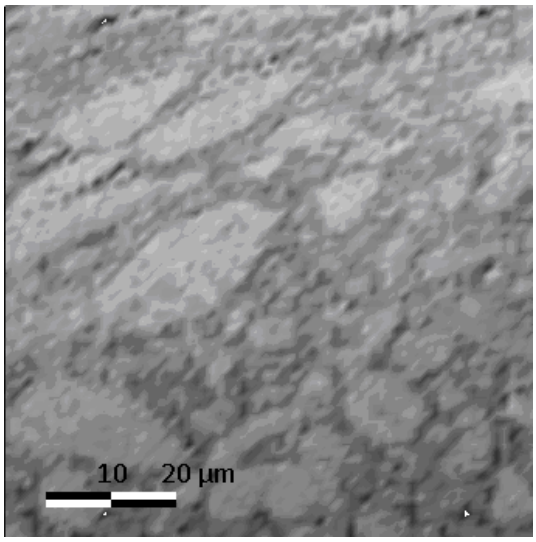


Fig. 6. SHeM image of polymer bonded explosive (PBX) polished flat to 50 nm surface roughness. Contrast is evident despite the lack of height difference between the domains.

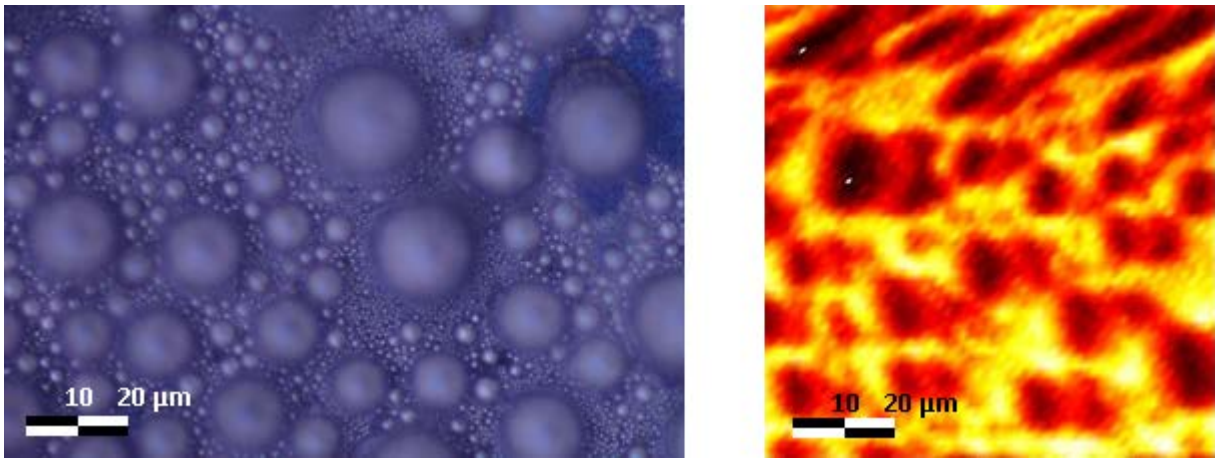


Fig. 7. Tin on graphite sample. (Left) Optical microscopy image, (right) SHeM image. The helium images show inverted contrast with respect to the optical, demonstrating contrast mechanisms other than topological.

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Miss Yeoh LaReine from the University of New South Wales visit to Cambridge University

Ms. LaReine Yeoh (UNSW) visit to Cambridge University, UK (15th August – 14th September) – Research Outcomes

About

LaReine is a Postgraduate student whose area of research interest lies in the emerging, multi-disciplinary field of spintronics, experimental condensed matter physics. Her current project involves studying different methods to manipulate and control spin. Part of this involves the fabrication and characterization of hole-based, low-dimensional semiconductor nanostructures in GaAs, such as quantum dots which have a variety of applications eg. quantum computing and cellular automata.

Summary

On the 15th August 2011 I visited Cambridge University for 4weeks to collaborate with members of the Semiconductor Physics Group (SP) in Cavendish Laboratory, as part of my PhD project which involves the study of spin-orbit interaction in order to control and manipulate the spin degree of freedom of a charged particle. Such unique spin physics can be more readily observed and quantified at milli-Kelvin temperatures, in spatially confined, low dimensional structures where a charged particle's momentum has a limited degree of freedom. These conditions can be found in nanostructures such as High Electron Mobility Transistors (HEMT) which operate similar to a FET. When a voltage is applied to an overall top gate, electrons from the doped n-type AlGaAs layer drop down into the undoped GaAs layer below it, creating a very thin depletion layer of highly mobile, conducting electrons known as a 2D electron gas (2DEG).

The traditional technique of modulation doping, used to create HEMTs consists of a layer of dopants separated from the 2DEG to prevent electrons scattering off the dopants and hence the losing their mobility, however this design means that close gating cannot be achieved due to the need for a buffer layer. This minimum thickness limit can be overcome by using a different design where the electron gas is electrostatically "induced" into the heterostructure via a doped metallic top-gate.

The main objective of my visit to Cambridge was to learn about a new cleanroom technique developed by Semiconductor Physics to fabricate very shallow, induced devices where the 2D electron gas (2DEG) is ~50nm below the surface.

Their procedure has been developed for electron-based systems. We are interested in adapting this technique at UNSW to work with hole-based systems, as they present a new set of spin physics and possess certain advantages over electron based systems such as longer spin coherence lifetimes. However, defining the ultra fine features necessary for creating small quantum dots using existing techniques is difficult, thus we require a new fabrication method that will allow us to pattern finer structures with much higher precision. This new shallow-

induced technique will give us the necessary resolution to fabricate devices with much smaller lithographic features, opening up the path to the creation of new small-scale hole based quantum dots and allow us to study their unique electrical and spin properties.

During my stay at Cavendish Laboratory, I worked together with Dr. Andrew Croxall, Dr. Francois Sfigakis and Ms. Wendy Mak (who originally published the shallow induced technique for electrons) to study and fabricate such a shallow 2D electron gas heterostructure. Working directly on site enabled us to swap ideas with greater efficiency as well as compare and test the different fabrication methods used by each group whilst operating in the cleanroom environment directly.

We were introduced into the cleanroom during our first week and underwent the required OH&S inductions. On top of this, we were given an overview of the process and the resources required to replicate the fabrication procedure of a shallow device. During the second week we stepped through a full cycle of the fabrication process. We took an incremental approach, where we created devices using standard depths and tested to see if they operated successfully before moving onto shallower structures. Such an approach allowed us to pinpoint which steps of the processing required refinement more rapidly. We first started off with a standard HEMT where the 2DEG located 300nm below the surface. The fabrication process involves using a combination of photolithography, wet etching and metal deposition via evaporation to create the features that define the device. Our devices were tested and found to be operational at a temperature of 4K when immersed in liquid helium. In the following weeks we successfully repeated the procedure upon shallower and shallower wafers until the final objective of creating a shallow device whose 2DEG was 50nm from the surface was achieved. Our collaborators were also keen to implement a similar style shallow device in holes, and during our last few days, we started to perform some initial tests using different materials to adapt the procedure for hole-based systems.

The new experience and exposure I have gained, including training in the cleanroom and device fabrication methods was invaluable to my learning. The main goals of the collaboration were satisfactorily achieved, including the acquisition of these new methods to be implemented at UNSW. As the initials results were promising, adaptations of the procedure to suit our cleanroom process workflow to create hole-based devices are now underway. This technique will eventually become an important part of my thesis, as the shallow induced 2DEG forms the base upon which a wide variety of different fine-featured, low-dimensional nanostructures can be built.

I would like to take this opportunity to thank the ANN for providing me the support for the visit and to our generous and skillful hosts at Cavendish Laboratory.

Dr Natasha Sciortino from Sydney University visit to the Institute de chimie de la matière condensée de Bordeaux (ICMCB) in Bordeaux France

Report due END JULY 2012

Dr Tracey Clarke from the University of Wollongong visit to the University of Groningen, Netherlands

Research visit with Professor Maria Loi at the Zernike Institute for Advanced Materials, University of Groningen, The Netherlands; eight weeks October – December 2011.
Tracey Clarke (University of Wollongong)

Background

Renewable energy sources (such as solar energy) are currently the focus of extensive research worldwide. In this context, nanostructured solar cells based on blends of π-conjugated polymers and fullerenes have attracted widespread interest in the academic and, increasingly, the commercia0.l communities. The advantages of polymer:fullerene solar cells is that they are low cost, flexible and easily processed. Furthermore, the polymer:fullerene blends are capable of forming nanoscale domains (that vary in size and composition as a function of pre- and post-processing conditions) that can direct charge transport to the electrodes. However, these solar cells are currently producing relatively low power conversion efficiencies ($\sim$ 5 – 10 %) compared to inorganic solar cells. In order for this technology to be commercially viable, the device efficiencies need substantial improvement.

The processes of charge photogeneration and recombination are strongly influential with respect to the solar cell efficiency. The charge transfer (CT) state is a crucial intermediate in the charge photogeneration process – and potentially the recombination process as well. The energy of this CT state is related to the open circuit voltage of the photovoltaic device, and its efficient dissociation is required for a high free charge carrier yield. As such, the characteristics of the CT state for any given system can have an appreciable impact on device efficiency. CT states can most easily be examined if they are emissive, and are often identified by a red-shifted, long-lived emission compared to the polymer S_1 fluorescence. In order to study this emission more effectively, time-resolved methods that allow the decay dynamics of the CT fluorescence to be measured have proven very useful.

Initial steady state studies on two promising polymer:fullerene systems, ZZ115:PCBM and C-ZZ115:PCBM, have revealed a possible emissive CT state for the latter. Due to the strong possibilities of this affecting the efficiency of the resultant solar cells, it was therefore proposed to investigate these two systems using time-resolved photoluminescence spectroscopy in order to explore the CT state existence and characteristics. Furthermore, this proposed work would have the additional benefit of furthering the understanding of the little-known and frequently debated charge transfer state.

Professor Maria Loi's group at the Zernike Institute for Advanced Materials, University of Groningen, the Netherlands, have extensive experience and expertise in using ultra-fast time-resolved photoluminescence spectroscopy to investigate CT states in polymer:PCBM blends.

They have published a number of papers on this topic and have shown, for instance, that addition of a dithiol processing additive to a particular polymer:PCBM blend not only improves the nanomorphology of the device active layer but also reduces the CT state emission quantum yield. It is this group with whom I spent eight weeks from October – December 2011 examining ZZ115, its analogue C-ZZ115, and their blends with the fullerene PCBM. My aims were to learn the experimental and analytical techniques involved in ultra-fast photoluminescence spectroscopy using more well-known polymer systems, and then address the potential CT behaviour of ZZ115 and C-ZZ115.

Results

The initial phase of this research project was to learn ultrafast photoluminescence spectroscopy by using polymer systems that have previously been studied in this regard (that is, reproducing literature results) in order to gain familiarity with this technique and its analysis methods. The specific equipment used for these measurements involves a 150 femtosecond pulsed Kerr mode locked Ti-Sapphire laser in conjunction with a streak camera for detection. The polymers chosen for this purpose were PCPDTBT and Si-PCPDTBT, and their blends with PCBM and PCBM/DIO. DIO (di-iodooctane) acts as a co-solvent for the PCBM, improving the nanomorphology.

PCPDTBT is a low band gap polymer, thus detection in the infrared is required. The 3D streak camera results for this polymer are shown in Figure 1, with the resultant photoluminescence decays over time presented in Figure 2. Because these types of polymers are air-sensitive, the measurements were done on encapsulated glass. The pristine polymer film has an emission maximum at ~ 880 nm and a monoexponential photoluminescence lifetime of ~ 170 ps (Figure 2a, red trace), very similar to that reported by Loi et al. (~ 200 ps). Addition of PCBM strongly quenches the polymer S_1 emission at 880 nm with a lifetime of only ~15 ps (Figure 2a, black trace) due to the dissociation of the polymer exciton via electron transfer to the PCBM. However, there is a residual, low quantum yield, red-shifted emission at ~ 1000nm that extends to very long times with a lifetime of ~ 350 ps (Figure 2a, blue trace). This has previously been identified as emission for the charge transfer state that exists between the polymer and PCBM. Note that it is difficult to determine the precise photoluminescence lifetime of the CT state due to its substantial spectral overlap with the remaining polymer S_1 emission. Addition of the DIO completely quenches the CT emission (Figures 1c and 2c), as expected.

