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The Australian National Fabrication Facility (ANFF) and the Australian Microscopy and Microanalysis Research Facility (AMMRF), in conjunction with our proud sponsors, present two days of research highlights from within the facilities, and invite you to join us for a celebratory dinner cruise on beautiful Sydney Harbour.

Abstracts

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Integrated Energy Storage for the Internet of Things

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The expanding scope of the Internet of Things will require delocalized, miniaturized energy sources, integratable with silicon technologies and offering high reliability. The miniaturization of power sources is particularly challenging, given the need for large energy storage volumes and the need for materials generally not compatible with semiconductor technology. Current silicon-based miniaturized devices need a stand-alone energy source, such as Li-ion battery for continuous powering. The silicon technology is yet to develop seamlessly integrated energy storage which can be integrated in silicon-in-package systems.

We have pioneered a unique approach to obtaining supercapacitors on silicon using graphene electrodes directly obtained and patterned at the wafer -scale. The devices show a double-layer capacitance with high cyclability, with both aqueous and solid-state electrolytes. By using the self -aligned (maskless) capability offered by our solid carbon source synthesis of graphene [4], 2D and 3D interdigitated electrodes can be easily achieved at the wafer -level (Figure 2) for obtaining planar supercapacitors. This approach can pave the way towards miniaturized and reliable energy sources in SiP systems. Current challenges include the recognized leakage phenomena at the SiC/silicon interface [5].

Bio

Prof.Francesca Iacopi received her MSc in Physics from Roma I University, Italy (1996), and her PhD in E.E./Materials Science from the Katholieke Universiteit Leuven, Belgium (2004). Materials Scientist and Nanoelectronics expert with nearly 20 years' experience in semiconductor Industry and Academia, she is author of over 120 peer-reviewed publications and holder of 8 granted patents. Her research emphasis is in the translation of basic scientific advances in nanomaterials and novel device concepts into industrial processes. In particular, her seminal work on low-k dielectrics for interconnects over the 1999-2009 decade has guided the industrial uptake of porous dielectrics into modern semiconductor microchips. She is Professor of Electronics in the Faculty of Engineering & IT, and leader of the Integrated Nano Systems (INSys) Lab, with focus on applications for the Internet of Things. She is a Fellow of the Institution of Engineers Australia and Senior Member of IEEE.

Microwave-assisted synthesis of few-layer black phosphorus and its application in SWCNT-Si solar cells

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High-quality, few-layer black phosphorus (FL-BP) flakes have been prepared in a common organic solvent (N-methyl-2-pyrrolidone (NMP)) with very short processing times using microwave-assisted liquid-phase exfoliation. A comprehensive range of analysis, combined with density-functional theory calculations, confirmed that the product prepared using the microwave technique is few-layer phosphorene with small- and large- area flakes. As a proof of concept, our FL-BP sheets have been introduced into carbon nanotube-silicon (CNTs-Si) based heterojunction solar cells (HJSCs) for the first time. The NMP based FL-BP sheets remain stable after mixing with aqueous CNT dispersion for device fabrication. Due to their unique two-dimensional (2D) structure and *p*-type dominated conduction, the FL-BP/NMP incorporated CNT-Si devices showed an impressive improvement in the power conversion efficiency from 7.52% (control CNT-Si cell) to 9.37%. Our density-functional theory (DFT) calculation revealed that lowest unoccupied molecular orbital (LUMO) of FL-BP is higher in energy than that of SWCNT. Therefore we observed a reduction in the orbitals localized on FL-BP upon highest occupied molecular orbital (HOMO) to LUMO transition, which corresponds to an improved charge transport. This study opens a new avenue in utilizing 2D phosphorene nanosheets for next-generation PVs.

Bio

Munkhbayar Batmunkh completed his Ph.D. study at the University of Adelaide, Australia in 2017. He received his B.Sc. and M.E. from the National University of Mongolia, Mongolia in 2010 and Gyeongsang National University, South Korea in 2012, respectively. Upon submission of his Ph.D. thesis, he has been immediately appointed as a postdoctoral researcher in Prof. Joe Shapter's group at the Flinders University of South Australia. His research interests involve the synthesis and modification of nanostructured materials such as carbon nanomaterials, 2D materials and novel nanofunctional materials for emerging photovoltaic application including perovskite solar cells, dye-sensitized solar cells and nanocarbon-silicon solar cells.

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5. Batmunkh et al. *Advanced Science*, **2017**, 4, 1600504.

Back-Contact Perovskite Solar Cells

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Back-contact concepts are well established in the field of silicon solar cells, where their implementation has resulted in significant efficiency gains, compared to conventional contacting architectures. Charge collection in these devices is typically facilitated by a set of two interdigitated finger electrode arrays, co-located on the backside of the silicon wafer. Here we describe the fabrication and study of back-contact perovskite solar cells (bc-PSCs) with novel contact geometries. The main advantage of back-contact concepts is that optical transmission losses can be avoided, arising from the top charge collection electrode, which for PSCs typically is a thin conducting oxide (TCO) layer. The back-contact design furthermore provides the opportunity to study the influence of post-processing treatments on device efficiency in situ. To demonstrate this we study the evolution of bc-PSCs performance during their exposure to pyridine vapors. Furthermore we report a novel photovoltaic device concept based on a gold-perovskite-gold Schottky-junction bc-PSCs in which the work-function of the gold electrodes is controlled by the presence of self-assembled molecular monolayers (SAM). We provide evidence of the successful workfunction tuning by means of Kelvin probe microscopy while also presenting the photovoltaic performance date of these devices. We show that the presence of these SAMs can produce photovoltages of up to 600 mV and photocurrents in excess of 12 mA/cm^2 under simulated sunlight, despite a large center-to-center electrode spacing of 6.5 µm.

Efficient organic photovoltaic cells on a single layer graphene transparent conductive electrode using MoOx as an interfacial layer

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The large surface roughness, low work function and high cost of transparent electrodes using multilayer graphene films can limit their application in organic photovoltaic (OPV) cells. Here, we use single layer graphene (SLG) films as transparent anodes for OPV cells that contain light-absorbing layers comprised of the evaporable molecular organic semiconductor materials, zinc phthalocyanine (ZnPc)/fullerene (C60), as well as a molybdenum oxide (MoOx) interfacial layer. In addition to an increase in the optical transmittance, the SLG anodes had a significant decrease in surface roughness compared to two and four layer graphene (TLG and FLG) anodes fabricated by multiple transfer and stacking of SLGs. Importantly, the introduction of a MoOx interfacial layer not only reduced the energy barrier between the graphene anode and the active layer, but also decreased the resistance of the SLG by nearly ten times. The OPV cells with the structure of polyethylene terephthalate/SLG/MoOx/CuI/ZnPc/C60/bathocuproine/Al were flexible, and had a power conversion efficiency of up to 0.84%, which was only 17.6% lower than the devices with an equivalent structure but prepared on commercial indium tin oxide anodes. Furthermore, the devices with the SLG anode were 50% and 86.7% higher in efficiency than the cells with the TLG and FLG anodes. These results show the potential of SLG electrodes for flexible and wearable OPV cells as well as other organic optoelectronic devices.

Bio

Dr. Hui Jin is an Australian Centre for Advanced Photovoltaics supported Postdoctoral Research Fellow at the Centre for Organic Photonics & Electronics (COPE), The University of Queensland. Dr Jin obtained her B.A., M.A. and PhD degree from Beijing Jiaotong University, China. From 2008 to 2010 Dr Jin carried out her Postdoctoral training in VTT Technical Research Centre of Finland, working on printable intelligent optoelectronics. In 2010, Dr Jin joined COPE as a research fellow to work on the device physics of organic solar cells.

Growth of Highly Boron-doped Diamond: Towards Superconductivity

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Boron doped diamond exhibits a range of electrical characteristics as a function of the boron concentration. It has already been shown [1,2] that if the boron concentration exceeds the metal-insulator transition concentration this p-type semiconductor becomes superconducting at liquid helium temperatures.

Fig. 1 (left) 3x3 mm <100> diamond substrate at the centre of the susceptor surrounded by the CVD plasma during growth. (right) Different sizes of pedestals that were used during the growths. Sizes ranges from ~24mm to 4.30mm.

Here we report local explorations of this material, using the diamond deposition tool at the Melbourne Centre for Nanofabrication. The plasma was formed from gas feeds of Trimethylborane(TMB), methane and hydrogen and using this we grew a range of highly boron doped diamond epitaxial layers with boron concentration over a wide range from $10^{18} B/cm^3$ to $10^{21} B/cm^3$ on optical-grade diamond <100> surfaces (see Fig 1). Here we report the investigation of grown diamonds with a range of different plasma parameters during the growth, including B/C ratio in gas phase, pressure of the chamber, size of the pedestal that confines the plasma, total gas flow rate and percentage ratio of methane in hydrogen. We have successfully grown superconducting boron-doped diamond films with a critical temperature at 1.4K, and discuss the outlook for improvements in this value with further growth modifications.

Presented analysis will include: comparisons of the Raman peak at 500 cm^-1 shift, arising due to Boron incorporation into diamond, broadening and relative intensity of zone centre phonon peak; secondary ion mass spectrometry to characterise the Boron concentration; Hall effect measurement for electrical characterisation; and the effect of buffer layer processes which help to relax the crystal lattice; as well as post-growth annealing studies on electronic properties.

Acknowledgements

This work has been supported by the Australian Research Council grant DP150102703 and the US Air Force Office of Scientific Research under contract FA2386-15- 1-4039. The secondary ion mass spectroscopy measurements were performed at University of Western Sydney. Boron-doped diamond samples were grown at Melbourne Centre of Nanofabrication, which is supported by Australian National Fabrication Facility.

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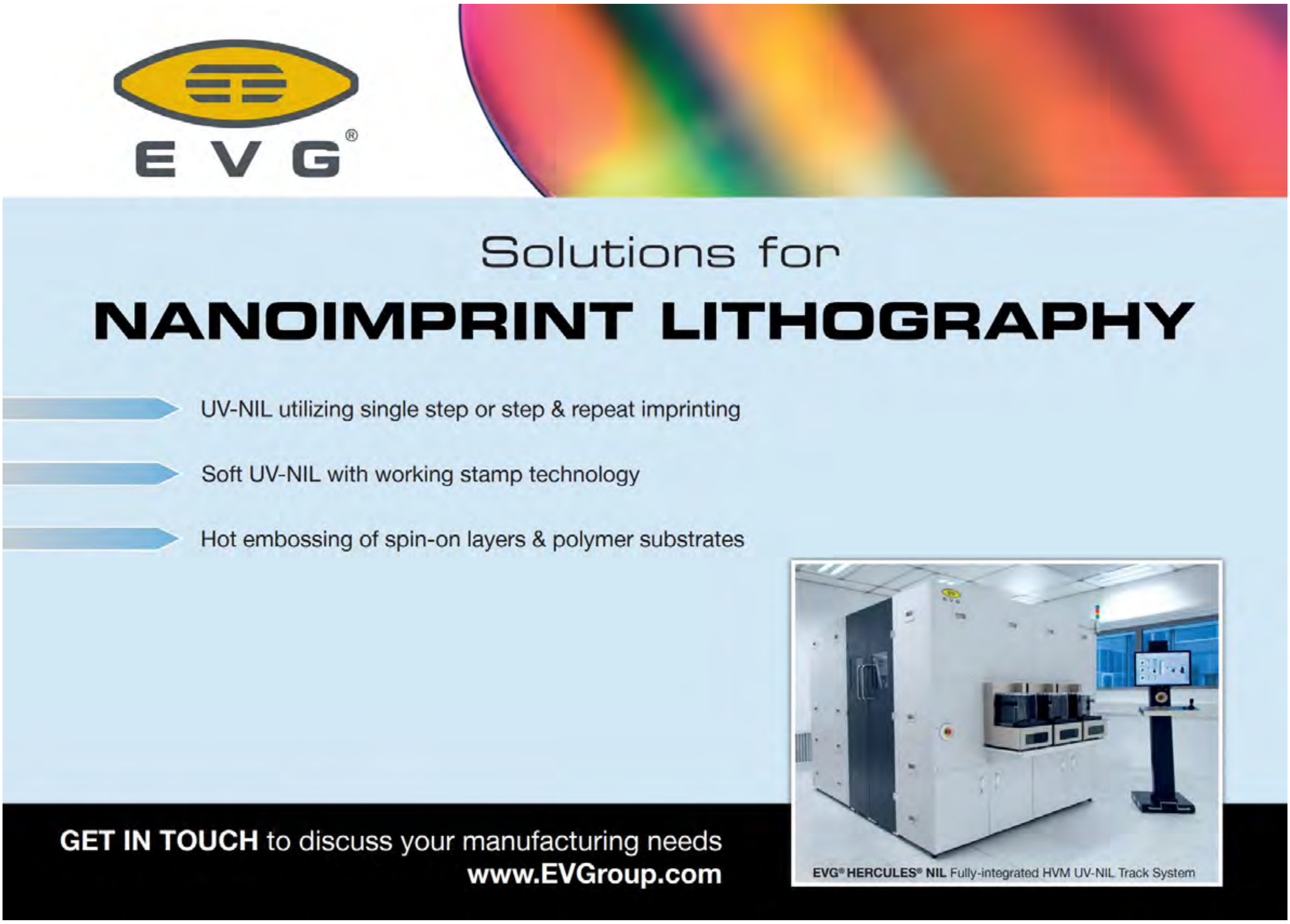
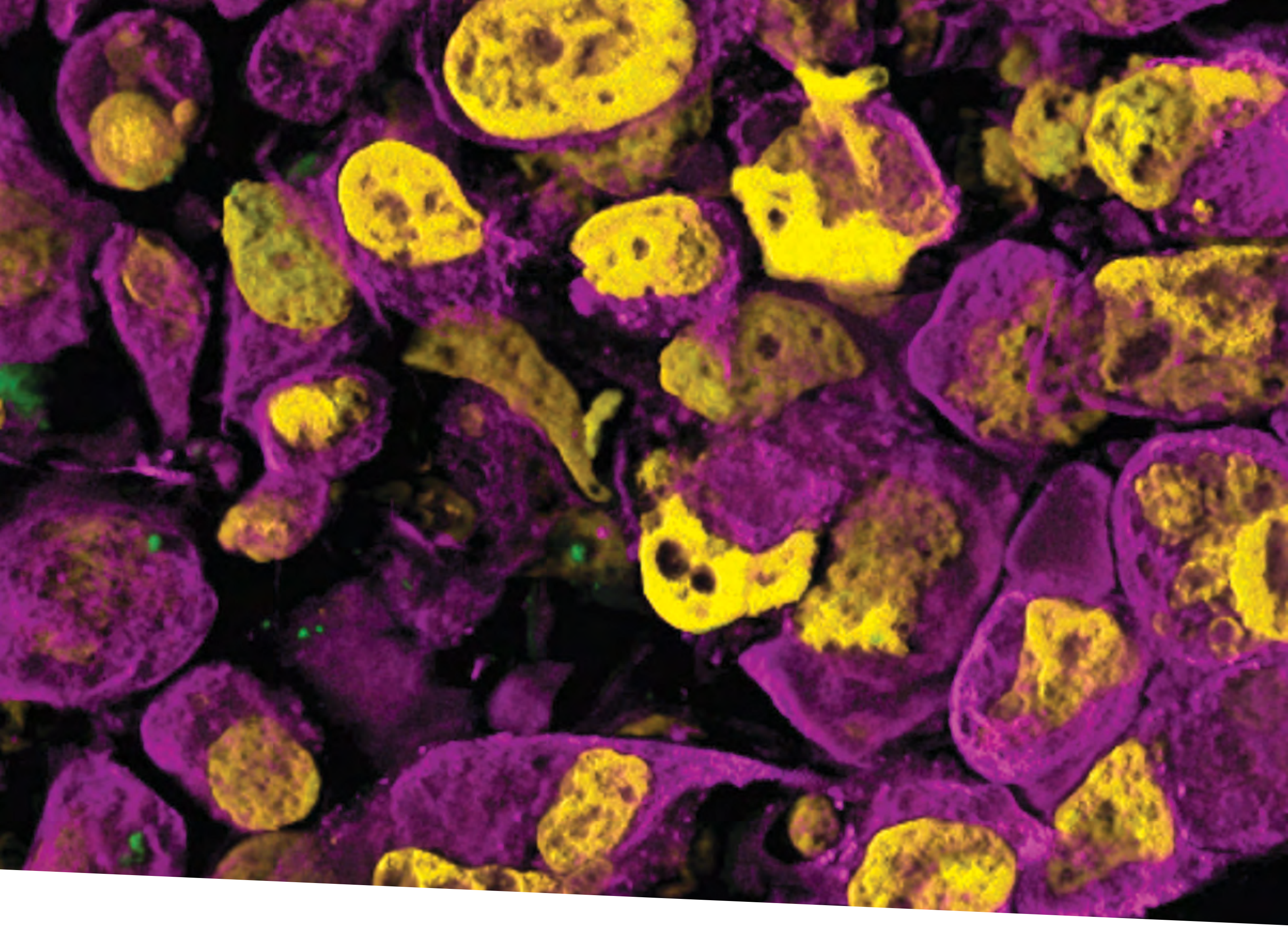
[2] Takano, Y., Superconductivity in CVD diamond films. Journal of Physics-Condensed Matter, 2009. **21**(25): p. 11.

Bio

Yi Jiang is a Master student in Physics working on superconducting boron-doped diamond. She started her Master degree since 2016 with Prof. David Jamieson, who has given her advices on the general view of her research project, broadened her view on experimental condensed matter physics. She started fabricating diamond at MCN with Dr. Alastair Stacey, who taught her from scratch the fabrication techniques, plasma conditions and ways to look at the quality of the diamond, also leaded her through the growth aspect of her Master research project.





An Advanced Drug Delivery Platform: Nanotopography Matters

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Affiliations

Australian Institute for Bioengineering and Nanotechnology, The University of Queensland

Recent advances in nanotechnology has greatly boosted the development of drug delivery systems, while the key challenge still lies in the rational design and fabrication of safe and efficient nano-carries. Herein, we showcase our recent progress in the development of silica based delivery platform. Through a biomimetic approach, silica nanopollens with an intrinsic spiky surface are fabricated. The nanoscale surface roughness enables the nanoparticles with strong adhesion towards the hairy bacterial surface, leading to an efficient antimicrobial enzyme delivery. This delivery system is extended to gene molecule delivery. Distinct from small drug or protein molecules, pDNA possesses unique rope-like (2-3 nm in width) loop structures with an average loop size around 50 nm and an overall length of several micrometres. We demonstrate that control over delicate nanotopography of silica nanoparticles as plasmid DNA vectors has significant impact on the transfection efficacy. For silica nanoparticles comprised of spike, hemisphere and bowl type subunit nanotopographies, the rambutan nanoparticles with spiky surfaces demonstrate the highest plasmid DNA binding capability and transfection efficacy. Moreover, the surface spikes of rambutan nanoparticles act as hooks to entangle the DNA loops and protect the gene molecules sheltered in the spiky layer against nuclease degradation. This delivery platform has potential to be translated into antibiotic-free animal feed and DNA vaccines.

Bio

Professor Chengzhong (Michael) Yu is a chemist and materials scientist. His research interests focus on rational designed nanomaterials for various applications. He has published over 250 peer-reviewed journal articles with citation over 15,000 times and an H-index of 61. Since 2010, he has attracted over 9 M A$ grants from the Australian Research Council (ARC), the Cancer Council of Queensland, Diabetes Australia, Queensland Government and industry partners. He has developed broad industrial collaborations to extend the applications of functional materials in a real world. He has received several awards including the Le Févre Memorial Prize from the Australian Academy of Science, the ARC Future Fellowship.

Correlative Electron Microscopy and NanoSIMS Imaging for Lipid Studies

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Lipids are essential molecules in organisms. They are critical components of membrane structures and also important sources for energy and carbon, and play critical roles in signalling pathways. Abnormalities in lipid metabolism can also lead to severe health conditions. However, our understandings of lipids are very limited. There are many factors limiting the progressing of lipid studies, and one of the most important ones is the lack of powerful techniques. Current lipid research has mostly relied on conventional biochemical or biophysical techniques. While these approaches have yielded key insights, most of the time the information regarding subcellular compartments and different cell types is lost.

There have been significant developments of lipid visualisation and quantification using secondary ion mass spectrometry (SIMS). The NanoSIMS, as a SIMS technique, allows high-resolution imaging of stable isotope labelled lipids. Using correlative electron microscopy and NanoSIMS imaging, one can track lipids at specific subcellular organelles with up to 50 nm lateral resolution [1]. This presentation will discuss our two recent lipid studies using the correlative method: (A) investigation of how the lipid products of triglyceride-rich lipoprotein processing move across capillary endothelial cells towards parenchymal cells [2]; and (B) development of a new probe, ^{15}N-ALOD4, for high-resolution visualisation and quantification of cholesterol, and its application in studying cellular cholesterol efflux mechanisms [3].

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Black silicon: bacteria busting surface

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Cellular interactions with nanostructured surfaces are the focus of intensive research. While it is well-established that the control of the surface topography on the micro-nano scale plays a vital role in determining the degree of bacterial attachment, it has been only recently realised that surfaces with specific nanotopographies are efficient at killing bacteria through a mechano-bactericidal action. We have previously reported on the bactericidal efficiency of natural surfaces such as cicada and dragonfly wings, towards the common human pathogens, *Pseudomonas aeruginosa* and *Staphylococcus aureus* and introduced the first synthetic analoque of such surfaces, black silicon.

In this study, we investigated four types of black silicon surfaces, fabricated by reactive ion etching, to review the relationship between surface nano-topography and bactericidal efficiency. The efficiency by which bacterial cells are ruptured on a nanostructured surface is governed by the nanoparameters of the surface. 'Tuning' of these parameters allows for greater control over bactericidal efficiency and the ability to target a wider range of bacterial species and bacterial spores. In doing so, we quantitatively relate bactericidal efficiency to the density, height and the inter-pillar distance of the nano-pillars, which then can be utilized in further understanding the underlying mechanisms of bactericidal activity. This data provides useful insights into the design and fabrication of mechano-responsive antibacterial surfaces.

Bio

Denver Linklater is a second year PhD candidate at Swinburne University of Technology. Her research involves the fabrication of nanostructured surfaces for biomedical applications and studying bacterial cell-surface interactions.

Delivery of Biomolecules into Mammalian Cells through VA-SiNW Arrays

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The interface between nanotechnology and life sciences is one of the fastest growing and most promising areas of material science. My project focuses on the engineering of vertically aligned silicon nanowire (VA-SiNW) arrays for the development of next-generation biodevices. VA-SiNWs have been used in intracellular delivery of a variety of biomolecules, including DNAs, RNAs, peptides and proteins, into mammalian cells. However, the interface between VA-SiNW and different types of cells, especially immune cells, remains elusive. Here, we investigated VA-SiNWs, with different geometrics, for their ability in influencing cellular adhesion, viability, morphology, migration, proliferation, and differentiation during short-term (1 hr) or long-term culture (1 day). It showed that VA-SiNW induced cell attachment while causing minimal toxicity to both adherent fibroblasts and suspension immune cells during short-term (1 hr) culture, whereas suspension immune cells exhibited a significant lower viability than adherent fibroblasts after 1 day culture. Interestingly, it was evident that blunt nanowire (diameter ~300nm) was more suitable for adherent fibroblast adhesion than sharper ones (diameter <100nm). Confocal, SEM and FIB images further confirmed the penetration of nanowires into nucleus. In addition, I also assessed the transfection efficiency of plasmid DNAs into immune cells utilising VA-SiNWs. Within 2 hr culture, cells were able to land onto the NWs and uptake coated plasmid DNAs, indicated by the reporter gene GFP expression 1 day after cell detachment from NWs. This study provides a novel bio-platform for various gene editing and modification, paving the way for the application of a safer and high-throughput nanotechnology into therapeutic interventions in treating numerous diseases and cancers.