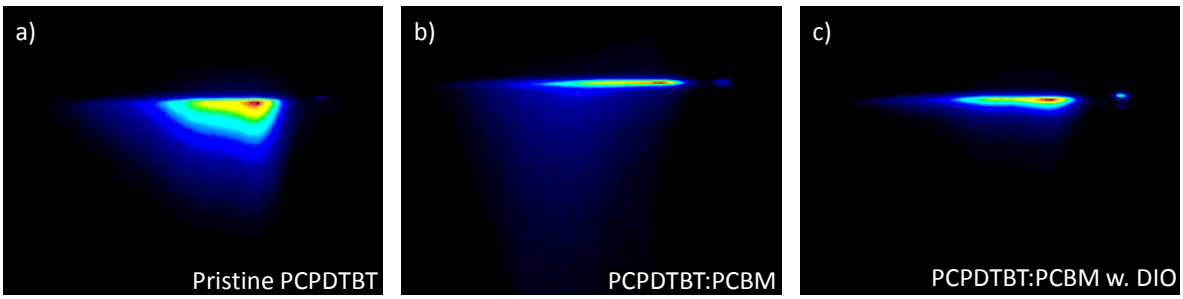


Figure 1. Infrared streak camera results for a) pristine PCPDTBT film on glass, b) PCPDTBT:PCBM (1:1) film and c) PCPDTBT:PCBM/DIO (1:1, 40 μg mL^{-1} DIO). The horizontal axis represents wavelength, where the right axis = 700 nm and the left = 1280 nm. The vertical axis represents time, where the top axis = 0 ps and the bottom axis = 2 ns (for a) and b)) and 800 ps (c)). The laser spot, with an excitation wavelength of 760 nm, is visible.

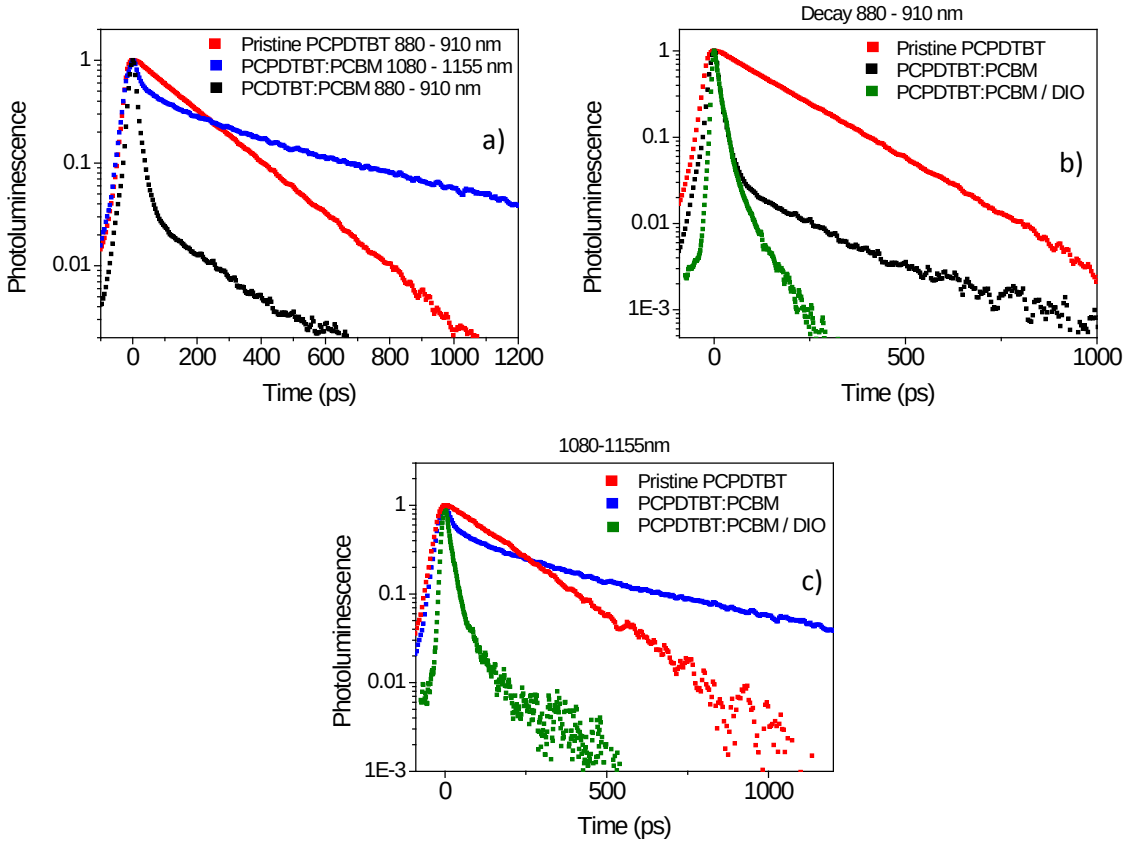


Figure 2. The time-resolved photoluminescence decays for the pristine PCPDTBT, PCPDTBT:PCBM and PCPDTBT:PCBM/DIO films measured at different wavelengths: 880 – 910 nm and 1080 – 1155 nm.

The same methods were then applied to Si-PCPDTBT (Figure 3), the silicon analogue of PCPDTBT. Pristine Si-PCPDTBT has a significantly longer S_1 lifetime (~ 300 ps) than PCPDTBT. Furthermore, addition of PCBM very efficiently quenches the photoluminescence, with a lifetime close to the instrument response of ~ 5 ps. Unlike PCPDTBT, Si-PCPDTBT shows no evidence of long-lived CT emission.

The second phase of this project was to repeat the same measurements on ZZ115 and C-ZZ115. However, it was discovered that the emission had a substantially weaker quantum yield than PCPDTBT and Si-PCPDTBT. Glass was therefore no longer an appropriate substrate as its emission began to interfere with that of the polymer's. As such, all experiments were done on encapsulated quartz samples instead. Furthermore, the emission extends over the 600 – 950 nm region, with the CT emission expected around 900 nm, and thus both visible and infrared detection were required. The extremely weak CT emission is close to the limit of detection for both detectors, thus adding a further complication. A final complication was that C-ZZ115 proved so air-sensitive that oxygen contamination within the polymer material itself had a detrimental effect on photoluminescence lifetimes (even when samples were encapsulated

under a nitrogen-only environment), thus leading to uncertainties in the photoluminescence lifetimes.

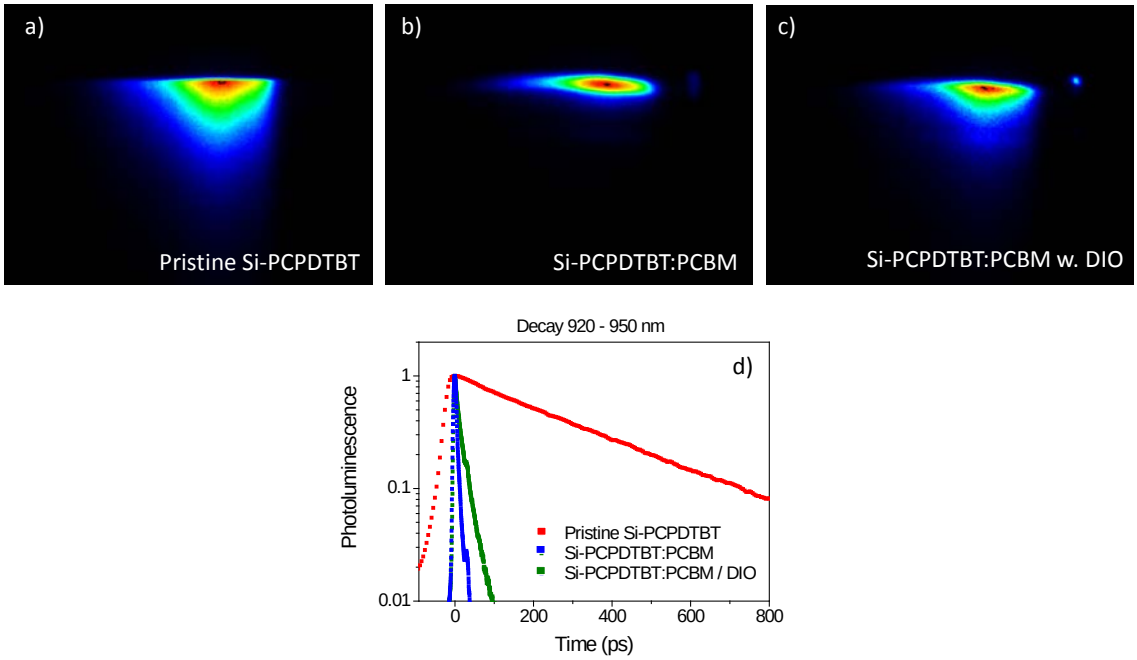


Figure 3. Infrared streak camera results for a) pristine Si-PCPDTBT film on glass, b) PCPDTBT:PCBM (1:1) film and c) PCPDTBT:PCBM/DIO (1:1, 40 μg mL^{-1} DIO). The horizontal axis represents wavelength, where the right axis = 700 nm and the left = 1280 nm. The vertical axis represents time, where the top axis = 0 ps and the bottom axis = 2 ns (for a)) and 170 ps (b) and c)). d) The time-resolved photoluminescence decays for the pristine Si-PCPDTBT, Si-PCPDTBT:PCBM and Si-PCPDTBT:PCBM/DIO films measured 920 – 950 nm.

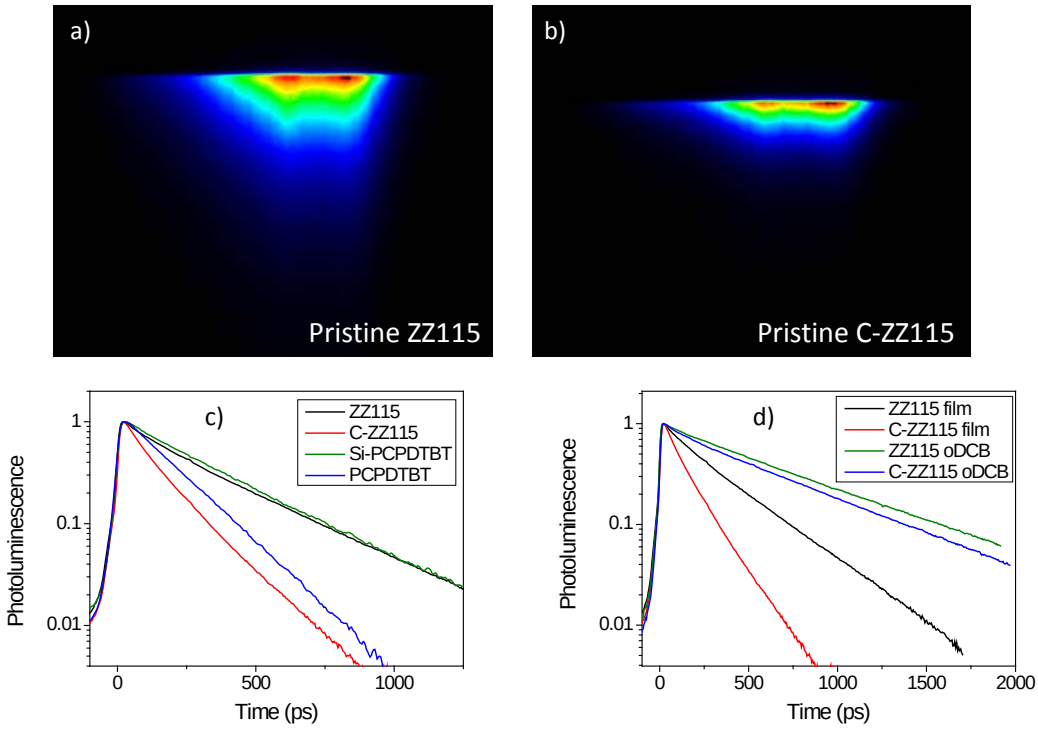


Figure 4. Visible streak camera results for a) pristine ZZ115 film on quartz and b) pristine C-ZZ115 film on quartz. The horizontal axis represents wavelength, where the right axis = 550 nm

and the left = 900 nm. The vertical axis represents time, where the top axis = 0 ps and the bottom axis = 2 ns. c) The photoluminescence decays at the peak emission for all four pristine films. d) The photoluminescence decays at the peak emission for ZZ115 and C-ZZ115 films and solutions (o-dichlorobenzene).

The visible streak camera results for pristine ZZ115 and C-ZZ115 films are shown in Figures 4a and 4b. The corresponding photoluminescence decays are displayed in Figure 4c, and compared to that of PCPDTBT and Si-PCPDTBT. It is evident that ZZ115 and C-ZZ115 show a similar trend to the other polymer pair, with the silicon analogues ZZ115 and Si-PCPDTBT having a very similar monoexponential lifetime of ~ 290 ps while the carbon analogues C-ZZ115 and PCPDTBT have a much shorter lifetime (130 ps for C-ZZ115). Note that the C-ZZ115 photoluminescence decay is not purely monoexponential (linear on a log-linear scale). There are a number of possible reasons for this in addition to the oxygen contamination: exciton diffusion effects, delayed fluorescence or geminate recombination of charges via the fluorescent singlet state. Given the close similarities in lifetime between the silicon analogues, it is likely that the true photoluminescence lifetime of C-ZZ115 in the solid state is much closer to that of PCPDTBT: 170 ps.

Figure 4d compares the film photoluminescence decays of ZZ115 and C-ZZ115 with that in solution (o-dichlorobenzene). As expected, intermolecular quenching effects between neighbouring π-stacked polymers are present, reducing the fluorescence lifetime in the solid state such that the decays in solution are substantial longer, with ~ 620 ps and 530 ps measured for ZZ115 and C-ZZ115 respectively.

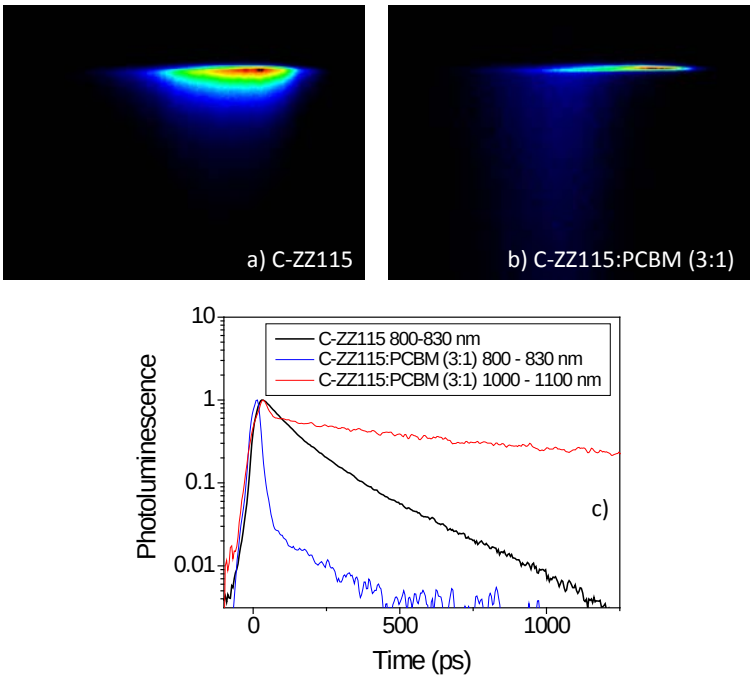


Figure 5. Infrared streak camera results for a) pristine C-ZZ115 and b) C-ZZ115:PCBM (3:1) films on quartz. The horizontal axis represents wavelength, where the right axis = 700 nm and the left = 1280 nm. The vertical axis represents time, where the top axis = 0 ps and the bottom axis = 2 ns. c) The time-resolved photoluminescence decays for the pristine C-ZZ115 and C-ZZ115:PCBM for two different wavelength ranges.

The addition of PCBM (25 %) to these polymers substantially reduces the polymer S_1 photoluminescence lifetime, as was observed with PCPDTBT and Si-PCPDTBT. This is shown in Figure 5 for C-ZZ115 and in Figure 6 for ZZ115. Upon addition of PCBM, the lifetime in the polymer S_1 800 – 830 nm range decreases to ~ 15 ps for both C-ZZ115 and ZZ115, close to the instrument response. The emission is not completely quenched by the PCBM at this low concentration, hence the lifetime is longer than that of PCPDTBT:PCBM and Si-PCPDTBT:PCBM. The long-lived red-shifted charge transfer emission (Figure 5b) is also observed for C-ZZ115. In this case, the decay from 1000 to 1100 nm can be fitted by two lifetimes: ~ 20 ps (residual polymer S_1 emission) and ~ 750 ps (the CT state emission). Although weaker than the CT emission of PCPDTBT, the CT emission of DT189 is clearly visible. The CT state was also unexpectedly observed for ZZ115 (Figure 6b and 6c), despite not being seen for its analogue PCPDTBT. The ZZ115 CT state is, however, extremely weak and barely visible. Its lifetime of ~ 400 ps is also shorter than that of C-ZZ115's.

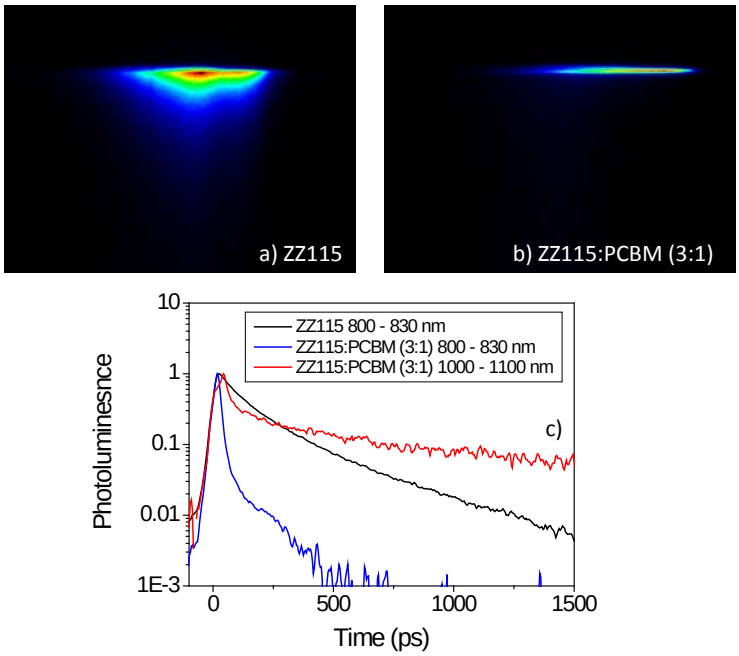


Figure 6. Infrared streak camera results for a) pristine ZZ115 and b) ZZ115:PCBM (3:1) films on quartz. The horizontal axis represents wavelength, where the right axis = 700 nm and the left = 1280 nm. The vertical axis represents time, where the top axis = 0 ps and the bottom axis = 2 ns. c) The time-resolved photoluminescence decays for the pristine ZZ115 and ZZ115:PCBM for two different wavelength ranges.

The CT state for C-ZZ115:PCBM was examined further by assessing the dependence on PCBM concentration. The results are displayed in Figure 7. The photoluminescence lifetime of the CT state clearly decreases as the concentration of PCBM increases. This is due to the CT state being more easily dissociated when large domains of PCBM are present. However, this is complicated by the very efficient exciton quenching at high PCBM loadings leading to an extremely weak emission signal (eg. Figure 7c).

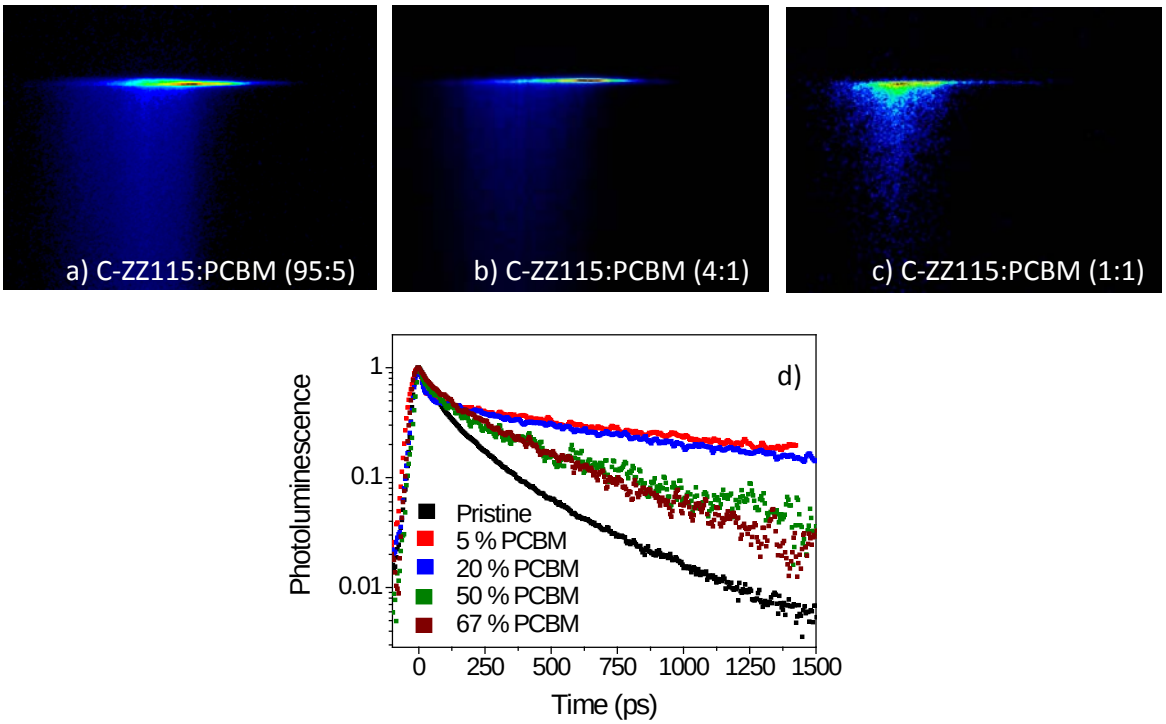


Figure 7. Infrared streak camera results as a function of PCBM concentration for a) C-ZZ115:PCBM (95:5), b) C-ZZ115:PCBM (4:1) and c) C-ZZ115:PCBM (1:1) films on quartz. The horizontal axis represents wavelength, where the right axis = 700 nm and the left = 1280 nm. The vertical axis represents time, where the top axis = 0 ps and the bottom axis = 2 ns. d) The time-resolved photoluminescence decays for the C-ZZ115:PCBM films' CT emission at 1000 – 1100 nm.

Finally, the effect of DIO was investigated. It was observed to reduce the lifetime of the CT emission lifetime, but did not completely quench it, as was the case for PCPDTBT. It is likely that a higher loading of DIO is required to achieve full quenching.

In conclusion, literature results for PCPDTBT and Si-PCPDTBT time-resolved photoluminescence results were duplicated. The same technique was applied to the new polymers ZZ115 and C-ZZ115 and, despite the air sensitivity issues and the fact that all of the desired experiments could not be performed during the length of this research project, the charge transfer state was successfully observed in both systems. More work is still necessary to elucidate the role of this crucial intermediate but this research visit has provided us with valuable information to aid in pursuit of this goal. I would like to thank the Australian Nanotechnology Network for their assistance in this research visit and their funding support is gratefully acknowledged.

Mr Rama Vasudevan from the University of New South Wales visit to the Oak Ridge National Laboratories in the USA

Australian Nanotechnology Network – ANN Travel Scholarship Outcomes Report

The Australian Nanotechnology Network Travel Scholarship was awarded to me (Mr. Rama Vasudevan, PhD Student at University of New South Wales, Sydney, supervised by Prof. V. Nagarajan from School of Materials Science and Engineering) to cover the costs of an overseas visit to Oak Ridge National Laboratory (ORNL) at Oak Ridge, Tennessee, USA. The funds allocated were used for accommodation and airfare purchases only.

The visit was co-funded by an ARC Discovery grant, and lasted for 6 months starting early November and continuing till late April, and the visit focused on advanced scanning probe microscopy techniques to probe ferroelectric and electrical properties of energy-related materials. The visit was highly productive, with numerous publications (outlined below) arising directly out of the experiments and expertise gained during the travel period. Additionally, more intangible outcomes, such as training on use of band excitation equipment, programming in MatLab and related computational packages, and other knowledge learned were very significant.

As a result of this visit to ORNL, numerous publications have been written, some have been submitted, and one has been accepted. These are listed in Table I below. ANN Travel Scholarship is listed as an acknowledgement in each of these publications.