Bio

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Research interests: nanowire, nanoneedle, biomaterial, gene modification, immunotherapy

Metal Microcapsules For Actively Triggered Localised Drug Delivery

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Until recently, small, volatile actives could not be efficiently encapsulated for timescales longer than a few days, due to the inherent porosity of the polymeric membranes used as the capsule shell material. Using electroless deposition of metals, we have developed a method for preventing undesired loss of encapsulated actives.[1] Metal nanoparticles are used to stabilise o/w emulsions, and these nanoparticles subsequently act as catalysts for the electroless deposition of a continuous gold shell.
An exciting application of these metal microcapsules could improve the prognosis of patients with high grade glioma, providing an alternative, more effective treatment to those currently available. Typical treatment of brain tumours involves surgical removal of the majority of the tumour, followed by radiotherapy and chemotherapy. Unfortunately, recurrence is common, often resulting in patient mortality.
The localised delivery of chemotherapy drugs using biodegradable wafers implanted into the resection cavity has demonstrated a modest improvement in survival in patients with both recurrent and newly-diagnosed glioma. A significant improvement to this approach could be gained by actively triggering drug release at the site of tumour recurrence. We have made considerable progress in the development of metal-shell microcapsules as responsive drug-delivery vehicles. In this way, we can deliver high doses of drug to recurrent tumours in a highly localised, controlled and non-invasive fashion. In this presentation we will demonstrate how these drug-delivery vehicles are characterised using a variety of microscopy techniques.

Bio

Alison Tasker graduated from the University of Bradford (UK) with a Masters (MChem) in Chemistry in 2009, and obtained a PhD in Food Colloids Chemistry at the University of Leeds (2013). She has since held Post-doctoral research positions in the Institute of Particle Science and Engineering (University of Leeds) and The University of Queensland. She also holds a diploma in Cosmetic Science, and is an RSC Chartered Chemist.

Dr Tasker has pioneered research into the use of metal shells to prevent unwanted diffusion of actives from polymeric microcapsules, resulting in 9 patent applications, encompassing two key discoveries. She developed a novel metal-shell microcapsule system, impermeable to small, volatile molecules within the microcapsule core, even in environments which promote diffusion from the core. Her recent work focuses on fundamental aspects of novel metal microcapsules including: polymer microcapsule morphology; metal nanoparticle synthesis/morphology; metal nanoparticles as stabilisers; electroless deposition of metal shells; and mechanical properties of metal shells.

Tuning Nanoscale Surface Roughness and Smoothness of Nanocellulose Film via Spray Coating

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We recently reported a new method to prepare smooth nanocellulose (NC) films [1] by spraying the nanocellulose onto a smooth and polished surface and then allowing the film to dry in air. Spraying has a notable advantage such as contour coating and contactless coating with the base substrate. The basis weight and thickness of the NC film is tailorable by adjusting NC suspension in spraying process. NC film prepared via spray coating has unique two-sided surface roughness with the surface in contact with the surface much smoother than the air-contact side. The surface roughness is one of the controlling parameter in barrier performance of the NC film and alterations in surface roughness switches the wettability. The RMS roughness of the two surfaces investigated by Optical Profilometry was found to be 2087 nm on the rough side and 389 nm on the spray coated side, respectively. The spray coated NC film has ultra-high smoothness on the side exposed to the polished stainless steel surface. The factors including the size of cellulose fibrils and surface smoothness of base surface that control the roughness of the film are currently being investigated and will be discussed in the presentation. The surface smoothness requirements for substrate applications in SERS and printed electronics will also be discussed.

[1] K. Shanmugam, S. Varanasi, G. Garnier, W. Batchelor, Rapid Preparation of smooth nanocellulose films using spray coating, Cellulose, 24 (2017) 2669-2676.

Bio

Warren Batchelor is the Deputy Director of the Bioresource Processing Research Institute of Australia (BioPRIA), part of the Department of Chemical Engineering at Monash University. His major research interest is in the manufacture, characterisation and application of cellulose nanomaterials.

From Automotive Waste to New Industrial Materials

Farshid Pahlevani[†*], Rahul Kumar[†], Narjes Gorjizadeh[†], Rumana Hossain[†], Sagar T Cholake[†], Karen Privat[‡] and Veena Sahajwalla[†]

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This project takes an innovative approach to the challenges of waste management and the need for new industrial materials. Complex industrial waste is not suited to conventional sorting and recycling methods due to its heterogeneous nature; consequently, much of it is ultimately disposed of in landfill. Steels and steel coatings with high abrasion and corrosion resistance are highly valued for industrial applications, but are both expensive and difficult to produce. Here we use complex automotive waste as an input stream in the modification of steel surfaces. Using a precisely controlled high-temperature procedure, a chemically-bonded ceramic surface is formed on normal carbon steel that increases the corrosion and abrasion resistance of the steel. The procedure is economical and can be modified to customise the surface to suit the intended application of the material. This novel methodology addresses industrial demands for durable steel products while also reducing the amount of industrial waste that ends up in landfill.

Acknowledgements: This research was supported under the Australian Research Council's Industrial Transformation Research Hub funding scheme (project IH130200025) and was undertaken with the assistance of resources from the National Computational Infrastructure (NCI), which is supported by the Australian Government. The authors acknowledge the facilities, and the scientific and technical assistance of the AMMRF node at the UNSW Sydney EMU.

Bio

Dr Karen Privat is a Research Associate at the UNSW Electron Microscope Unit specialising in SEM-based imaging and microanalysis of a wide range of materials, and is custodian of the AMMRF flagship JEOL JXA-8500F electron microprobe. An archaeological scientist by training, Karen maintains a research profile in this field while also branching out to collaborate in projects in materials science, geology and environmental science. Earlier this year, Karen participated in her first art exhibition, *Ku-ring-gai pH Art+Science*, at Manly Art Gallery and Museum.

Novel nanostructure patterning by ZEP tone reversal and dielectric lift-off

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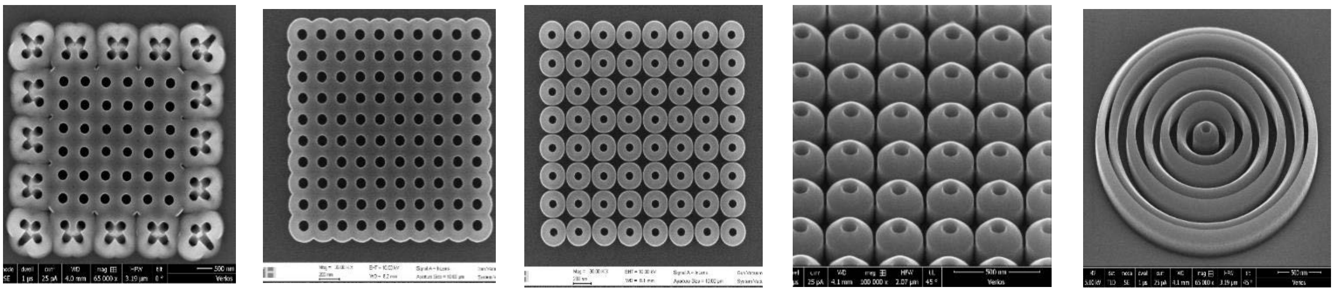
Functional nanostructures are nowadays routinely produced through "top-down" and "bottom-up" approaches; however, there are still great demands for exotic materials and structures which are difficult to materialise via these conventional methods. In this study I developed a novel approach for the fabrication of unconventional nanostructures by combining these two techniques as well as leveraging tone-reversal of ZEP electron beam resist.

Dielectric lift-off process is exploiting complete conformal coating of atomic layer deposition (ALD) process. In the process a ZEP patterned sample is over-coated with a dielectric by ALD, thicker than the resist; then blanket etching of the dielectric to expose the resist, is followed by oxygen plasma ashing of the resist. Applying this technique, TiO_2 nanopillar arrays with high aspect ratio was demonstrated for colour filters, whilst conventional top-down approach is difficult to attain because TiO_2 is refractory to plasma etching.

ZEP is one of the most practical positive resist materials for electron beam lithography due to its high resolution, excellent sensitivity, and superior plasma etch resistance. On the other hand it is not well-known that ZEP changes from a positive- to negative-tone with a high dose of electron beam. Utilising this phenomenon I could produce extreme resist patterns, for instances nanopillar with 30nm diameter and 250nm tall, and long lines with 10nm width and 500nm height. By merging dielectric lift-off process with these patterns a few exotic nanostructures could be demonstrated, as shown below.



Bio

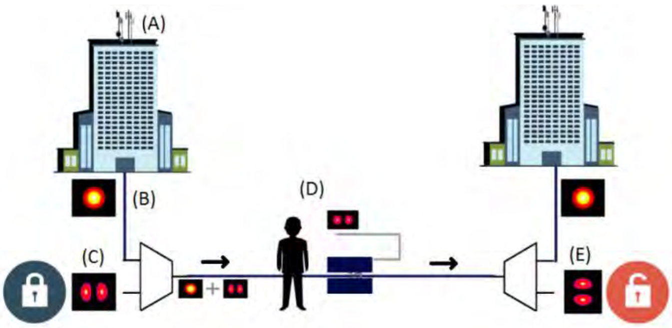
Dr. Duk-Yong Choi is an associate professor at the Laser Physics Centre in the Australian National University. He has been a member of CUDOS (Centre for Ultra-High Bandwidth Devices in Optical System) program since 2005. In the program his role is to develop the fabrication process of nonlinear optic devices utilizing chalcogenide glass films and to study the structural, optical and electrical properties of the materials. Recently his research has extended to silicon photonics – Germanium laser & photo-detector, hydrogenated amorphous silicon. He got his PhD at 1998 from Materials science and engineering in Seoul National University in Korea, and then worked at Samsung electronics.

Fiber integrity monitoring based on short-wave spatial mode multiplexing in single-mode telecom links.

Andrew Ross-Adams, Simon Gross, Michael Withford

1. CUDOS, Modular Photonics, and MQ Photonics Research Centre, Department of Physics and Astronomy, Macquarie University, NSW Australia.

This work describes an innovative solution for real-time optical fibre integrity monitoring and intrusion detection. While optical fibre links commonly operate on single-mode transmission in the C-band, around 1550nm, these fibres will also support multimode guiding at shorter wavelengths. The propagation evolution of these higher order modes, if precisely prepared and injected into the fibre, can be used to indicate the mechanical stress and tampering along the fibre link. The enabling device for this hybrid-wavelength optical fibre sensing platform, is a femtosecond laser direct-write (FLDW) photonic chip. To optimise the chip, FLDW waveguide fabrication in Corning Eagle 2000 alumino-borosilicate glass was studied in depth, with special regard for refractive index modification evolution as a function of laser pulse energy, and thus, waveguide size. This data formed the basis of a model which aided in improved predictions of waveguide characteristics. This enabled reliable production of devices which selectively excite higher order LP11 modes at 780nm in a standard single-mode fibre designed for 1550nm. The devices have an average insertion loss of 3.36dB and an average mode extinction ratio (modal purity measure) of 16.52dB. These devices were used to demonstrate fibre torsion sensor capable of readily detecting physical fibre handling events such as in intrusion scenarios. Preliminary investigation suggests a resolution of approximately 0.07 rad/m



Principal of operation of a fibre integrity monitor utilising short-wave spatial mode multiplexing.

Bio

Andrew received the degree of Bachelor of Telecommunications Engineering from Macquarie University in 2017, and recently submitted his masters dissertation. Andrew's work contributes to Modular Photonics and focuses on the development of spatial mode multiplexers based on integrated asymmetric tapered mode-selective couplers, for sensing and telecoms applications.

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Re-evaluating the classifications of opal using X-ray diffraction (XRD) and Raman spectroscopies

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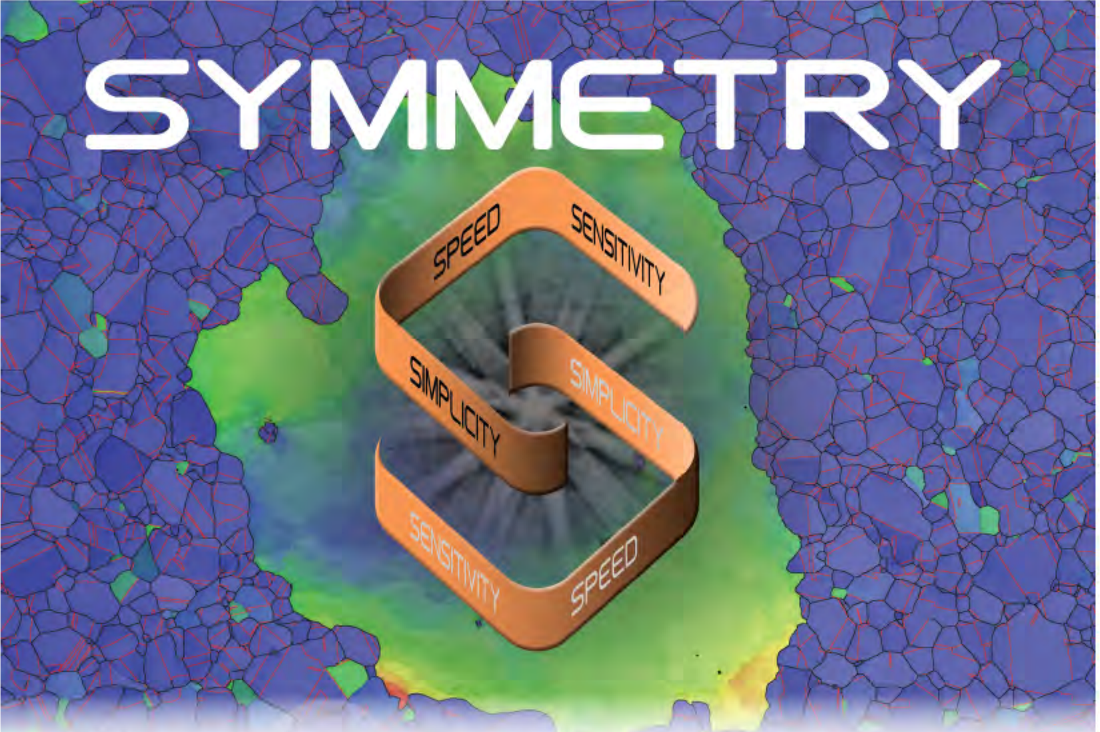
The classification scheme used to describe the various forms of common opal (hydrated silicas) originated over 40 years ago and was largely based on X-ray diffraction data. Over the subsequent decades, many investigations have correlated diffraction data with other spectroscopic and imaging techniques. Interestingly, an analysis of the Raman spectra in literature hints that it may be possible to further categorise opals beyond the original classification scheme. We have recently embarked on a comprehensive investigation using over 80 opal samples sourced from North and South America, Central Europe, Africa and Australia. These encompass a wide variety of opals ranging from amorphous "precious opals" to highly crystalline opals, and include samples formed from both sedimentary and volcanic processes. By correlating X-ray diffraction data with Raman spectroscopy, we have identify (at present) six different categories of opal. Furthermore, confocal Raman microscopy has been used to show some samples of opal can be significantly inhomogeneous, displaying various forms of silica over relatively small areas.

Bio

Jason Gascooke is an ANFF-funded member of staff at Flinders University who is responsible for overseeing the operations of various imaging and spectroscopic equipment. Jason's background is in high resolution gas phase molecular spectroscopy including rotational (microwave), vibrational (infrared) and electronic (UV) spectroscopies. He is actively engaged in research in fundamental molecular spectroscopy as well as applying spectroscopic methods to understand processes in applied physics and chemistry.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SIMPLICITY
SIMPLICITY
SENSITIVITY
SPEED


SYMMETRY

Synthesis of GelMA and its scale up to facilitate development of bioinks

Sanjeev Gambhir, Sepidar Sayyar, David L. Officer and Gordon G. Wallace*

The Materials Node, The Australian National Fabrication Facility, Intelligent Polymer Research Institute, AIIM Facility, Innovation Campus, University of Wollongong, Wollongong, NSW, Australia.

Photo-crosslinkable hydrogels, in particular gelatin methacryloyl (GelMA), are gaining increasing importance in bio-fabrication and tissue engineering. While often described as mechanically 'tunable', the crosslinking kinetics of GelMA with the increasing degree of methacrylation and its purification have not been well investigated.

In this work, we will present in situ photo-rheology to monitor the relative rate of crosslinking of GelMA samples prepared by different degree of methacrylation, as a function of photo-crosslinking conditions. In situ rheological measurements were used to quantify the rate of reaction of different GelMA hydrogels samples as a function of light intensity, exposure time and photo-initiator concentration following the previously standardized conditions. Finally the mechanical properties were obtained through compression of cross-linked GelMa scaffolds prepared under identical conditions. Several practical expressions were derived which may be generally applicable when preparing GelMA and other hydrogels as biomaterials for the encapsulation of living cells. Challenges of scale up and detailed investigation of co-product formation and its control while meeting the strict quality requirements involving extensive characterisation.

These investigations helped in developing product for St.Vincent project for creating softer functional neural structures for cartilage repair; 3D printed scaffolds for Australian Institute for Musculoskeletal Science (AIMSS) for neuro muscular junctions and for Peter Choong's group at University of Melbourne for biopen project. Other clinical collaborations that will benefit from the scale-up capability include Royal Prince Alfred Hospital for 3 D printed ears and the Royal Adelaide Hospital developing bio-inks to print islet cells in scaffolds to improve transplantation to treat diabetes.

Bio

Dr Sanjeev Gambhir obtained his PhD in 1988. He started his career working with multinational pharmaceutical industry in its R&D division. He left the industry as Head of Custom Synthesis Division in 2000 and joined the Nanomaterials Research Centre, Massey University, Palmerston North, New Zealand. In 2007, he joined Dyesol, Australia and successfully set up the pilot scale facility for the syntheses of kilograms quantities of dyes and intermediates. Since 2008, he has worked in the IPRI and the Materials Node of the ANFF at the University of Wollongong. Dr Gambhir oversees the development of scalable materials, such as graphene, GelMA and other biopolymers required for all projects. He is working with clinical partners at St. Vincent Hospital for developing the biopolymer for cartilage regeneration.

Surface area to volume ratio measurement of red blood cells using microfluidics

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Red blood cells (RBCs) play a crucial role in transporting oxygen to tissues and carbon dioxide to the lungs. One of the most important features of the RBC is its ability to squeeze through narrow capillaries. This cellular deformability can be significantly affected by certain pathological diseases such as malaria.

The cellular deformability of RBCs depends on the membrane elasticity and on the surface area to volume ratio (SA/V ratio). Nonetheless, it is still unclear how sensitive the cellular deformability is to these different factors. Thus, the aim of this study is to identify the impact of the SA/V ratio on the cellular deformability of RBCs in health and disease conditions. This could shed light on the mechanisms of host cell subversion and help biologists with finding new treatments for diseases such as malaria.

We used a microfluidic device called Human Erythrocyte Microchannel Analyser (HEMA) (Gifford, Frank et al. 2003) to entrap RBCs and conform them into wedge-shaped microchannels that permits the precise determination of cell surface area and volume. Using the HEMA device, the results showed that although immature RBCs have approximately 16% more surface area and 20% more volume rather than mature RBCs, the SA/V ratio remains unchanged during the maturation process. We also found that the position of an arrested cell correlates to its SA/V ratio. We are currently investigating the impact of the SA/V ratio on cellular deformability.

Bio

Mr. Arman Namvar is currently pursuing a PhD in biomedical engineering at the University of Melbourne under the supervision of Prof Peter Vee Sin Lee, Dr Vijay Rajagopal, and Prof Leann Tilley. He received a B.S. degree in mechanical engineering from Shiraz University and an M.S. in solid mechanics from Sharif University of Technology.

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Unlocking the distribution of fluorescent-albumin in zebrafish through correlative microscopy

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The zebrafish has become increasingly common in many research disciplines for their genetic and functional resemblances with that of humans. To-date, only a few publications report on drug delivery into the zebrafish liver, resulting in limited information on drug behavior in relation to fine structure at the organ and cellular levels. The efficacy of therapeutic drugs relies on the accumulation of sufficient amounts of drug at the target site. Hence, it is important to understand the behavior, uptake rate and site of accumulation of prospective drugs to better tailor alternative drug targeting strategies. The present study reports on the widely-used drug carrier, albumin, known to accumulate in the different liver cell types. By injecting fluorescently-tagged albumin into the zebrafish liver and applying the concept of correlative microscopy, novel functional and structural insights were obtained on the distribution of albumin. First, live-confocal was used to monitor albumin distribution over-time. Next, the zebrafish were fixed and processed for electron microscopy (EM) using a protocol whereby fluorescence is retained. Serial sections across and throughout the liver were generated and subsequently imaged using both fluorescence- and EM. Correlative data analysis disclosed insights on the cellular accumulation sites, as well as respective accumulation rates. The workflow established herein allowed to demonstrate albumin transport ways within the zebrafish liver. Our multimodal bio-imaging approach provides a strong basis for future albumin-based drug-complexes studies. Furthermore, we validate the zebrafish as a suitable experimental animal model for targeted drug delivery studies to the hepatic endothelium and liver parenchymal cells.

Bio

After 5 years as a microscopist (technical staff) at The University of Sydney, I decided to undertake PhD research studies. My work involves the application of different microscopy techniques to explore different aspects on liver cell biology. I have gained experience in optical- and electron microscopy, including cryo-techniques, tomography and correlative microscopy. This multimodal correlated imaging approach facilitated our understanding of the different structure-function aspects of the zebrafish liver.

Immune cell engineering via microfluidic vortex shedding

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Indee. Pty. Ltd., 231 Chapel Street, Prahran VIC 3181 Australia

Gene-modified cell therapies (GMCTs) – cell therapies requiring a gene delivery step – offer the opportunity to radically impact patient outcomes across several challenging disease areas. These GMCTs are shown to (1) substantially improve the standard-of-care and (2) address an unmet need for indications such as blood cancers, solid tumours and rare disease. While the clinical outcomes are substantial, therapeutic development is cumbersome and manufacturing remains complex and limited in scale. Thus, the aim of this work is demonstrate a rapid and flexible gene delivery technology that allows for the efficient development and scalable manufacturing of GMCTs.

To this end, we have developed a gene delivery technology based on microfluidic vortex shedding (μVS) that enables the delivery of various constructs (e.g., mRNA, plasmid and Cas9 RNPs) to human immune cells (e.g., PBMCs along with pan T cells and T cell subsets). As an example, we demonstrated high cell recovery (e.g., 96.3 ± 1.1%, mean ± stdev), high cell viability (e.g., 83.7 ± 0.7%) and high EGFP expression efficiency (e.g., 57.4 ± 6.8%) after transfecting human pan T cells with EGFP mRNA. We also demonstrated μVS does not adversely affect pan T cell growth over the course of 7 days nor does μVS change T cell activation profiles for CD69, CD154, CD44, CCR7, CD45RA and CD25 activation markers. Furthermore, our small-scale prototype(s) allow for processing rates of over 2 million cells s^{-1}.

Future work is focused on demonstrating μVS as a platform for comprehensive immune cell engineering capabilities.