Table I. Publications arising out of travel scholarship to ORNL

Publication Title	Authors	Abstract	Status and Notes
Spectroscopic Imaging in PFM: new opportunities for studying polarization dynamics in ferroelectrics and multiferroics	R.K. Vasudevan, S. Jesse, Y. Kim, A. Kumar, and S.V. Kalinin	Piezoresponse Force Microscopy (PFM) has emerged as a powerful tool to characterize piezoelectric, ferroelectric and multiferroic materials on the nanometer level. Much of the driving force for the broad adoption of PFM has been the intense research into piezoelectric properties of thin films, nanoparticles, and nanowires of materials as dissimilar as perovskites, nitrides, and polymers. Recent recognition of limitations of single-frequency PFM, notably topography-related cross-talk, has led to development of novel solutions such band-excitation (BE) methods. In parallel, the need for quantitative probing of polarization dynamics have	Accepted for publication in the journal ***MRS Communications*** The travels scholarship allowed me to develop expertise in band-excitation spectroscopies, facilitating writing of this review article.

		led to emergence of complex time- and voltage spectroscopies, often based on acquisition and analysis of multidimensional data sets. In this perspective, we discuss the recent developments in multidimensional PFM, and offer several examples of spectroscopic techniques that provide new insight into polarization dynamics in ferroelectrics and multiferroics. We further discuss potential extension of PFM for probing ionic phenomena in energy generation and storage materials and devices.	
Domain wall geometry controls conduction in ferroelectrics	R.K. Vasudevan, A.N. Morozovska, E.A.Eliseev, J. Britson, J.C.Yang, Y.-H.Chu, P. Maksymovych, L.Q. Chen, V. Nagarajan, and S.V. Kalinin	A new paradigm of domain wall nanoelectronics has emerged recently, in which the domain wall in a ferroic is itself an active device element. The ability to spatially modulate the ferroic order parameter within a single domain wall allows the physical properties to be tailored at will, and hence opens vastly unexplored device possibilities. Here, we demonstrate via ambient and ultra-high-vacuum (UHV) SPM measurements in bismuth ferrite that the conductivity of the domain walls can be modulated by up to 500% in the spatial dimension as a function of domain wall curvature. Landau-Ginzburg-Devonshire calculations reveal the conduction is a result of carriers or vacancies migrating to neutralize the charge at the formed interface. Phase-Field modeling indicates that anisotropic potential distributions can occur even for initially uncharged walls, from polarization dynamics mediated by elastic effects. These results are the first proof of concept for modulation of charge as a function of domain wall geometry by a proximal probe, thereby expanding potential applications for oxide ferroics in future nanoscale electronics.	Submitted to ***Nano Letters***. The travel scholarship enabled experiments to be performed that led to this paper.
Anisotropic conductivity of uncharged	Anna N. Morozovska, Rama K. Vasudevan,	Experimental observations suggest that nominally uncharged, as-grown domain walls in ferroelectric thin films can be	Submitted to ***Phys. Rev. B.***

domain walls in $BiFeO_3$	Peter Maksymovych, Sergei V. Kalinin, and Eugene A. Eliseev	conductive, yet comprehensive theoretical models to explain this behavior are lacking. Here, Landau theory is used to evolve an analytical treatment of the anisotropic carrier accumulation by nominally uncharged domain walls in multiferroic $BiFeO_3$. Strong angular dependence of the carrier accumulation by 180-degree domain walls originates from local band bending via angle-dependent electrostriction and flexoelectric coupling mechanisms. Theoretical results are in qualitative agreement with experimental data, and provide a Landau-Ginzburg-Devonshire counterpart that is consistent with recent first principles calculations. These studies suggest that a significantly more diverse range of domain wall structures could possess novel electronic properties than previously believed. Similarly, emergent electronic behaviors at ferroic walls are typically underpinned by multiple mechanisms, necessitating first-principle studies of corresponding coupling parameters.	The travel scholarship allowed experiments on conductivity to be carried out, which became a focal point for further theoretical investigations in this paper.
Nanoscale origins of nonlinear behavior in ferroic thin-films	R.K. Vasudevan, M.B. Okatan, C. Duan, H. Funakubo, A. Kumar, S. Jesse, L.Q. Chen, S. V. Kalinin and V. Nagarajan	The nonlinear response of a ferroic to an applied stimulus (e.g. electric field, mechanical stress) is a fundamental characteristic that underpins a number of technologically significant applications. It is also the driving feature in numerous physical phenomena, such as interfacial motion, spin glasses, relaxors and phase transitions. In particular, nonlinearity associated with minor hysteresis loops is an extremely useful avenue to explore energy dissipation and losses in such systems. This knowledge is necessary for the design of future materials with enhanced low-field properties. Quantitatively, the macroscopic nonlinear response of ferroic systems at low to mid-range amplitudes of driving fields is given by the phenomenological	Submitted to ***Adv. Func. Mat.*** The travel scholarship enabled some supplementary experiments to be performed, that allowed completion and submission of this paper.

		Rayleigh law, first conceived in 1887 for magnetic materials. Yet, the applicability of the Rayleigh law at small length scales has not been extensively studied. Here, we show using a combination of scanning probe techniques and phase field modeling, that nanoscale response appears to follow a non-Rayleigh regime. However, through statistical analysis, we find that a distribution in the individual responses can lead to directly to Rayleigh-like behavior of the strain on a macroscale. The studies shed light on the nanoscale origins of nonlinear behavior in disordered ferroics.	
Unraveling the sources of electromechanical response in a mixed-phase system	R.K. Vasudevan, M. Baris Okatan, Y.Y. Liu, S. Jesse, J.-C. Yang, Y.-H.Chu, J.Y. Li, S.V. Kalinin, and V. Nagarajan	The source of giant electromechanical response in a mixed phase thin film is probed using sub-coercive field measurements. Scanning Probe Microscopy techniques are used to map the 1st and 2nd harmonic contributions to the strain, and simultaneously probe dissipation. Results indicate significant contributions to the strain arising from a second-order harmonic response. Theoretical calculations and phase-field modeling reveal that the source of the enhanced electromechanical response is due to the mostly reversible motion of phase boundaries, as opposed to polarization rotation or electrostriction. These findings reveal the source of enhanced strain response in mixed phase systems, and suggest pathways to design films with larger electromechanical coupling coefficients.	Manuscript in preparation. The travel scholarship allowed experiments to be performed, that led to this paper, which is currently in preparation.

Mr Jing Ren from the University of Melbourne visit to Nagoya University in Japan

The Australian Nanotechnology Network (ANN)
Overseas Travel Fellowship
Outcome Report

Details of student

Name: Jing Ming Ren

Department & Faculty: Chemical & Biomolecular Engineering, School of Engineering, the University of Melbourne

Details of supervisor

Name: Prof. Greg G. Qiao

Department & Faculty: Chemical & Biomolecular Engineering, School of Engineering, the University of Melbourne

Details of supervisor at host institution

Name: Prof. Masami Kamigaito

Host institution: Kamigaito Laboratory, Department of Applied Chemistry, Graduate School of Engineering, Nagoya University, Japan

Period spent at the host institution

8 Nov 2011 – 1 July 2012 (~ 8 months)

During the eight-month period of stay at Kamigaito Laboratory, Nagoya University, Japan. I had accomplished my research mission of preparing an unprecedented stereospecific cyclic polymer – syndiotactic poly(methyl methacrylate), under the supervision of Prof. Masami Kamigaito. During the course of my research, I have acquired the Stereospecific Living Radical Polymerization (SLRP) technique – a cutting-edge polymer synthetic technology, which is not commonly practiced in Australia. Polymer synthesized through SLRP not only has well-defined structure but also with engineered stereochemical properties, hence, they may form useful nanomaterials in a diverse spectrum of applications including in chiral separation, molecular recognition and asymmetric reaction catalysis. Upon my return, I will help disseminate this SLRP technique within my research group, as well as the wide research community in the field of material science and nanotechnology in Australia.

I have delivered a one-hour research seminar at the host research institute titled ‘Organic Catalyst-Mediated Ring Opening Polymerization towards the Near-quantitative Synthesis of

Polyester-based Star Polymers', in order to introduce the ongoing research activities at my home research institute, and generate exposure of my own research work. I had also attended the 8th Global COE International Symposium on Elucidation and Design of Materials and Molecular Functions, and the 3rd and 4th Yoshimasa Hirata Memorial Lectures, Nagoya University, Nov. 28 - 30, 2011, during which I had the rare opportunity to interact with the world leaders in the field of organic chemistry and macromolecular science.

One publication is currently being prepared based on the results obtained from my research trip. However, given the timeframe, more characterisation and analysis results on the polymeric material synthesized are still required to complete the investigation, and these characterizations and analyses could be done at the home research institute. It is estimated that the manuscript of this study will be ready for submission in approximately two months to high impact international chemistry journal.

At a personal level, I have greatly benefited from the overseas research trip. I have augmented and advanced the research and laboratory skills through the involvement in the leading-edge research project, and conducting experiments in host institute - one of the world leading research laboratories in polymer chemistry. By generating exposure of my research work at an international stage, my profile as early career researcher has been enhanced. The travel enhanced my educational experience, broadened my personal and educational perspectives, and provided me with the opportunity to explore, appreciate and understand Japanese culture. Furthermore, I have also established valuable friendships with overseas research peers. The overall research experience forms a precious asset to my personal life as well as future career.

The research visit strengthened the established collaboration between the home [Polymer Science Group] and the host [Kamigaito Laboratory] institutes. As a result of the success of this collaboration, it is decided that a long-term collaborative project based on the stereospecific polymeric architecture will be formed between the home and host organisations, to further explore the intricate and exquisite chemistry of this novel class of nanomaterials.

This research project would not be successful without the support of the Overseas Travel Fellowship from the Australia Nanotechnology Network (ANN). This award did not only benefit me in term of my personal life and career path, the two collaborative research institutes and but also the wide scientific research community of the home and host countries. I highly appreciate the financial support from ANN and wish the ANN will continue funding the fellowship scheme, so that more young researchers or scientists could benefit from the overseas research experiences.

Ms Xia Wu from the University of Queensland to visit the Ecole Polytechnique Federale de Lausanne (Switzerland)

REPORT ON RESEARCH TRAVEL

Departure Date: 17 Jan 2012 Return Date: 18 May 2012

Laboratory of Photonics and Interfaces (LPI), Ecole Polytechnique Federale de Lausanne (EPFL) Switzerland

Outcomes of Research Travel

1. Conducted fundamental research of the electron transport efficiency of DSSCs by means of electrochemical impedance spectroscopy and voltage/current transient measurement. Two systems were investigated; the first project is based on DSSCs with 001 enriched TiO2 nanoplates in comparison with the home made TiO2 nanoparticles, results showed that enhanced electron transport efficiency and longer life time were obtained with the 001 enriched TiO2 nanoplates. However, when comparing the overall performance of those two cells, the nanoplates cell exhibited a lower current than the homemade cell, and the reason has been attributed to the dye-loading problem.

This problem has become the bottleneck of the project; further collaboration will also focus on how to solve this problem. The second system is focus on testing DSSCs with different gel-like electrolyte and their stability performance under long term sun light irradiation.

2 different dyes and 4 different electrolytes were investigated to understand how the cell response to different dye/electrolyte system. Results are recorded and used as guidance for future project.

2. I was also involved in the research of understanding how and where does dye molecules sit on the TiO2 matrix by means of SEM, STEM and AFM. Micron-sized 001 enriched TiO2 microplates were employed. The first and most important step in this project is to evenly disperse such microplates in a flat substrate; preliminary SEM result showed that ethanol and high dilution would facilitate the plate dispersion. This part of work is still undergoing.

3. Besides, my cell fabrication skill is also improved via discussion and collaboration with the researchers in LPI. Connections and collaborations are built between the two research groups for further research cooperation.

Dr Javad Faroughi from the University of Wollongong visit to the Nantech Institute at the University of Texas (USA)

Australian National Fabrication Facility (ANFF), ARC Centre of Excellence for Electromaterials Science(ACES),Intelligent Polymer Research Institute(IPRI) University of Wollongong

Novel Carbon Nanotube Graphene Fibres

Aim: Enhancement of mechanical, electrical and electrochemical properties of CNT yarns

The primary aim of this visit is to explore possible strategies for introducing graphene sheets into carbon nanotube (CNT) yarns. This project intends to gain significant understanding of the spinning process involved in fabricating multifunctional CNT yarns by incorporating a new material (graphene) into the CNT structure and allow for its application into actuators, batteries, sensors and electronic textiles.

CNT fibres and films have been developed most prominently by the collaborating group of Prof. Ray Baughman at the University of Texas at Dallas (UTD). While the properties of these CNT materials are impressive, their electrical conductivity and electrochemical properties can be further enhanced using graphene as an additive. Recently, graphene has been converted chemically into a dispersion form sutiable for further processing by researchers at the University of Wollongong (UoW). Several researchers have been working to develop these graphene dispersions for various applications, however, there are still some limitations due to difficulties in processing. Recently, I have developed a novel approach to producing high performance bicomponent multi-walled carbon nanotube (CNT) / graphene (G) fibres. An electrospinning method has been used to develop CNT-G nanofibers using the UoW graphene dispersion as the spinning solution and a drawn CNT forest (from UTD) as the collector. Initial results show that the novel CNT-G nanofibers exhibited improved electrical conductivity and mechanical properties compared to pristine CNT yarn (Figure 1). These high performance fibres may be useful for several applications such as sensors, actuators, batteries and fuel-powered artificial muscles.