Bio

Ryan Pawell is an engineer and scientist turned biotech entrepreneur. He is an alumni of Y Combinator's Winter 2017 cohort and the 2014 NSW Health Medical Device Commercialization Training Program. He completed a BSci Mechanical Engineering at UC Santa Barbara while working with NuVasive and Inogen on medical device development. More recently, Ryan raised a meaningful amount of grant, angel and venture financing to develop biomicrofluidic devices for immune cell engineering.

X-ray micro-computed tomography in the bio, geo and materials sciences

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Imagine a technique that requires minimal or no sample preparation and allows you to explore the internal structure of your sample down to the micrometre scale without the need for a single cut. This can be achieved using X-ray microscopy (XRM), which, as for medical CAT scanners, uses the penetrative power of X-rays to non-destructively image through materials. The data generated by an XRM is converted to a digital format that can be investigated in almost limitless ways. The technique is highly flexible, with wide ranging applications in biological, geological and materials science. The Centre for Microscopy, Characterisation and Analysis (CMCA) at UWA has two X-ray imaging systems and this presentation will cover the basics of the XRM technique, its applicability to the study of a broad range of samples, and a number of gratuitously pretty videos of objects imaged by XRM.

Bio

Dr Jeremy Shaw is the X-ray microscopy Technique Group Leader and the Biological Applications Group Leader at the CMCA and also specialises in the application of electron microscopy in biology. While Dr Shaw has roots in marine biology, for the past four years he has held an ARC DECRA focusing on the study of magnetoreception in honey bees. His main research interest lies in the study of biomineral formation in animals and specialises in iron mineralisation processes in the teeth of marine chitons (Mollusca).

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ANFF – The underpinnings of training partnerships

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The most dramatic impact of the US$5 Billion+ additive manufacturing industry, may soon be seen in the field of medicine. The 2016 Wohlers Report highlighted that the Medical/Dental sector already makes up 12.2% of the 3D printing market. Ongoing advances in materials and process research has brought us to the cusp of a wave of new medical therapies, implants and treatments dependant on advanced fabrication technologies. However, the key to realising these new opportunities will be the workforce that enable them, the Biofabricators, multidisciplinary technologists who develop integrated constructs containing structural components, cells and bioactives. This expertise is not yet widespread. However, informed by industry demand we have established multiple levels of training initiatives to aid meet the needs of these emerging industries.

Bioprinting: 3D Printing Body Parts, an open online course has attracted more than 25,000 participants since starting in 2016. A partnership between UOW and QUT in Australia, University Medical Center Utrecht in the Netherlands and University of Würzburg in Germany, facilitates a double master's degree linking biofabrication students with clinical mentors to address practical clinical issues. The ARC Training Centre in Additive Biomanufacturing brings together universities, companies and clinicians, under the Industrial Transformation Training Centres scheme to train PhD students in the industrial environment ensuring that their skills meet the needs of future manufacturing.

These training initiatives are underpinned by the knowledge base and infrastructure accessible though ANFF ensuring industry and students access to the most recent and relevant fabrication advances.

Bio

Dr Beirne was awarded a PhD in Nov 2008, by the School of Mechanical and Manufacturing Engineering, DCU, Ireland. He is a Senior Research Fellow at the University of Wollongong's, Intelligent Polymer Research Institute (IPRI) and an Associate Investigator with the ARC Centre of Excellence for Electromaterials Science. Since 2010 Dr Beirne has led the development of additive fabrication facilities at IPRI while Additive Fabrication Manager for the Australian National Fabrication Facility (ANFF). His research focuses on the application of advanced fabrication techniques in the areas of energy and medical bionics through development of additive fabrication strategies, technologies and materials.

Making sure you measure up – standards for nanoscale measurements

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Malcolm B. Gray and Jan Herrmann

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The nanotechnology community needs nanoscale measurements that are accurate, internationally recognised and relevant for the intended applications: researchers need to calibrate or verify their measuring instruments, industry must compete with their products in national and international markets and comply with regulations, governments need to establish or interpret regulatory requirements, and consumers want to know what their products contain.

Physical standards that are traceable to internationally agreed references and documentary standards that specify validated methodology provide the confidence in measurement results that users can rely on. Here, we summarise the contributions made by the National Measurement Institute (NMI) to the development of such standards.

We highlight the critical role of the electron microscopy facilities at AMMRF for NMI's participation in the characterisation of certified nanoparticle reference materials and discuss the influence of image analysis parameters and their effects on the measurement uncertainty. We discuss NMI's contribution, again facilitated by AMMRF facility access, to the development of validated protocols for the measurement of primary particle size distributions by transmission electron microscopy (TEM), for example for silica and titania nanoparticles and gold nanorods, as part of pre-normative research that will result in consensus-based international standards.

To ensure the comparability and international recognition of nanoscale dimensional measurements, NMI developed Australia's primary standard, implemented in a metrological scanning probe microscope. We describe the performance of the instrument, highlight some of the challenges in achieving the required accuracy and outline how Australia's nanotechnology community can benefit from NMI's nanometrology infrastructure and expertise.

Bio

Victoria Coleman leads the Nanometrology Section at the National Measurement Institute (NMI). The Nanometrology group has developed a primary standard for nanoscale dimensional measurements based on an atomic force microscope, to ensure that Australia has access to accurate, reliable and traceable measurements on the Nanoscale. In addition, the group also operates a comprehensive suite of instruments within its Nanoparticle Characterisation Facility.

Electronic Structure of Titania Surfaces Modified by Au Clusters

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‡ *Department of Chemistry, The University of Adelaide, Australia*
§ *The MacDiarmid Institute for Advanced Materials and Nanotechnology, Department of Chemistry, University of Canterbury, New Zealand.*

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Metal clusters with a size of less than 100 atoms are suitable for modifying the electronic properties of semiconductor surfaces. [1, 2] In order to avoid agglomeration of the metal clusters and in order to retain their specific electronic structures, the coverage of the surface with metal clusters has to be kept below 10%. The main challenges in this field are a) to maintain the size and thus the properties of the metal clusters and b) to determine the electronic structure of the clusters.

The first challenge is considered as one of the main challenges in the field of surface modification with metal clusters can be addressed by introducing defects on the metal oxide surface, specifically oxygen vacancies. The second challenge can be addressed by using experimental techniques which are exclusively sensitive for the electronic structure of the outermost layer. Metastable Induced Electron Spectroscopy (MIES) is such a technique and has been used successfully to determine the change in electronic structure due to the deposition of Au clusters. Applying techniques such as singular value decomposition, the changes of the electronic structure can even be quantified. [2]

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Biographical Information

In 1998 Gunther Andersson completed his PhD applying ion scattering spectroscopy on liquid surfaces at the University of Witten/Herdecke (Germany) under the supervision of Prof Harald Morgner. The following two years he at the Technical University Eindhoven on a project on polymer based light emitting diodes. In 2000 Gunther moved to Leipzig University (Germany) were he developed the method neutral impact collision ion scattering spectroscopy (NICISS) for investigation of soft matter surfaces to its current stage. He completed his Habilitation in 2006. In 2007 he was appointed at Flinders University (Australia). He is now leading as a full Professor a research group with activities in liquid and polymer surfaces and catalysis based on nano-clusters.

Morphological control and characterization of InP nanostructures grown by selective area epitaxy

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Group III-V semiconductors have revolutionised electronics and optoelectronics due to their superior physical and optoelectronic properties including high carrier mobility, direct bandgap and rich band alignment engineering capability. Among them, InP is highly relevant as a platform for optoelectronic applications due to the low surface recombination velocity. Reducing their size to nanoscale brings many unique properties, such as large surface-area-to-volume ratio, high aspect ratio, carriers and photons confinement effect. These nanostructures have already been demonstrated for potential applications in solar cells, light emitters, water splitting, etc. However, to date most efforts on the growth of group III-V nanostructures including InP have been limited to nanowires. In this work, we demonstrate selective area growth of InP nanomembranes and nanorings (see Fig.1), showing the possibility of obtaining other functional nanostructures, the capability beyond the limitation of rod-like nanostructure and opening the way to more advanced device geometries.

Many facilities provided by ANFF-ACT Node and AMMRF-ACT Node are used in this project, including plasma enhanced chemical vapour deposition system for depositing SiOx mask, electron beam lithography system for patterning the substrate, barrel etcher for removing the remaining resist, Aixtron 3×2’’ close coupled showerhead metal organic chemical vapour deposition system for the epitaxial growth, scanning electron microscope system with cathodoluminescence (SEM-CL), focused ion beam system for preparing the TEM sample, and JEOL 2100F field emission transmission electron microscope (TEM) system. Based on the SEM-CL and TEM results, we confirm that the defect-free InP nanostructures with controllable morphology and superior optical property are achieved.

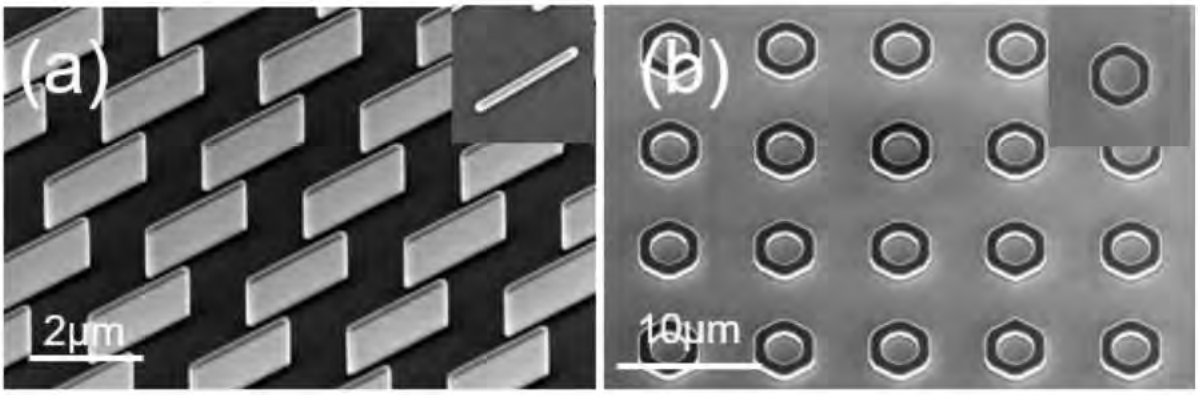

Fig. 1. SEM images of InP (a) nanomembranes and (b) nanorings.

Bio

Naiyin Wang was born in China in 1986. He received the B.Sc. degree in Microelectronics from the School of Physics, Shandong University, China in 2010 and M.Eng. degree in Microelectronics and Solid State Electronics from South China Normal University in 2013. Currently, he is working toward the PhD degree in the Department of Electronic Materials Engineering, The Australian National University. His research interests include the growth and characterization of group III-V semiconductor nanostructures for optoelectronic applications.

Fabrication and characterization of single crystal diamond membranes for quantum information technologies

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Diamond has received increased interest in the last decade due to its novel optical, mechanical, and electrical properties, as well as its high refractive index and wide-bandgap. In particular, single crystalline diamond (SCD) is a unique material as it is known to host numerous color centers from ultraviolet to infrared. It is thus one of the promising candidates for applications in nonlinear optics and quantum information processing. Here, we present a novel, effective means of fabricating high-quality and ultra-thin SCD membranes on a thick diamond scaffold. The fabrication steps include: an ion implantation of SCD substrates, an overgrowth of SCD layer using a microwave plasma chemical vapor deposition (MPCVD) on implanted substrates, a laser micromachining of diamond to create supporting scaffolds for membranes, a fusion growth of SCD layer using a MPCVD, an electrochemical etching to lift-off the membrane from the substrate, and a reactive ion etching of the lifted-off surface of the membrane to obtain a desired thickness[1-2]. The resulting membranes have a maximum dimension of ~ 3 × 3 mm with a thickness ranges from ~ 350 nm – 2 µm. These membranes are single crystalline with an interatomic spacing of ~ 0.14 nm. Atomic force microscopy investigations also indicate that the membranes are uniform and smooth with a surface roughness of < 3 nm. Furthermore, confocal microscopy studies show that the membranes are free of optically active nitrogen-vacancies, which could then be produced in the membrane by irradiation and subsequent annealing. This work allows for the creation of on-chip devices, enabling various applications, such as quantum information technologies.

Bio

I am a postdoctoral researcher in the School of Physics at the University of Melbourne. In addition, I have completed my postdoctoral research in the Department of Chemistry at Texas A&M University in September 2016. I have also completed my first postdoctoral research at the Center for Sustainable Materials Chemistry at the University of Oregon in January 2015. I obtained my Ph.D. in Applied Physics at Portland State University in August 2012. My research has been involved in design, build, and study of novel materials/inorganic compounds and structures for various applications from solar energy conversion devices to electronics.

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Aberration-corrected STEM characterisation of minerals in the Cu-U-Au-Ag deposit at Olympic Dam, South Australia

Ashley D. Slattery[†], Cristiana L. Ciobanu[‡]*, Alkiviadis Kontonikas-Charos[‡], Nigel J. Cook[‡], Kathy Ehrig[§], Benjamin P. Wade[†]

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Scanning transmission electron microscopy (STEM) is an extremely powerful nanoscale characterisation technique, especially where aberration correction can provide atom-scale probes with enhanced chemical characterisation. An aberration-corrected Titan Themis S-TEM is employed here to study the atomic-scale structure of various minerals from the Olympic Dam Cu-U-Au-Ag deposit, South Australia. These investigations include the visualisation of short-range stacking sequences in REE-fluorocarbonates (Fig. 1) and the incorporation of trace elements such as uranium and tungsten in iron oxides. Direct lattice-scale imaging combined with EDX-TEM mapping allows interpretation of trapping of these elements within a crystal structure as well as their release as nanoparticles. This has important consequences for constraining the 'robustness' of iron oxides as U-Pb geochronometers for directly dating ore assemblages. Relationships between minerals formed during evolution of the deposit from early magmatic (spinel exsolutions in magnetite) to hydrothermal stages (REE-fluorocarbonates, hematite and Cu-Fe-sulphides) provide constraints on ore formation. Atomic-scale changes in oxidation state of elements, such as iron or copper, can be tracked by EELS–TEM. Such changes can be related to redox conditions, one of the important mechanisms for concentration of metals contributing to large, complex hydrothermal deposits such as Olympic Dam.

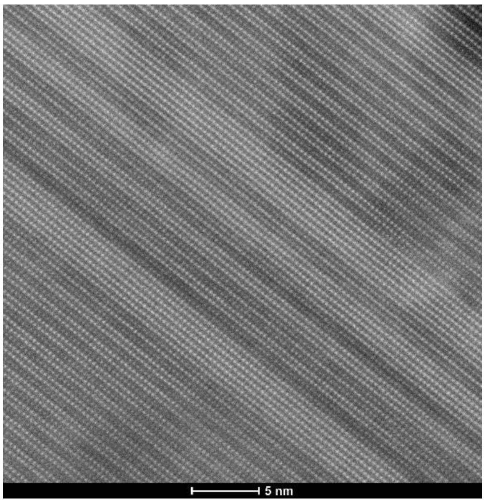

Figure1: HAADF STEM image of REE-fluorocarbonate stacking sequences.

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Bio

Ashley Slattery is a TEM microscopist in Adelaide Microscopy at the University of Adelaide, with a PhD from Flinders University and a background in nanotechnology and microscopy.

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Acoustic-based Microfluidic System for Cell Mechanical Characterisation

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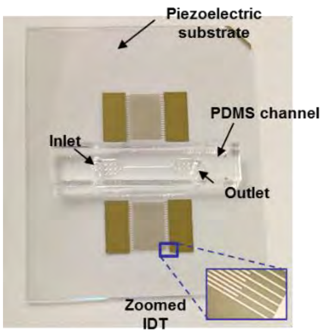
Cell's mechanical property has been reported as a bio-indicator for cell function study like cell migration, and human diseases research like early detection on cell level. Among variety of technologies to measure cell's mechanical property, also known as cell mechanical characterisation, microfluidic technology has advantages on high throughput as a fluidic-based method, flexibility and low cost due to micro scale. Acoustic-based microfluidic is known as high biocompatibility method combining acoustic wave with microfluidic, enriching traditional microfluidic technology while harm to cell is minimal. Surface Standing Acoustic Wave (SSAW), as one of the acoustic-based technologies, is comprised of two identical counter-propagating acoustic waves travelling on the surface of piezoelectric substrate, generated by two identical interdigital transducers (IDTs) placed on the substrate. When two acoustic waves meet in the centre of the chip, they form an interference of waves and reflect into microfluidic channel. The particles inside the microfluidic channel tend to be concentrated by acoustic radiation force towards interference trough (i.e. pressure node), where the acoustic radiation force is related to particle's property such as density and deformability. Hence, the acoustic radiation force can be used to measure or reflect cell's deformability effectively. This presentation aims to demonstrate the promising application of SSAW microfluidic on cell mechanical characterisation.



Bio

Yanqi Wu is a current PhD candidate in the Department of Biomedical Engineering, the University of Melbourne, with the supervision of Prof. Peter V.S. Lee and Prof. Alastair G. Stewart. He obtained his Bachelor of Engineering from Tsinghua University, China. His research interest is microfluidic on cell mechanobiology.

Systematic investigation of the effect of shear stress in a microfluidic intestine-on-a-chip model

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Nano- and micro-particulate carriers with abilities to protect their biological payloads from the harsh environment of the gastrointestinal tract have high potential to enhance oral peptide/protein absorption. However, their uptake and transport through the intestinal epithelium is sub-optimal and inconsistent. This remains a significant bioengineering challenge that hampers the much needed implementation of oral vaccines.[1] Current preclinical animal and *in vitro* models based on Transwell culture often fail to accurately predict the uptake of orally administered drugs. Indeed, these models don't accurately mimic the human intestinal epithelium and provide only limited insight about uptake mechanisms.[1] The integration of microfluidics with living biological systems has paved the way to the exciting concept of "organ-on-a-chip".[2, 3] However, the mechanical conditions needed to grow intestinal epithelium in a microfluidic device have not been investigated.[4, 5] To this end, a single layer microfluidic device was developed to create, within a single device, a range of shear stress physiologically relevant to the intestinal epithelium. In turn, this device allows for systematic investigation of the effect of fluid shear on the key characteristics of epithelial monolayers. Building on this study, an *in vitro* microfluidic model of the intestinal epithelium was developed to investigate the uptake of particulate carriers and provide greater mechanistic insights.

Caco-2 cells were cultured in a PDMS-based microfluidic device under dynamic flow conditions mimicking those of the intestinal lumen. The structural and functional differentiation of the enterocyte monolayer in the apical chamber, including the presence of tight junctions, F-actin, microvilli and mucus, and the drug transport activity, was studied using confocal microscopy and digital holographic microscopy. Silica particles of various sizes and biointerfacial properties (i.e. with or without PEG or mucoadhesive) were injected in the intestinal chamber. Their uptake and degradation were quantitatively and qualitatively characterized with imaging flow cytometry (IFC) and confocal microscopy (Zeiss S1).

This project is supported by the ARC Linkage Grant LP150100032.

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Bio

Ludivine Delon is a second year PhD student at the UniSA's Future Industries Institute. Ludivine did 2-year undergraduate course specializing in Biology, Chemistry, Physics, Mathematics, and Earth Sciences and graduated a Dual Diploma "Engineer in Food Science-Master Research" in Human Nutrition in 2015.

A Microfluidic Needle for Sampling and Delivery of Chemical Signals by Segmented Flow

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A microfluidic needle-like device that can extract and deliver nanolitre samples has been developed. One step DRIE (Deep Reactive Ion Etching) were performed on the silicon to make the channels, and a borofloat 33 wafer was fusion bonded to seal the channels. Bonding consisted of a reverse RCA (Radio Corporation of America) clean, followed by 375 ℃ baking for 12 h. The device consists of a T-junction to form segmented flows, parallel channels to, and from, the needle tip, and seven hydrophilic capillaries at the tip that form a phase-extraction region. The main microchannel is hydrophobic and carries segmented flows of water-in-oil. The hydrophilic capillaries transport the aqueous phase with nearly zero pressure gradient, but require a 19 kPa pressure gradient for mineral oil to invade and flow through. We demonstrate the delivery of nanolitre segmented flows, and sampling by the formation of segmented flows at the tip of our device. By recording the fluorescent intensities of the segmented samples formed at the tip while the concentration of dye outside the tip is varied, we measured a response time of approximately 3 s. The linear relationship between the recorded fluorescence intensity of samples and the external dye concentration (10 to 40 µg/mL) indicates that this device is capable of quantitative, real-time measurements of rapidly varying chemical signals.

Bio

Shilun Feng was a Bachelor student in Pharmaceutics, Faculty of Pharmacy, Yanbian University, Jilin, P.R.China (University of 211 Project in China) during 08/2009-06/2013. He was a Master student in Biomedical Microelectromechanical systems (Bio-MEMS) Department of Micro and Nano Systems Technology (IMST), Faculty of Technology and Maritime Sciences (TekMar), Buskerud and Vestfold University College (HBV), Tønsberg, N3103, Norway during 08/2013-06/2015; Now he is a PhD student in Microfluidics needle project, Department of Engineering, Faculty of Science and Engineering, Macquarie University, Australia from 09/2015 till now. His supervisor is Dr. David Inglis from Macquarie University focusing on the biomedical Microfluidics, microfabrication and Simulations. His co-supervisors are Prof. Ewa Goldys and Dr.Guozhen Liu from Macquarie University in biomedical imaging.

Microfluidic Devices with Optical Side Access, Comparing Methods

James White and David W. Inglis*

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Nanodiamonds are useful biological labels, but their brightness is inconsistent due to widely ranging density of colour centres. Nanodiamonds with consistently bright fluorescence are needed for a range of quantum optical and biological applications. A bright nanodiamond has the same size and chemistry as a dark one, it just contains colour centres. Actively sorting these one at a time on a fast optical sorting machine like a flow cytometer would take thousands of years to process just 1 gram of 20 nm particles.

In ARC DP170103010 we (Thomas Volz, Louise Brown, David Inglis) proposed to passively sort fluorescent NDs according to their brightness. The innovative idea uses high powered lasers in an optofluidic device and is millions of times faster than active sorting methods. In this work we describe 3 ways we have made prototype sorting chambers: SU-8 to PDMS soft lithography, pulsed laser ablation of borofloat glass, and DRIE of fused silica. We examine the sidewall roughness and compare the optical transmission efficiency for key wavelengths through the sidewall.

Bio

Dr Inglis received a B.Sc in Engineering Physics from The University of Alberta in 2001 and a PhD in Electrical Engineering from Princeton University in 2007. He was an Australian Postdoctoral Fellow in the Physics Department of Macquarie University from 2008 to 2011. He is now a Senior Lecturer in the School of Engineering at Macquarie University. Dr Inglis research interests lie in microfabrication for medicine and biology. He is well known for work on deterministic lateral displacement separations.