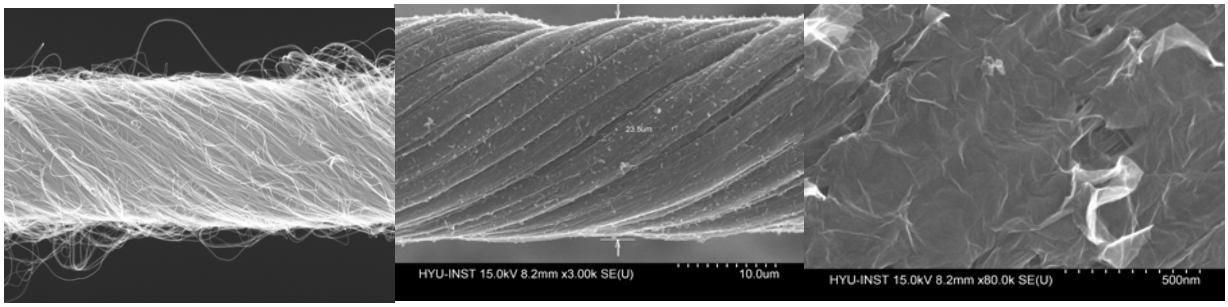


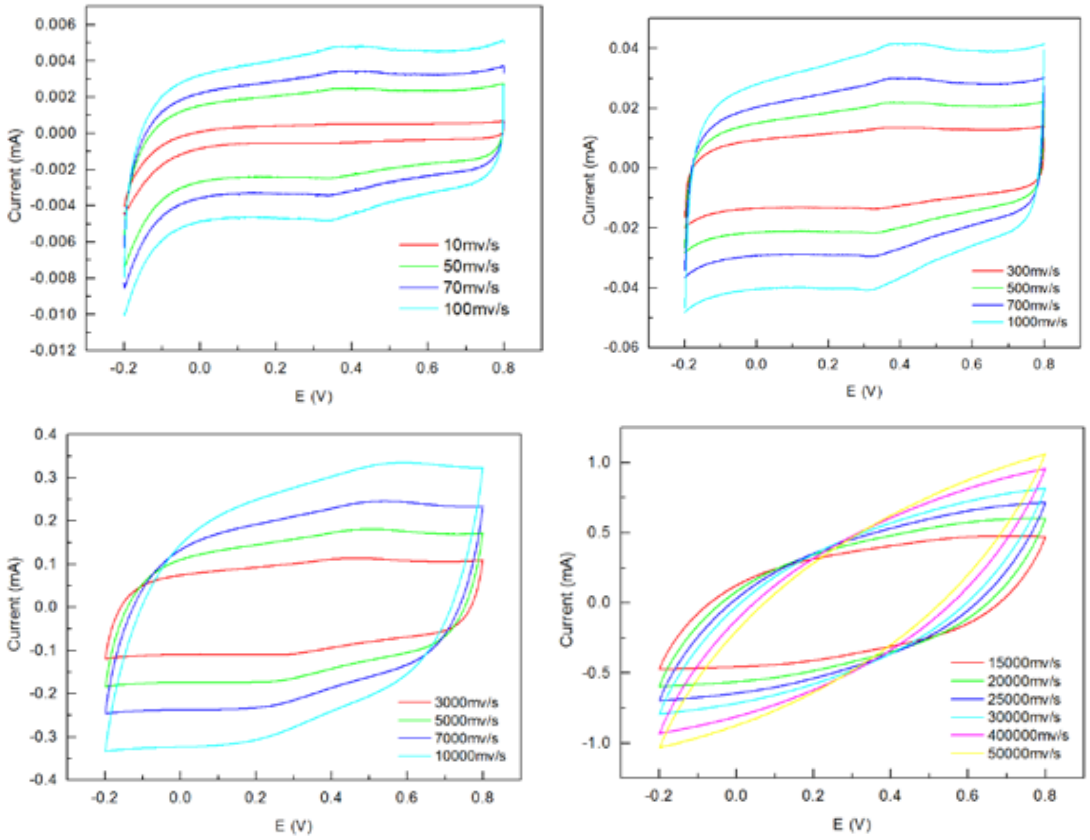
Figure 1: SEM micrographs of (A) pristine CNT yarn and CNT-Graphene yarn at (B) low and (C) higher magnification. *Novel CNT-Graphene nanofibers exhibit higher electrical conductivity (~ 900 S/cm) compared to pristine CNT yarn (~200 S/cm)*

Methodology:

The proposed method for manufacturing high graphene content CNT yarn is by spinning the CNT yarn and electrospinning the dispersed graphene. Ultrathin polymer nanofibers, with diameters down to a few nanometers are achievable via the electrospinning process. It involves the application of a strong electric field to a pendent drop of a polymer solution or polymer melt. A jet is ejected and moves towards the counter electrode once the electrostatic forces are strong enough to overcome the surface and viscous forces. A broad range of polymers, including polymer blends or polymers containing solid nanoparticles or functional small molecules can be electrospun.

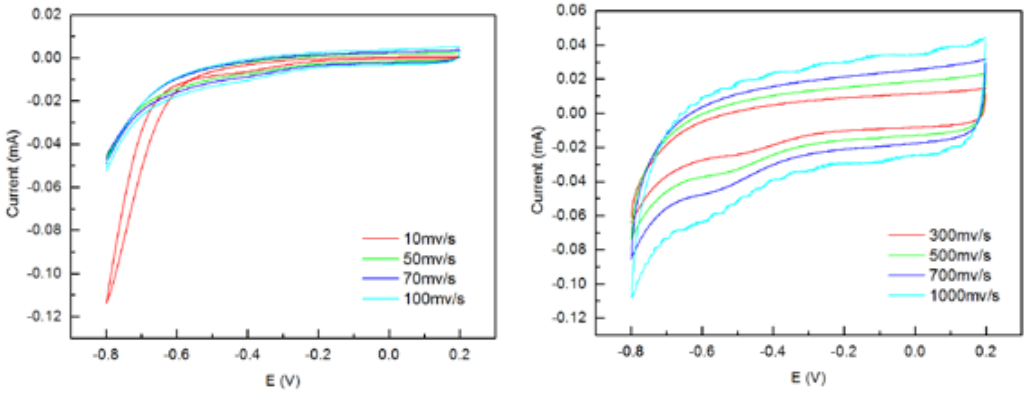
A special set up is required to allow us to carry out spinning of the CNT yarn and electrospinning of graphene into CNT yarn simultaneously. The main purpose of the Dallas visit will be to explore methods for coating individual CNT fibres with graphene during the yarn spinning operation

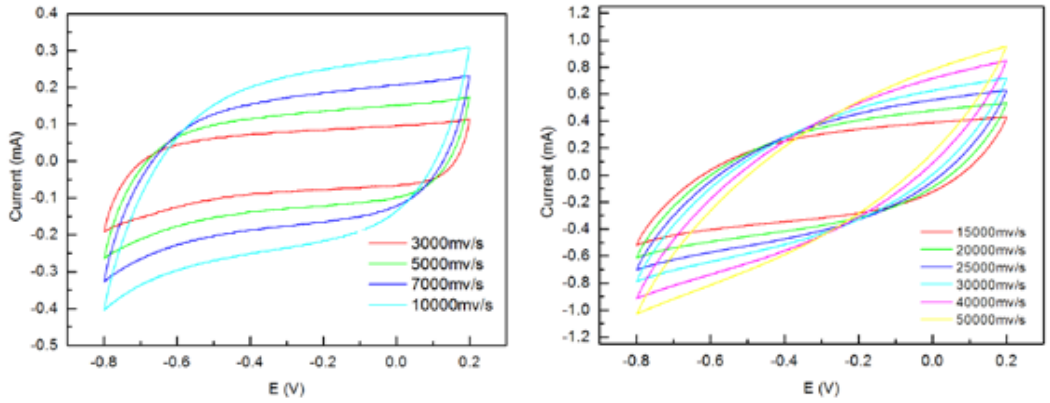
chievement



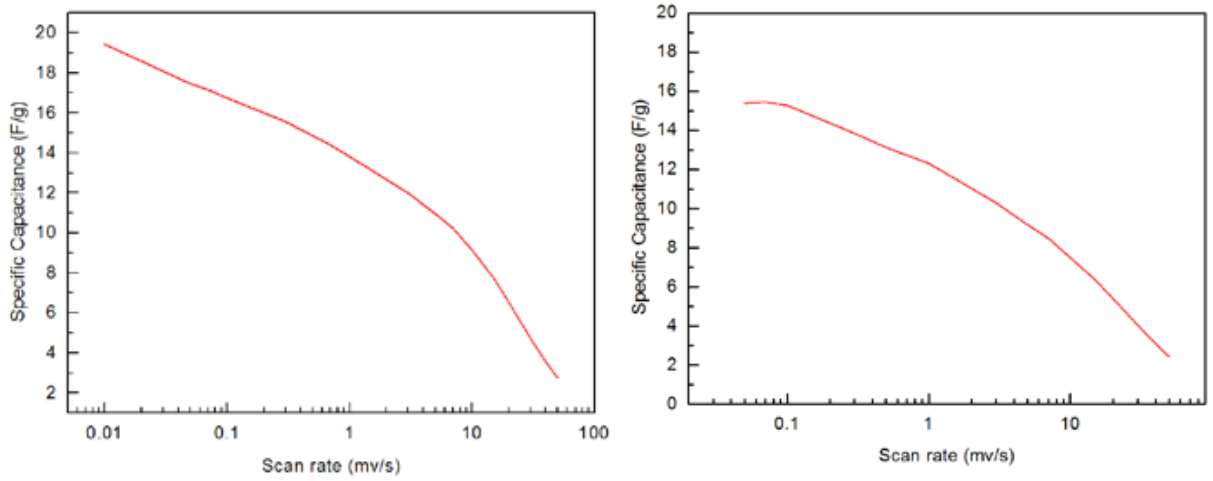
Electrochemical performance of CNT/graphene yarn

Scan rate of 10 mV/s to 50 V/s, -0.2V ~ 0.8V





Electrochemical performance of CNT/graphene yarn Scan rate of 10 mV/s to 50 V/s, -0.8V ~ 0.2V

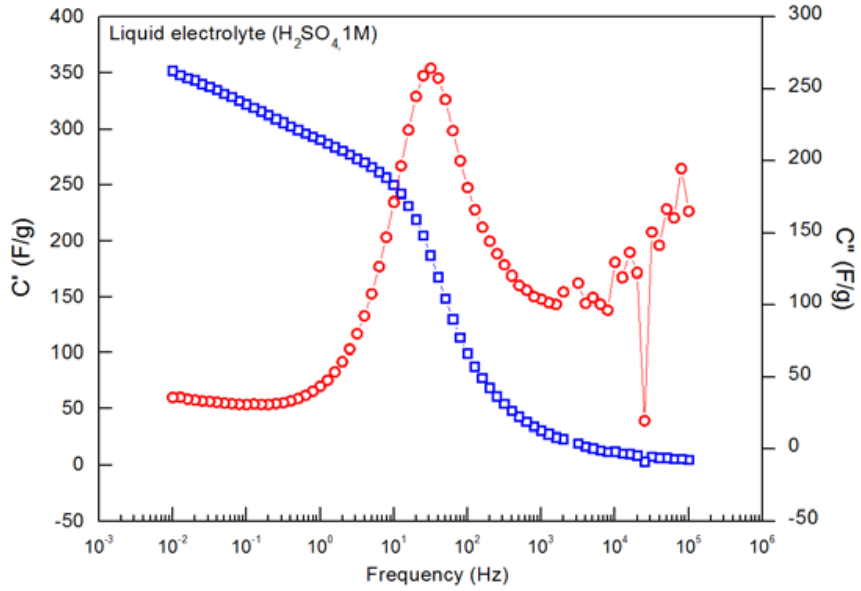


●Scan rate of 10 mV/s to 50 V/s, -0.2V ~0.8V

●Scan rate of 10 mV/s to 50V/s, - 0.8V~ 0.2V

Electrochemical performance of CNT/graphene yarnSpecific capacitance at various scan rates

ESR in Nyquist plot



Evolution of the real and imaginary part (C′ and C″)
Electrochemical performance of CNT/graphene yarn

Mr Jason Chen from the University of New South Wales visit to the University of Nebraska (USA)

Jason is at present in the US

Dr Angel Tan from the University of South Australia visit to the University of Copenhagen (Denmark)

Angel is at present in Denmark

Dr Peter Metaxas from the University of Western Australia visit to the Georgia Institute of Technology (USA)

Peter is at present in the US

Asia Nano Forum -Asia Nano Camp 2011 - Korea

Asia Nanotech Camp is a program initiated by Asia Nano Forum (ANF) as a platform for young nanotechnology researchers to learn about the state of the art and nanotechnology advancement in ANF network economies. It provides unique educational opportunities for these young researchers to communicate, network, and collaborate with one another.
For the past four years, the Asia Nano Camp was held in Japan (2008), Taiwan (2009) and Singapore / Malaysia (2010).

The program includes technical lectures by experts in various areas of nanotechnology, industry seminars, visits to universities and research institutes, as well as networking/ social activities. The participants are also requested to share their research activities, work on group assignments and present their findings at the workshop.
ANN has provided return economy class airfare for the Korean Asia Nano Camp. The Asian organizing committee provided local hospitality including accommodation, meals, local transportation, and social activities.

The following three young scientists (PhD students and ECRs) from Australia have been selected and have participated in the 4th Asia Nanotech Camp (ANC) 2011 which took take place on Aug. 15th through Aug. 28th 2011 in Korea.

- Mr Sankara Sundaram from the University of New South Wales
- Mrs Sumaiya Islam from Monash University
- Ms Xia Wu from the University of Queensland

WORKSHOPS, CONFERENCES AND EVENTS

WORKSHOPS, CONFERENCES AND EVENTS

The purpose of the workshops, Conferences and Events is to take stock of the status of the field nationally and internationally, identify emerging areas of research and exchange information and to identify opportunities for collaboration and training. A Large number of ECRs and students have been supported to attend these events.

Trilateral Nanophotonics Workshop, February 2011, McLaren Vale

Report for Australian Nanotechnology Network (ANN)

Project title

International Workshop for Nanophotonics for sensing & nonlinear optics - next generation photonic materials, structures and devices.

Executive Summary

The Trilateral Nanophotonics Workshop was held 24-26 August 2011 at Serafino McLaren Vale South Australia, and brought together leading researchers and their groups from Australia, Italy and France with the aim of fostering and strengthening collaborations amongst these nations in nanophotonics research. Sixteen Italian and French participants attended as well as 14 interstate participants and 21 local participants.

In addition to strengthening the collaborations between our countries and building stronger links between the participating research groups, this workshop focused on building interactions between early career researchers and students from each of the participating organisations, which included University of Western Australia, Australian National University, University of Melbourne, Macquarie University, University of Sydney, UniSA and the Institute for Photonics & Advanced Sensing (IPAS) at the University of Adelaide.

Generous sponsorships were provided by the Italian and French Embassies in Australia, the South Australian State Government, The Department of Innovation, Industry, Science and Research (DIISR), the Australian Nanotechnology Network (ANN) and IPAS. The funds kindly provided by ANN went towards the costs of flights (where necessary), accommodation, meals and some venue costs for the 17 attending Australian Early Career Researcher's and students.

Attending ECRs and PhDs

The table below demonstrates the amount expended on interstate and local ECR and PhD attendees to the Nanophotonics Workshop from the ANN funding received.

Name	Institution	ECR/PhD
Andrew Richardson	IPAS	ECR
Chris Kalnins	IPAS	PhD
Daniel Stubing	IPAS	PhD
David Low	IPAS	PhD
Eric Schartner	IPAS	PhD
Florian Englich	IPAS	ECR
Gino Putrino	University of WA	PhD

Name	Institution	ECR/PhD
Haofeng Lu	Australian National Uni	PhD
Herbert Foo	IPAS	PhD
Jiangbo Zhao	Macquarie Univeristy	PhD
Kristopher Rowland	IPAS	ECR
Linh Nguyen	IPAS	ECR
Matt Henderson	IPAS	PhD
Rebecca Lodin	University of Sydney	PhD
Regis Mejard	University of SA	PhD
Stephen Warren-Smith	IPAS	ECR
Tim Karle	University of Melbourne	ECR

Outcome and Achievements

The event was considered a great success with extremely positive feedback from the delegates from all three countries and all levels of researchers providing positive verbal comments about the workshop throughout the event. These comments predominantly centred around the high quality of the event, the presentations and posters and the value of the event in terms of establishing new contacts and networks to develop.

Following the event, we placed all the presentations and posters into a Dropbox folder and uploaded presentations and photos taken at the Workshop. All participants were invited to access this facility as a useful resource for delegates to refresh themselves with the presentations. A website was established prior to the event to ensure all delegates had access to information regarding confirmed attendees, location, program and other relevant news on the event. Appendix A contains photos from the Nanophotonics Workshop.

An early outcome of the event has been the signing off of a new collaboration and funding agreement between the Universities of Adelaide and Trento (Italy), funded by the SA State Government and the Trento Provenance Government. The **$241k nanophotonics project** will be led by Prof Pavesi from the University of Trento and A/Prof Heike Ebendorff-Heidepriem, Dr Shahraam Afshar and Prof Tanya Monro from IPAS. ECR's and students from both universities will be involved on the project, further adding to the collaborations formed at the Nanophotonics Workshop.

Another fruitful outcome of the Workshop has been the acceleration of our collaboration with Macquarie Univeristy with visits to each others labs in late 2011. We are currently working together on the China Mission bid and we are preparing a couple of papers for publication.

Closing Statement

The Institute for Photonics & Advanced Sensing would like to thank the ANN for providing funding for this highly successful event. Some excellent collaborations, fostered at the Workshop, have already been secured which will allow early career researchers and PhD students to undertake their research in exciting new nanophotonics projects.

Australian and New Zealand Micro- and Nano-fluidics Symposium 28th-29th April 2011, UNSW

Report from Chair: Gary Rosengarten, School of Mechanical and Manufacturing Engineering University of NSW

Co Chairs: Leslie Yeo Department of Mechanical & Aerospace Engineering, Monash University

David Inglis Department of Physics, Macquarie University

This was the second incarnation of the conference. The first was in 2010 and was limited to about 15 invited speakers from Australia and NZ and was held over one day. We decided to expand it in 2011 and sent out invitations to about 80 people in Australia and New Zealand. We wanted to make it accessible so we had no registration fee for students and a nominal $100 for others. We were supported by the Faculty of Engineering at UNSW (venue and technical support) and by the Australian Nanotechnology Network (ANN) for ECR and student attendance (see below).

Some statistics include:

- Approximately 60 attendees from 17 difference universities and institutions
- 15 different cities represented
- University departments represented included Mechanical Engineering, Chemical Engineering, Physics, Chemistry, Electrical Engineering and Biomedical Engineering, highlighting the highly interdisciplinary nature of the research field.

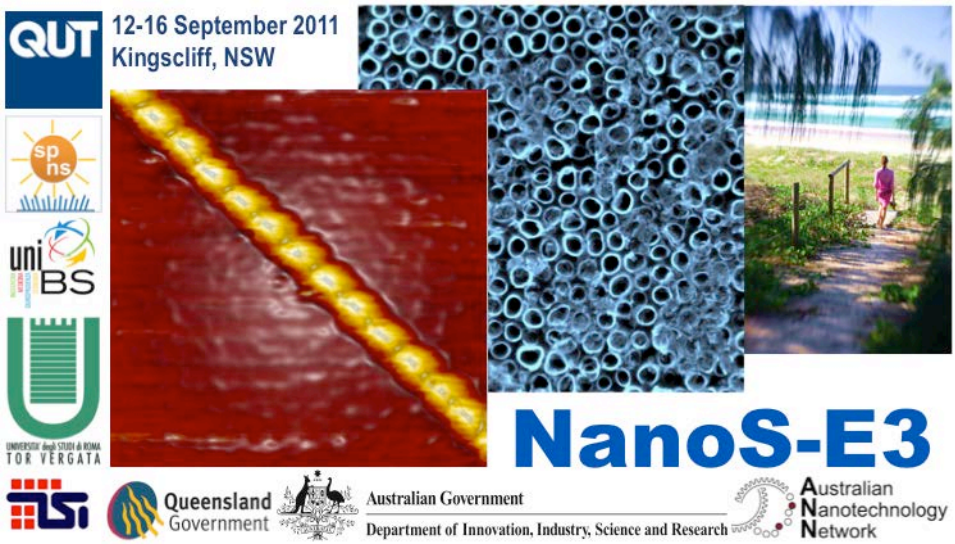
Two morning teas, two lunches and one afternoon tea were provided ensuring the attendees continued the discussions and meeting in the breaks (which did work). A website was set up with information and for credit card payment.

The ANN funding was used to sponsor six early career researchers from around Australia to attend the conference. The details are listed in the table below.

Name	Association
Khashayar Khoshmanesh	Deakin University
Ben Chea	UWA
Aisha Qi	Monash
Jingfang Zhou	ADFA
Dmitry Khodakow	Flinders
Kunwar Singh	University Sydney

The conference ended up being highly successful with excellent feedback both from academic attendees and the relatively large industry contingent. At the end discussion it was agreed that the informal nature of the symposium was the right format (i.e no full paper- only abstract review) and that it was conducive to forming new collaborations (in some instances people from the same universities met for the first time!). Given the success (the number of attendees exceeded expectations and very good discussions were had) we decided to hold it again in 2012 with New Zealand's IRL (Industrial Research Limited) offering to run it. It will be held during the Easter Break in Wellington.

Nanostructures for Sensors, Electronics, Energy and Environment
NanoS-E3 Kingscliff (NSW) 12-16 September 2011



International School and Workshop on Nanotechnology
Web: www.nanose3.com

Chairs: N.Motta, J.Bell, M.De Crescenzi

The rapidly emerging areas of nanoscale science and technology are focussed on the design, fabrication, and characterisation of functional objects having dimensions at the nanometer length scale. New advances in this field are expected to have long-range implications in a wide variety of different scientific and engineering disciplines. The importance of nanoscale science is growing worldwide and it is now widely recognised as a critical component to the future growth of the world economy.

Following the successful NanoE3 Australian-Italian workshops in 2007 and 2008, this third edition (NanoS-E3) broadened the topics area to sensors and nanotechnology and opened to other international scientists. Through this international School and Workshop, the scientists have been able to exchange their knowledge and research in the field of nanotechnology focusing on sensors, electronics, energy and environment as well as to establish fruitful collaborations and extend the existing one.

This event hosted 34 scientists from Australia, Italy, France, Japan, Germany, Malaysia and Canada, leaders in their specific fields.

ORGANISING COMMITTEE

Chairs

Nunzio Motta	Queensland University of Technology (QUT)	Brisbane, Australia
John Bell	Queensland University of Technology (QUT)	Brisbane, Australia
Maurizio De Crescenzi	Universita' Degli Studi Di Roma "Tor Vergata"	Roma, Italy

Members

Federico Rosei	EMT-INRS Universite' du Quebec	Montreal, Canada
Guido Faglia	Universita' Degli Studi Di Brescia	Brescia, Italy

Giuseppe Tettamanzi	The University of New South Wales	Sydney, Australia
Giordano Scappucci	The University of New South Wales	Sydney, Australia
Eric Waclawik	Queensland University of Technology	Brisbane, Australia
Mahnaz Shafiei	Queensland University of Technology	Brisbane, Australia
Andrea Capasso	Queensland University of Technology	Brisbane, Australia

Advisory Committee

Nunzio Motta	Queensland University of Technology	Brisbane, Australia
John Bell	Queensland University of Technology	Brisbane, Australia
Maurizio De Crescenzi	Universita' Degli Studi Di Roma "Tor Vergata"	Roma, Italy
Federico Rosei	EMT-INRS Universite' du Quebec	Montreal, Canada
Guido Faglia	Universita' Degli Studi Di Brescia	Brescia, Italy
Chennupati Jagadish	Australian National University (ANU)	Canberra, Australia
David Jamieson	The University of Melbourne	Melbourne, Australia
Michelle Simmons	The University of New South Wales	Sydney, Australia
Wojtek Wlodarski	Royal Melbourne Institute of Technology (RMIT)	Melbourne, Australia

SPONSORS

In addition to ANN sponsorship, the event was sponsored as well by:
QUT, University of Roma Tor Vergata, University of Brescia, Queensland Government, TSI.

SCHOOL

The two day school, attended by 21 students coming from several universities in Australia and overseas, was a very successful introduction to physics and chemistry of new materials and nanostructures, ranging from self-assembly of organic molecules to use of carbon nanotubes in solar cells and fuel cells, down to the fascinating quantum computing realm.

SCHOOL LECTURERS

F. Rosei	Institut national de la recherche scientifique (INRS)	Canada	Organic Molecules
C. Raston	University of Western Australia (UWA)	Australia	Chemical Assembly of Nanoparticles
J. Shapter	Flinders University	Australia	Solar Cells Using Carbon nanotubes
M. De Crescenzi	Università Roma Tor Vergata	Italy	Carbon Nanotubes for Photovoltaics
N. Motta	Queensland University of Technology (QUT)	Australia	Graphene
K. Kalantar-zadeh	RMIT University	Australia	Nanosensors
J. Dobson	Griffith University	Australia	Forces in Nanostructures
E. Traversa	National Institute for Materials Science (NIMS)	Japan	Fuel Cells
M. Ford	University of Technology Sydney	Australia	Calculation of Optical Properties of Nanostructures
S. Rogge	The University of New South Wales (UNSW)	Australia	Quantum Devices
C. Jagadish	Australian National University (ANU)	Australia	Quantum Lasers
Y. Tachibana	RMIT University	Australia	Dye Sensitized Solar Cells
D. Jamieson	The University of Melbourne	Australia	Quantum Computing

POSTER SESSION

At the end of school, a poster session allowed the students to present their own 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 AU$200 and an award certificate for the best poster** was granted to the PhD student:

Mr. Chee Pei Song from Fakulti Kej Elektrik, Universiti Teknologi Malaysia.