Magneto-transport insights into Arsenic doped p-type HgCdTe for eSWIR Applications

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Electronic transport characterisation of Arsenic doped *p*-type HgCdTe was carried out for Selex ES (UK), who are a world-leader in HgCdTe-based infrared detector technology, with the aim of gaining insight into the mechanisms limiting p-type conductivity in As-doped films. Although the HgCdTe semiconductor alloy system is currently the most important semiconductor material for high-performance infrared detectors, there is a significant lack of knowledge regarding hole transport for CdTe mole fractions $x \geq 0.5$, a composition range required for extended short-wavelength infrared (eSWIR) photodetector arrays operating over the 1.7–3.0 µm wavelength range. The determination of hole mobilities and concentrations in high CdTe mole fraction HgCdTe layers is also important for the optimization of barrier layers in unipolar *n-type*/barrier/*n-type* (*n*B*n*) photodetectors operating over the traditional midwave (3–5µm) and long-wave (7–12µm) infrared spectral ranges. In this work, the HgCdTe samples studied were epitaxially grown by metal-organic vapor phase epitaxy (MOVPE) on buffered GaAs substrates at Selex ES. Hole mobilities were extracted by performing resistivity and Hall-effect measurements on square-geometry Van der Pauw test structures. Extracted experimental hole concentrations and mobilities were then analysed against theoretical results obtained from the solution of Boltzmann's transport equation. The analysis results indicate that, at temperatures of interest for eSWIR photodetector operation, hole mobility for CdTe mole fraction ≥ 0.56 is predominantly limited by ionized impurity and polar-optical phonon scattering, exhibiting relatively low compensation. The ionization energy of the As-acceptors was found to exhibit a quadratic dependence on the CdTe mole fraction *x*, increasing monotonically with increasing *x*. The results provided to Selex are deemed to be of significant value for MOVPE growth and doping optimisation of HgCdTe layers for high performance eSWIR photodetector imaging arrays.

Bio

Hemendra Kala received his PhD in Electrical and Electronic Engineering from the University of Western Australia in 2016, where he is currently employed as a research associate at the WA node of the Australian National Fabrication Facility (ANFF-WA). His current research activities include characterization of electronic transport in semiconductor materials, and the development of microelectromechanical systems (MEMS) for spectroscopic applications in the infrared and terahertz wavelengths.

Nanodevice fabrication: Hf-based Memristive devices

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Memristor is a new nanoscale device that was postulated by Leon Chua from UC Berkeley in 1971. It continued to be a hypothesis till a group in HP, led by Stan Williams, has demonstrated the existence of such device at nanoscale level in 2008. The unique properties of such device is its ability to store data for a long period of time, similar to non-volatile memory. Also, it has a thin film structure that allows its integration in a 3D form to allow more storage density, and its structure can be scaled without compromising its properties.

The device structure consists of metal-oxide (active material) sandwitched between 2-metal electrodes. Different active and electrode materials have been used to build such device including TiO_2, TaO_x, Cu_xO, ZnO, etc. As the interest is to integrate such device with CMOS technology, materials used in such process have been investigated. Of these, Hafnium was considered as some semiconductor fabrication processes use its oxide in 45 nm feature size and less processes, hence the interest to build Hf based memristor devices. For this purpose ANFF SA Node was utilized to build Hf based memirstors that has Ta(TE):Hf:HfO:Ta(BE) structure. The fabricated wafers included varying geometries and materials thicknesses. In the process, growth profiles for Ta, Hf and HfO materials were developed and technique related identification of these materials were utilized to check the percentage of Hf:HfO ratio.
Initial electrical testing were carried out using RMIT facilities. Currently we are conducting further testing and analytics to characterize the built structures.

Acknowledgements

This project was supported through KUSTAR–KUIRF L2 internal research grant (no: 2014-210066) from Khalifa University, UAE and PRIF Grant CPP-39 from South Australian Department of State and Development. The authors also thanks Dr Omid Kavahei from RMIT University for providing support to testing facilities to measure fabricated devices. Also acknowledge in kind support and help from ANFF SA Node for their help and support.

Bio

Said F. Al-Sarawi received B.Eng. degree (1st Class Hons.) in marine electronics and communication from AAST, Egypt, 1990, and the Ph.D. degree in mixed analog and digital circuit design techniques for smart wireless systems with special commendation in 2003, from the University of Adelaide. He also received the Grad Cert. in Education (Higher Education), in 2006, from the same university. Currently, he is the Director of the Centre for Biomedical Engineering with interest in design techniques for mixed signal systems in CMOS for high performance radio transceivers, low power RFID and MEMS for sensing. Awarded the University of Adelaide Alumni Postgraduate Medal (formerly Culross) for outstanding academic merit at the postgraduate level. Earlier, while pursuing his Ph.D., he won the Commonwealth Postgraduate Research Award (Industry).

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Fabrication of hollow and exposed core fibres for sensing applications

Erik P. Schartner, Georgios Tsiminis and Heike Ebendorff-Heidepriem

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Microstructured fibres (MOFs) are of key interest across a wide range of sensing applications, as the wide variety of possible structures enables the light guidance to be tailored for the desired use. In recent years MOFs have found use in biological sensing applications. Here we present two examples of structured fibres, fabricated via different methods, which have potential for use in biosensing applications.

Fabrication of hollow core fibres (HCFs) is typically based on capillary stacking of hollow tubes, a complex, time-consuming and therefore costly process that limits their potential for use in practical devices. Glass billet extrusion, an alternative to the capillary stacking process, presents a potential pathway to reducing the high fabrication cost of HCFs. Precise fabrication tolerances are critical to the optical properties of these fibres, with sub-micron, uniform wall thicknesses required for broad spectrum, low-loss visible transmission. Here we discuss improved fabrication methods for these fibres, leading to a reduction in the variations seen in these fibres, and their potential for use in fields such as Raman sensing.

Exposed core fibres (ECFs) are another fibre type that have strong potential for applications in biological sensing, as they enable the use of distributed measurements along the length of the fibre. Previous fibres have either been restricted in sensitivity by large core sizes, or by high material losses for the soft glass examples. Here we demonstrate low-loss fibres with ~1.5 µm core diameters, exposed to the environment along the length of the fibre.

Bio

Erik completed his PhD at the University of Adelaide in 2011, on the use of microstructured fibres for chemical sensing. He is currently working as a postdoctoral researcher at the University of Adelaide looking at high temperature sensing for industrial applications, as well as fibre sensors for biological and medical applications.

An internet-based initiative to standardise the calibration of atomic force microscope cantilevers

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Atomic force microscope (AFM) users often determine the spring constants of cantilevers using functionality built into individual instruments. This calibration is performed without reference to a global standard which limits the comparison of force measurements reported by different laboratories. Here, we describe an internet-based initiative whereby users from all laboratories can instantly and quantitatively compare their calibration measurements to those of others—standardising AFM force measurements—and simultaneously enabling non-invasive calibration of AFM cantilevers of any geometry. This global calibration initiative (GCI) requires no additional instrumentation or data processing on the part of the user. It utilises a single website where users upload currently available data. A proof-of-principle demonstration of this initiative is presented using measured data from five independent laboratories across three countries, which also allows for an assessment of current calibration.

Bio

Dr. Christopher Gibson completed his undergraduate and postgraduate studies at Griffith University in Brisbane and then completed a number of post-doctoral research posts at universities in the United Kingdom including the University of Nottingham, University of Birmingham, Leeds University and Cambridge University. His expertise is in scanning microscopy with a focus on quantitative measurements using atomic force microscopy and he currently manages the scanning microscopy laboratory at Flinders University in Adelaide. This laboratory forms part of the South Australian Research Facility node of the AMMRF.

Interdisciplinary electron microscopy and microanalysis research at CMCA: from planets to shipwrecks

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The combined capability of the electron microscopy and microanalysis at CMCA provides an important tool for analysis of complex materials as diverse as extra-terrestrial samples (eg., lunar minerals returned to Earth by NASA space missions), archaeological objects (eg., silver coins from Western Australia shipwrecks), microfossils from 3.5 billion-year-old rocks of Western Australia, nanoscale materials built for new technology platforms. Examples of a few applications will be presented, where the TEM, FIB-SEM, and the electron microprobe can provide the researcher with the microstructural and compositional information that will help with understanding of how an object was fabricated and what materials it was made from. Electron microscopes help researchers to make discoveries!

Bio

Alexandra is based at the UWA's Centre for Microscopy, Characterisation and Analysis and focuses on the use of advanced electron microscopy techniques to support a wide range of research projects in materials science, geology and archaeology in Western Australia. Originally trained as a physicist, Alexandra is a Head of Physical and Engineering Application group at CMCA.

Diffraction limited and high contrast imaging of circumstellar environments at the Anglo Australian Telescope: Guided Light Interferometric Nulling Technologies

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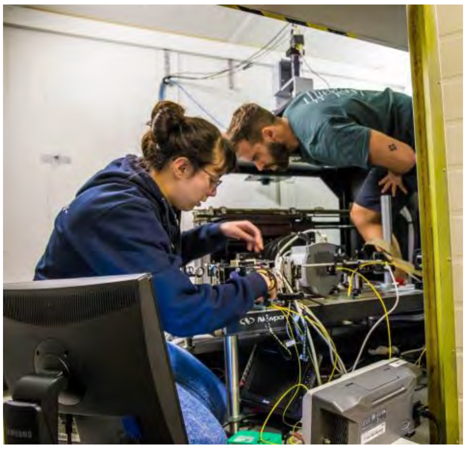
With many thousands of exoplanets discovered, one of the important next steps in astronomy is to be able to characterise them. This presents a great challenge and calls for new observational capabilities with both high angular resolution and extreme high contrast in order to efficiently separate the bright light of a host star to that of a faint companion. Glint South is an instrument that uses photonics technology to perform nulling interferometry. The light of a star is cancelled out by means of destructive interference in a tiny photonics chip. One of the challenges is the star light injection into the chip. This is done by a unique active system that optimises the injection and provide low order correction for the atmospheric turbulence. We are reporting on the latest progresses following several tests on the Anglo Australian Telescope.



Bio

Tiphaine receiver her Masters in Physics and Photonics from Lund University, Sweden in 2014. Tiphaine is currently working on her PhD at the Sydney Institute for Astronomy, University of Sydney, NSW, Australia.

Taking Science to Industry: Changing Print as we know it

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After more than a decade of research and development, The Centre for Organic Electronics (COE) at the University of Newcastle delivered their first public demonstration of printed solar. This took the form of an installation designed to engage the print industry in thoughts about their industries future at PacPrint Melbourne 2017.

PacPrint is Australia's most comprehensive and relevant business-to-business print industry event held once every four years where more than 12,000 industry professionals meet to talk print in the Asia-Pacific region. It includes over 8,000 square meters of state-of-the-art printing equipment and technology.

Leveraging the ANFF funded and supported pilot-scale roll-to-roll printing facilities at the University of Newcastle, the COE team produced a walk-through demonstration that allowed visitors to see, touch, and truly engage with printed solar technology. PacPrint was the perfect setting to begin a conversation with the print industry around this new technology, their role in its development, and more broadly the potential for the industry to transition into the functionalized printing space.

This project is an excellent example of ANFF facilities and staff spanning the gap between basic research and product development. The ANFF team at Newcastle supported the initial experimentation, helped develop the fabrication methods, and have been critical in formulating pre-conditions for commercial-scale printed solar operations.

As a result of this project, Australia's first commercial test installation of printed solar is being developed with CHEP, a multinational pallet and container pooling services company, to truly make and measure the opportunities for commercial application.

Bio
Dr Dickinson began his career designing sets and special effects for television and film production. He then undertook commercial product design, notably chairs and light fittings. His diverse and practice-oriented career has made him adept at finding design solutions to problems, which feeds into his teaching of studio and theory-based design courses. Dr Dickinson has lectured and supervised students at both undergraduate and RHD levels and has presented and exhibited both his design thinking and design practice at national and international forums. His primary research interest centers on the relationship between design practice and design theory. He has also conducted research in the areas of industrial product design, glass materials processing, design for robotics, and the theoretical principles underpinning design.