LIST OF STUDENTS FUNDED BY ANN

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5	Guillaume Jolly	PhD, QUT	guillaume.jolly@student.qut.edu.au
6	Vincent Tiing Tiong	Master, QUT	vincent.tiong@student.qut.edu.au
7	Bharati Gupta	PhD, QUT	bharati_basta@yahoo.com
8	Andrea Capasso	PhD, QUT	a.capasso@qut.edu.au
9	Xianjue Chen	PhD, UWA	20851859@student.uwa.edu.au
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11	Sherman Wong	PhD, ANU	u4404885@anu.edu.au
12	Leonardus Bimo Bayu Aji	PhD, ANU	lbb109@physics.anu.edu.au
13	Amir Sidek	Master, Fakulti Kej Elektrik Universiti Teknologi Malaysia	amirsidek@gmail.com
14	Chee Pei Song	PhD, Fakulti Kej Elektrik Universiti Teknologi Malaysia	pschee2@live.utm.my
15	Mohd Fazli Aziz	PhD, Fakulti Kej Elektrik Universiti Teknologi Malaysia	mfazli25@live.utm.my
16	Dario Zappa	PhD, University of Brescia	dario.zappa@ing.unibs.it
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18	Sushil Kumar	Master, CQU	s.kumar3@cqu.edu.au
19	Nina Eikenberg	PhD, University of Melbourne	ninaeikenberg@gmx.de
20	Fabio Matteocci	PhD, University Roma Tor Vergata	Fabio.Matteocci@uniroma2.it
21	Luca Persichetti	PhD, Università Roma Tor Vergata	Luca.Persichetti@roma2.infn.it
22	Dario Zappa	Università di Brescia	dario.zappa@ing.unibs.it

WORKSHOP
The three day workshop focused on the following topics:
Semiconductors, Photonic devices, Quantum devices, Graphene/carbon nanotubes, Nanomaterials, Sensors, Solar Energy, Environmental materials

KEYNOTE SPEAKERS

M. Simmons	The University of New South Wales (UNSW)	Australia	Semiconductors
C. Jagadish	Australian National University (ANU)	Australia	Photonic Devices
M. De Crescenzi	Università di Roma Tor Vergata	Italy	Graphene/CNT
D. Jamieson	The University of Melbourne	Australia	Quantum Devices
L.Favre	L2MP- CNRS	France	Nanomaterials
D. Fiorani	ISM – CNR Roma	Italy	Nanomaterials
G. Faglia	Universita' Degli Studi Di Brescia	Italy	Sensors
J. Bell	Queensland University of Technology (QUT)	Australia	Solar Energy

INVITED SPEAKERS

L. Persichetti	Università Roma Tor Vergata	Italy	Semiconductors
S. Ruffell	Australian National University (ANU)	Australia	Semiconductors
A. Petrozza	Politecnico di Milano	Italy	Photonic Devices
S. Rogge	The University of New South Wales (UNSW)	Australia	Photonic Devices
A. Capasso	Queensland University of Technology (QUT)	Australia	Graphene/CNTs
M. Rybchuk	Queensland University of Technology (QUT)	Australia	Graphene/CNTs
A. Li Bassi	Politecnico di Milano	Italy	Nanomaterials
J. Drennan	University of Queensland (UQ)	Australia	Microscopy of Nanomaterials
G. Scappucci	The University of New South Wales (UNSW)	Australia	Quantum Devices
L. Hollenberg	The University of Melbourne	Australia	Quantum Devices
G. Tettamanzi	The University of New South Wales (UNSW)	Australia	Quantum Devices
A. Sgarlata	Università di Roma Tor Vergata	Italy	Nanomaterials
E. Waclawik	Queensland University of Technology (QUT)	Australia	Nanomaterials
J. Liu	Queensland University of Technology (QUT)	Australia	Nanomaterials
C. Raston	University of Western Australia (UWA)	Australia	Nanomaterials
M. Shafiei	Queensland University of Technology (QUT)	Australia	Sensors
P. Shaw	University of Queensland (UQ)	Australia	Sensors
M. Ahsan	Queensland University of Technology (QUT)	Australia	Sensors
H. Wang	Queensland University of Technology (QUT)	Australia	Solar Energy
E. Traversa	National Institute for Materials Science (NIMS)	Japan	Environmental Materials

SOCIAL ACTIVITY
Wine tour to Mt Tambourine 15th September 2011.

CONFERENCE OUTCOME

It is difficult to evaluate now the networking outcome of the event, as networking activities will require a few months to produce fruits, however the interaction has been very effective, thanks to the many opportunities offered during the common meals and free time.
I have been informed of Post Doc positions in Australia and overseas offered by some of the lecturers or invited speakers to the PhD students.

Nunzio Motta & Mahnaz Shafiei

2nd International NanoMedicine Conference Coogee Beach Sydney, 14-16th July

The Australian Centre for NanoMedicine (ACN), based at the University of New South Wales (UNSW) was successful in attaining a grant of $5000 from the Australian Nanotechnology Network (ANN) for assistance in a program aimed at encouraging early and mid-career researchers to attend and participate in the 2011 *2nd International NanoMedicine Conference* Coogee Beach Sydney.

ACN was officially established as a research centre at UNSW on 20th July 2011 under the co-directorship of Professor Tom Davis, Professor Justin Gooding and Professor Maria Kavallaris. ACN is a multi-disciplinary research centre incorporating researchers from UNSWs Faculties of Engineering, Science and Medicine. ACN has two key aims, first and foremost as a research centre dedicated to finding solutions to provide a better way of life for those in our population afflicted with hard to treat diseases; and second to work with a diversity of stakeholder groups to communicate research findings and be an Australian hub for nanomedicine discussion and commentary.

Both of these aims are central to ACN hosting the *2nd International NanoMedicine Conference* from July 14 to 16 2011 at Coogee Beach Sydney. 200 attendees representing over 25 invited speakers, 30 posters and ten nationalities discussed their research under the headings of targeted delivery, diagnostics, imaging, sensing, nanosafety, regenerative medicine and a special session on translational medicine.

For the second consecutive year it was ACNs pleasure to bring together the top minds in a discipline that crosses boards incorporating medicine, chemistry, and engineering and truly represents the adage of "bench to bedside", but just as importantly "bedside to bench".

The first of four plenary speakers opened the Conference program, this being Professor Mark Kendall of the Australian Institute of Bioengineering and Nanotechnology (AIBN) with his address on *Nanopatches for Target Vaccine Delivery to Skin: Improving Vaccines*. Three more outstanding plenary sessions continued including Professor Calum Drummond CSIRO's Group Executive, Manufacturing, Materials and Minerals; Professor Ian Frazer Chief Executive Officer and Director of Research at the Translational Research Institute (TRI) Pty Ltd; and Professor Justin Gooding of the Australian Centre for NanoMedicine UNSW. It was a deliberate decision that the plenary speakers showcased the very best of Australian nanomedicine research and researchers. But certainly international participants were heavily represented in our invited speaker including in a special session highlighting up and coming Early and Mid-Career Researchers (EMCR).

This group of EMCR researchers included:

1. Dr Nicolay Tsarevsky, Southern Methodist University USA – *"Functional (Bio)degradable Polymers with Disulfide Groups for Drug Delivery"*
2. Dr Julien Nicolas, University of Paris Sud France – *"Advanced Poly(alkyl Cyanoacrylate) Nanoparticles for Cell Imaging and Against Alzheimer's Disease"*
3. Dr Sidi Bencherif, Harvard University USA – *"Injectable Preformed Scaffolds for Biomedical Applications"*
4. Dr Peter Wich, University of California Berkeley, USA – "*Destran Based Particle Systems as Multifunctional Delivery Vechicles"*

5. Dr Cecile Nouvel, Nancy University France – *"Nanoparticles Obtained by Miniemulsion AGET ATRP from Destran Inisurfs"*
6. ***Dr Simon Corrie Australian Institute of Bioengineering and Nanotechnology Australia – "***
7. ***Dr Joshua McCarroll, Children's Cancer Institute Australia –*** *"Development of RNAi Delivery Agents for the Treatment of Non-Small Cell Lung Cancer"*
8. ***Dr Angus Johnston, The University of Melbourne Australia*** *"Targeted Delivery of Encapsulated Therapeutics using nanoegineered Capsules"*
9. ***Dr Kristofer Thurecht, The University of Queensland Australia –*** *"Polymeric^{19} F Molecular Imaging Agents – Targeted MRI In Vivo"*
10. **Jason Deng, The University of Queensland – "**
11. ***Dr Tony Aitchison, Flinders University Australia***
12. ***Kisha Roy, Deakin University Australia –*** *"Chitosan based novel anti-cancer nanoformulation"*
13. ***Rasika Samarasinghe, Deakin University Australia*** *_"A Prospective Nano Formulated Answer to the Inflammatory and Degenerative Dilemma Involved in Arthritis"*
14. **Nathan Boase, The University of Queensland – "***Detailed Characterisation of the Thermal Transitions of a Series of Novel Thermo-responsive Copolymers"*
15. **Adrian Sulistio, The University of Melbourne**
16. Dr Megan Lord, The University of New South Wales Australia – *"Molecular Interactions between Cells and Surface Nanotopography and Chemistry: Towards Biomimetics for Vascular Applications"*
17. Dr Cyrille Boyer, The Australian Centre for NanoMedicine Australia – *"New Biodegradable Polymer Star Structures for Dual PET Imaging and Drug Delivery: Design of PET Imaging Modality"*.
18. Dr Helder Marcal, The Australian Centre for NanoMedicine Australia – *"Tissue Repair and Regeneration"*
19. Dr Hien Duong, The Australian Centre for NanoMedicine Australia – *"Micelles: NO Delivery"*

EMCRs including Nicolay Tsarevsky, Sidi Bencherif, Cyrille Boyer, Peter Wich and Julien Nicolas

(names above in bold represent those individuals ACN provided assistance towards their attendance). In total 10 EMCRs were assisted in attending this conference with the provision of $500 towards airfares, accommodation or registration.

A full house at the 2nd International NanoMedicine Conference with Prof Ian Frazer addressing the audience on translational medicine

a central part of the NanoMedicine conference is a social program that encourages the building of cross disciplinary and cross institutional relations. The conference dinner on the final night saw the much awaited outcomes of oral and poster prizes which were announced by the NSWs Chief Scientist and Chief Engineer Professor Mary O'Kane.

Professor O'Kane's Department, The NSW Department of Trade and Investment hosted the prizes which included:

- Trade and Investment Early Career Researcher for Excellence in NanoMedicine Research – Oral: Dr Cindy Gunawan, The University of New South Wales
- Trade and Investment Early Career Researcher for Excellent in NanoMedicine Research – Poster: Dr Seet Ruj Simon Ting, The University of New South Wales

- Trade and Investment PhD Award for Excellence in NanoMedicine Research - oral: Mr Shawn Stapleton, University of Toronto
- Trade and Investment PhD Award for Excellence in NanoMedicine Research - poster: Mr Kisha Roy, Deakin University

The Children's Cancer Institute Australia (CCIA) awarded further honourable mention prizes which were presented by CCIA's head of the Tumour Biology and Targeting Program, Professor Maria Kavallaris. Winners were:

- CCIA Honourable mention prize for Early Career Researcher – Oral: Dr Hien Doung, Australian Centre for NanoMedicine
- CCIA Honourable mention prize for Early Career Researcher – Poster: Dr Mariana Beija, The University of New South Wales
- CCIA Honourable mention prize for PhD student – Oral: Mr Denison Chang, The University of Melbourne
- CCIA Honourable mention prize for PhD student – Poster: Mr Zhou (Jason) Deng, The University of Queensland

Great Research at a Great Location. Coogee Beach is the home of ACNs annual International NanoMedicine Conference

Jagat Kanwar (Deakin University).

The dinner marked the end to three great days of discussion, which will all commence again in July 2-4 2012. But the 2011 conference lives on through the special *Research Front* of the *Australian Journal of Chemistry* comprises selection of papers that epitomizes the current sentiments in the emerging field. The seven papers included come from attendees at the July 2011 conference – Niclay Tsarevsky (Southern Methodist University USA); Peter Wich (University of California Berkeley USA) Hans Griesser (Ian Walk Institute University of South Australia); John Hayball (University of South Australia) Neil Foster (The University of New South Wales); Mariusz Skwarczynski (The University of Queensland) and

What ACN is most pleased about is that we now scan through newspapers and news programs where virtually daily we hear or read about advances in the treatment of diseases, especially those diseases that may have meant a life sentence just a few years back. Today our cutting edge research has enormous potential to influence future clinical care, especially for patients with cancer, diabetes, cardiovascular diseases, multiple sclerosis, Alzheimer's and Parkinson's disease and inflammatory and/or infectious diseases. What is most exciting is that often the researchers' names are Australian researchers working in some of the world's best research institutions and facilities. Undoubtedly Australia's work in medical research, including in NanoMedicine, is world class.

The ACN thanks the Australian Nanotechnology Network for allowing us to provide financial support to some of the attending EMCR. We are delighted that through the funds provided we were able to attract a large number of young scientists that may not have been able to afford to attend this conference.
In summary, the ACN provides the following summarised details on the 2nd International NanoMedicine Conference:

ANN Selection Criteria that will be used to evaluate all Event applications

1. **Broader benefit to the Australian nanotechnology community**
   There is a global unmet need to cure and prevent diseases for which we currently lack efficient treatments and which cause suffering and a shortened life expectancy. The ageing population, the

high expectations for improved life quality and the changing lifestyle also call for improved, more efficient and affordable healthcare.

NanoMedicine, the application of nanotechnology in health care, offers numerous promising possibilities to significant improve medical diagnosis and therapy, ultimately leading to higher standards of living. Furthermore, nanomedicine is an important strategic issue for sustainable competitiveness in Australia. The global competition in the field is very strong and the strategic importance of nanomedicine is being increasingly recognised by industry and government around the world.

Australia is facing strategic challenges in the field of health due to issues such as an ageing population, negative environmental effects on personal health and a demand for improved personal healthcare

Healthcare expenditures presently account for 10% of gross domestic product (GDP) in industrialised countries and are expected to grow at an average of 6% pa in the future. Nanomedicine offers numerous promising possibilities to significantly improve medical diagnosis and therapy and the field thus has a large potential for developing public welfare and economic growth. There is a large industrial enthusiasm for nanomedicine, with the US National Science Foundation has estimated that by 2015 half of the world's pharmaceutical industry products will be made with nanotechnology, and that the contribution of products incorporating nanotechnology to the global economy will be around $1 trillion

2. **Event organised by ANN members, and the level of involvement of ANN members**

The 2nd International NanoMedicine Conference was fully organised by the Australian Centre for NanoMedicine, it being a member of the ANN. A review of the ANN database highlights that a significant number of ANN members attended the conference.

3. **Size of Event - anticipated number of attendees (number of students, number of ECR's); anticipated number of international attendees**

The conference attracted some 200 attendees representing over 25 invited speakers, 30 posters and ten nationalities discussed their research under the headings of targeted delivery, diagnostics, imaging, sensing, nanosafety, regenerative medicine and a special session on translational medicine.

4. **Quality of invited speakers**

Four plenary speakers led the program these being:

- Professor Mark Kendall, AIBN, University of Queensland
- Professor Ian Frazer, Translational Research Institute
- Professor Calum Drummond, CSIRO Materials Science and Engineering
- Professor Justin Gooding, Australian Centre for NanoMedicine, The University of New South Wales

5. **Availability of invited speakers to give talks in other parts of Australia as ANN Distinguished Lecturer(s)**

Not Applicable

6. **Level of reduced or no registration cost for Students and Early Career Researchers**

Ten EMCRs were provided subsidies to the value of $500 each

7. **Level and quality of nanotechnologies component in the technical program**

This conference was dedicated to nanotechnology and ensured the involvement of researchers, clinicians and industry.

8. **Funding support already gained from other sources**

Sponsors (financial and in-kind) included:
Sigma Aldrich, NSW Department of Trade and Investment, CAMD, UNSW Engineering
Shelston IP, Grace Davison Discovery Sciences, Davies Collison Cave, Therapeutic Innovation Australia, Australian Nanotechnology Network,Children's Cancer Institute Australia
Australian Microscopy and Microanalysis Research Facility, NSW Stem Cell Network

Yours sincerely,
Conference Chairs:
Professor Tom Davis and Professor Maria Kavallaris

Materials and Complexity V111 Workshop, 13-16th December 2011- Kioloa Campus (NSW coast)

REPORT
Registered delegates: 40 including 11 students and 13 ECRs

Invited speakers:
Prof. Norm Morrow, University of Wyoming,
Prof. Phil Evans, University of British Columbia,
Dr Drew Evans, University of South Australia,
Dr Dave Dunstan, University of Melbourne,
Dr Mahyar Madadi, Curtin University,
Dr Linnéa Andersson, Oregon State University,
Dr Shannon Notely, Swinburne University,
Dr Toen Castle, Arrhenius Laboratory, Sweden,
Xuehua Zhang, Melbourne University,
Sara Olsson, SP Technical Research Institute of Sweden/KTH.

Summary:
The Materials and Complexity annual workshop series have been held since 2001.
The aim of the workshop is to bring together researchers and students working across a wide range of discipline in order to facilitate collaboration between research fields.
This year it took place between 13th-16th of December 2011 at the ANU's Costal Campus at Kioloa. As in previous years, the theme for the workshop was centered on the "Materials and Complexity". The Department of Applied Mathematics at ANU hosted the workshop, which was organised this year by Dr. Mohammad Saadatfar.

The participants arrived at Kioloa around noon on December 13th, and the first talks commenced shortly after. A great variety of lectures, with topics such as wood corrosion, climate change, high-performance computing, Graphene and design of complex materials structures were discussed throughout the workshop. We had 40 scientists participating in the event, among them 11 students and 13 ECR's. The participants included representatives from 4 Australian Universities as well as 5 universities outside Australia.

The talks covered computational, theoretical and experimental research, with a main focus on the following areas:
Complexity studies, Soft Matter and nanorheology, Nanobubbles, Surfactants, polymers and Liquid crystals 3D Characterisation of materials' microstructure, Granular materials and Imaging of complex objects from nano- to the meter-scale.

We were fortunate to gather quite a few prominent researchers on these topics from around the world, ensuring that the discussions following each session were fuelled by ideas from the forefront of materials science research. Sessions were chaired by students, ECRs or senior scientists of the host department (Dept. of Applied Mathematics, ANU).

Funding and funding distribution:
The sponsorship of $5000 from ANN allowed us to reduce the registration fee for students to $200 and for ECRs to $450.

WEBSITE

NANOTECHNOLOGY FACILITIES AND CAPABILITIES REGISTER

NEWSLETTER

MEMBERSHIP

NanoQ Magazine

PLANNED 2012 ACTIVITIES

WEBSITE

http://www.ausnano.net

The ANN Website is a very popular website and as at the end of 2011 it received more that 3,500,000 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.

NANOTECHNOLOGY FACILITIES AND CAPABILITIES REGISTER

The Nanotechnology Facilities and Capabilities Register was established at the end of 2006 and the list of registered facilities and their capabilities can be accessed on the following page http://www.ausnano.net/index.php?page=facilities
Members and visitors to the site are able to access specific nanotechnology facilities and expertise that is available across Australia.

NEWSLETTER

A newsletter which is sent to all members is another means of communication that ANN uses as an information management tool. The newsletter is sent out every six months and details information and events held in the field on Nanotechnology in Australia. Newsflashes are released in between newsletters to make members aware of events with a short deadline.

NanoQ (Nano Quest Magazine)

The purpose of this magazine is to highlight resent developments in the field of Nanotechnology in Australia and also to provide information of interest to policy makers and the public.
Two editions were published in 2011 and these issues was distributed to several schools.Copies can be accessed on the ANN website.
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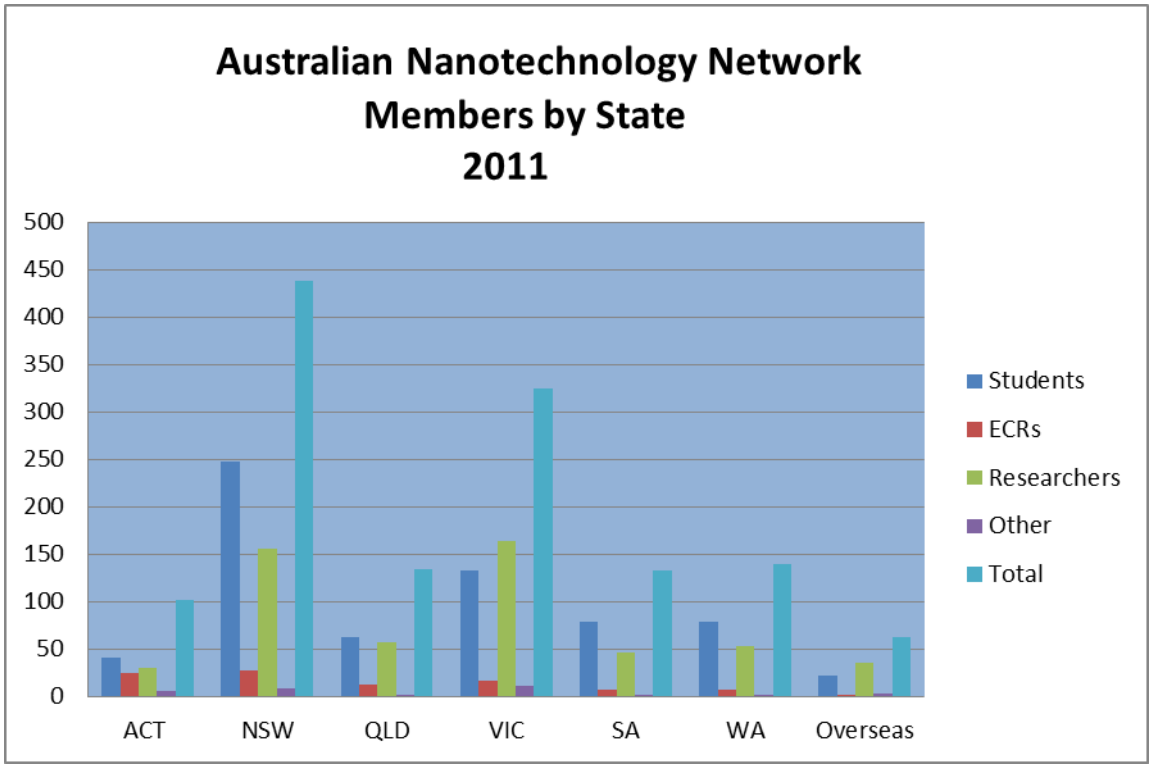
MEMBERSHIP

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 business.

The following is a chart representing ANN members per state for 2011.



	Students	ECRs	Researchers	Other	Total
ACT	41	24	30	6	101
NSW	248	27	155	8	438
QLD	63	13	57	1	134
VIC	133	16	164	11	324
SA	79	7	46	1	133
WA	78	7	53	1	139
Overseas	22	2	36	3	63
					1332

PLANNED 2012 ACTIVITIES

The Australian Nanotechnology Network (ANN) plans to continue funding Workshops, Conferences, Forums, encouraging and supporting participants in getting together and networking for the growth in the research of Nanotechnology in Australia.

The management committee has also been involved in preparing for the

- **International Conference on Nanoscience and Nanotechnology 2012(ICONN)** which will be held at the Perth Convention Centre during 5th - 9th of February 2012 which is shaping up to be as outstanding as the previous three conferences. This will be co-located with the 10th Asia-Pacific Microscopy Conference (APMC 10), and the 22nd Australian Conference on Microscopy and Microanalysis (ACMM 22)

There will be a continuation of the successful Overseas Travel Fellowships, Short and Long Term visits and Young Nanoscience Ambassador Awards. To encourage collaborations among its members the Following Events are planned:

2nd Workshop on Dynamics & Control of Micro and Nanoscale Systems
23/02/2012 - 24/02/2012 - The University of Newcastle

NT12Thirteenth International Conference on the Science and Application of Nanotubes
24/06/2012 - 29/06/2012 - Brisbane Convention & Exhibition Centre

OZCarbon 2012
01/07/2012 - 03/07/2012 - Ingkarni Wardli, the new Faculty of Engineering, Mathematical and Computer Sciences building,The University of Adelaide

3rd International NanoMedicine Conference
02/07/2012 - 04/07/2012 - Coogee Beach,

4th WUN International Conference on Spintronics
23/07/2012 - 25/07/2012 - The University of Sydney

International Conference on BioNano Innovation
18/07/2012 - 20/07/2012 - Brisbane Convention & Exhibition Centre

International Organic Excitonic Solar Cells Conference
03/09/2012 - 07/09/2012 - Coolum Beach, Queensland

3rd Asia-Pacific Symposium on Nanobionics
19/09/2012 - 21/09/2012 - Innovation Campus, North Wollongong, NSW

International Workshop on the risk assessment of manufactured Nanomaterials
08/10/2012 - 09/10/2012 - Mawson Lakes Campus of the University of South Australia

ICEAN-2012: International Conference on Emerging Advanced Nanomaterials
22/10/2012 - 25/10/2012 - Mercure Hotel - Brisbane

Appendix A – ICONN 2012 Poster