Compact integrated actively Q-switched waveguide laser

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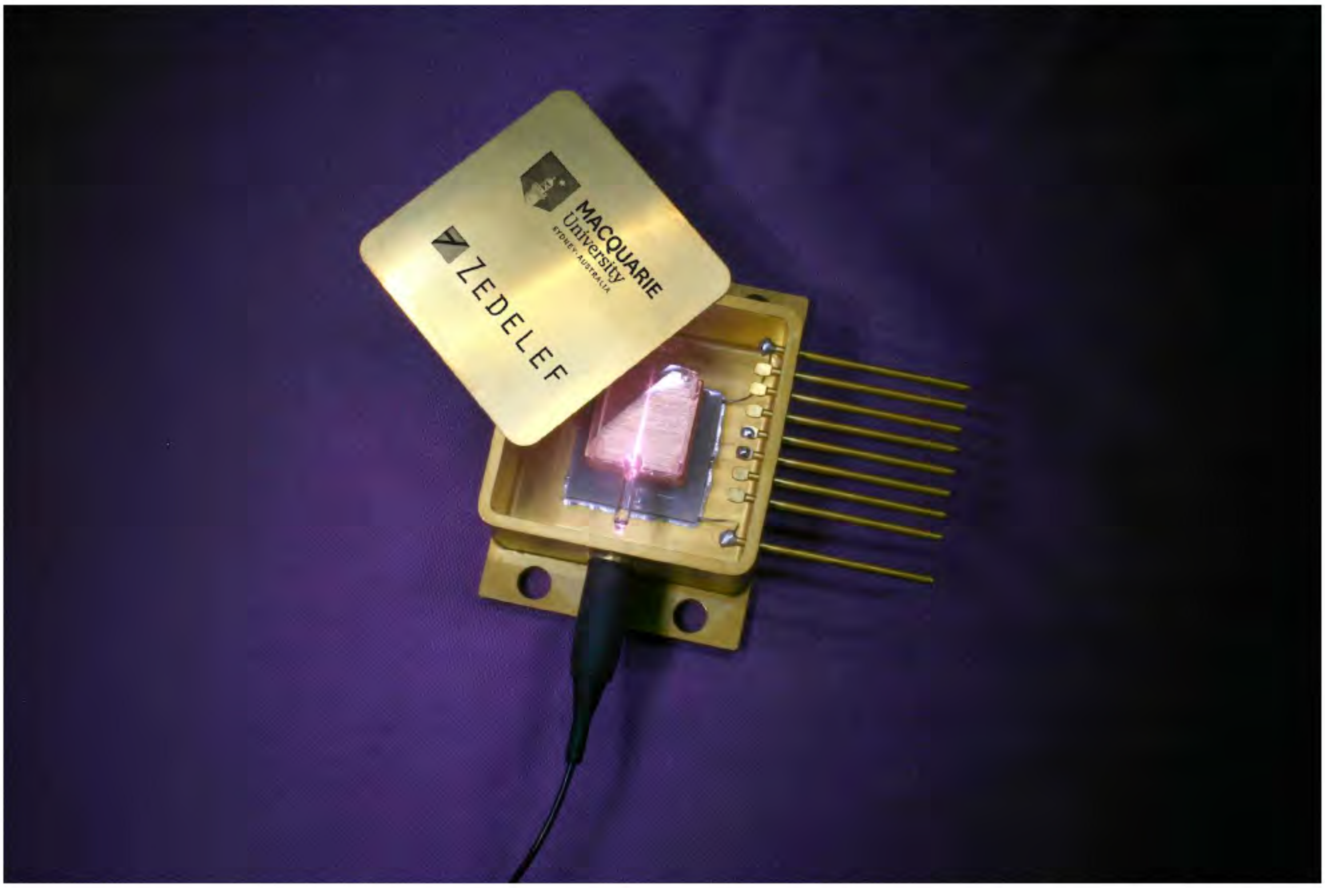
We have recently designed and demonstrated a new class of fully monolithic, actively Q-switched waveguide chip lasers. By marrying optically pumped waveguide lasers (Macquarie) with ferro-electric liquid crystal modulators (UNSW), ultra-compact short-pulsed laser sources capable of generating peak power levels in excess of 100 W at repetition rates ranging from single-shot to hundreds of kHz have been realised. The integrated and miniaturised nature of these new sources combined with their extraordinary versatility makes them attractive candidates for a range of application fields which prompted us to protect the invention by a patent and to seek industrial partners for future commercialisation.

Interestingly, both of the above-mentioned underlying technologies were originally developed within the confine of ANFF. OptoFab at Macquarie supported the waveguide chip efforts while the UNSW node sustained the development of liquid-crystal based transducers originally designed for sensing applications and now used as the Q-switching mechanism.

The next steps of the project seek to greatly improved on the early prototypes being developed by laying the foundation for a full understanding of the lasing dynamics and to investigate the most promising aspect of the system's parameter space. We will report on the latest developments.

Bio

Prof François Ladouceur graduated from ANU and held a number of position both in academia (ANU, LÉTI) and in the private sector (Virtual Photonics Pty Ltd, Bandwidth Foundry Pty Ltd) before joining UNSW in 2005. Prof Ladouceur has been an active participants in the Australian photonics landscape for 25 years and currently is involved in optical sensing with special enphasis on translation activities.



Artistic representation of a monolithic, low-power, actuve Q-switched laser as developed in the context of this case study. Credit: Mr Christoph Wieschendorf (Macquarie University).

Graphene Bolometer for VIS-IR Spectral Range on Nano/Micro SiN Membranes

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We propose a high sensitive bolometric detectors for visible and infrared wavelengths based on a novel assembly principle of a monolayer graphene on a nano/micro SiN membrane. The basic operating principle of optical detectors relies on the absorption of electromagnetic radiation in a photosensitive element, where its energy is converted into an electronic signal. Hence, detection efficiency is directly related to the efficiency of the optical absorption process. Recent photocurrent graphene based detectors demonstrated strong photoresponse signal near graphene/metal boundaries. Here at the Melbourne Centre for Nanofabrication (MCN), we demonstrate a metal-graphene-metal bolometer on a micrometer-thin SiN membrane for the first time. A main point regarding SiN membranes are their high quality factor (up to 10^6-10^7), low mass and excellent optical properties, regardless of the temperature gradient enhancement mechanism. Two different types: lithography-free and high precision bolometers defined with electron beam lithography and lift-off are demonstrated. The two demonstrated modalities of bolometer fabrication via 1) lithography-free and direct write Ag-electrodes and 2) high-precision EBL write (Vistec EBPG5000plusES) on a micrometer-thick membrane followed by depositing dissimilar metal (Ag and Pd) contacts by using e-beam evaporation (Intlvac Nanochrome II) shadowing technique, which was carried out at a 60 degree tilted orientation of the membrane sample, opens new possibilities in miniaturisation of bolometers. A new capability to embed such spectrally broad bolometers in integrated sensing/detection systems including those 3D laser printed are promising future direction of this first study.

Bio

Soon Hock is a SIEF STEM+ business fellow at Swinburne University of Technology. He completed his BSc and BEng at Monash University, where he also completed his PhD in 2016, with a focus on lithography and the self-assembly of nanoparticles. He began working at the Melbourne Centre for Nanofabrication as a Process Engineer in the latter half of 2016 before perusing postdoctoral research in the Centre for Micro-Photonics at Swinburne University of Technology in early 2017. His interests include self-assembly of nanoparticles in lithographically defined templates, PVD and RIE of nanostructured thin films and recently, porous silicon.

The New JEOL F200 Analytical S/TEM at UNSW

Richard F Webster, Soshan Cheong and Richard D Tilley

The JEOL F200 was installed and commissioned at UNSW in early 2017. This was the first of this model to be installed in a research institution worldwide. This state of the art transmission and scanning transmission electron microscope provides atomic resolution imaging, nanoscale element mapping and chemical analysis. It provides an enhancement in data quality and is a valuable addition to the existing facilities at UNSW.

The F200 has a lattice resolution of 0.16 nm in ADF STEM imaging and 0.1 nm in TEM mode at 200 kV. Major features of this microscope include: a high brightness cold field emission gun; a 100 mm^2 silicon drift X-ray detector that enables efficient EDS spectra and elemental mapping at resolution of approximately 0.5 nm; a high tilt holder (±80°) and TEMography software that allow the acquisition of high angle tilt series for tomography in TEM, STEM and EDS imaging modes.

This talk will demonstrate the capabilities of the microscope and present some of the latest work including EDX analysis of catalytic nanoparticles and thin films.

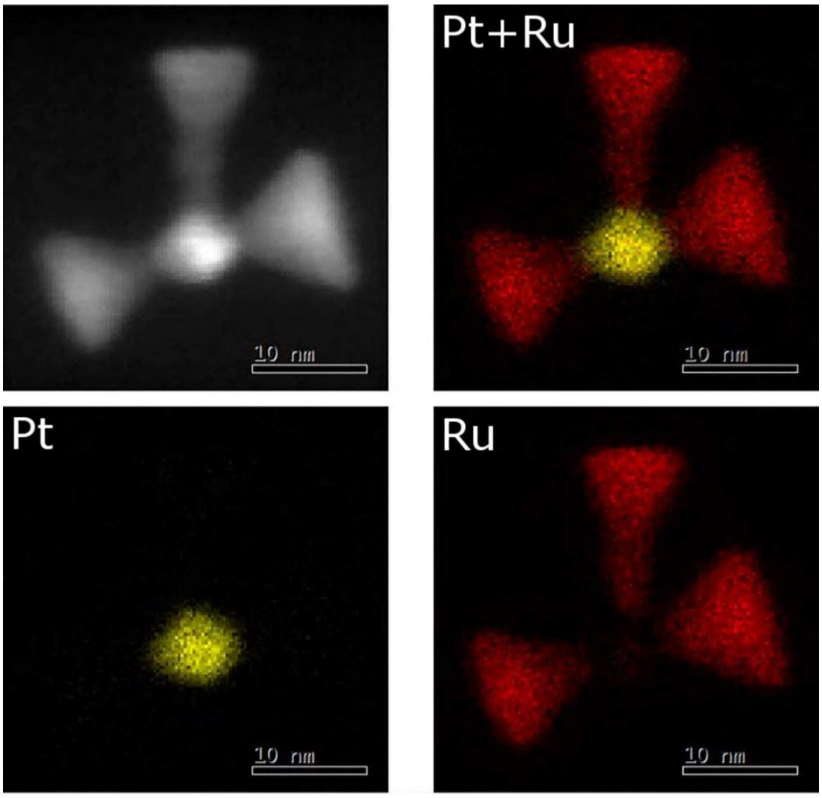

Figure 1. HAADF STEM and elemental EDX mapping of Pt nanocubes with branched Ru growths.

Bio

Originating from the north east of England, Richard F Webster read physics at the University of Bristol, graduating in 2011 with an MSci (hons). Continuing at Bristol to complete a PhD thesis in 2015 entitled "Transmission Electron Microscopy of Indium Gallium Nitride Nanorods" and under the supervision of Prof. David Cherns. Richard moved to Sydney in Jan 2017 to work in the Electron Microscopy Unit at UNSW as a Research Associate running the new JEOL F200 S/TEM.

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2017 Research Showcase Abstract Submissions

The atomic scale structure of human dental enamel

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Human dental enamel, the hardest tissue in the body, plays a vital role in protecting teeth from wear as a result of daily grinding and chewing as well as from chemical attack. It consists of a mineral phase, mainly in the form of highly oriented ribbon-like nanowires of carbonated hydroxyapatite. It is well established that enamel mechanical strength and fatigue resistance is derived from its hierarchical structure, which consists of periodically-arranged bundles of HAP nanowires. However, we do not yet have a full understanding of the HAP crystallization process that leads to this structure. It was recently proposed that magnesium (Mg) ions play a critical role in the stabilization of this amorphous calcium phosphate (ACP) phase and the formation of the HAP mineral, where surface Mg ions retard the growth of HAP crystals, leading to the nanometer-sized HAP crystallites.

Laser-assisted atom probe tomography (APT) was used on rodents tooth to reveal the presence of Mg in the ACP phase as well as an iron based ACP phase in pigmented enamel, rendering it harder and more resistant to acid attack. Inspired by this work, we studied the diffusion of iron in human tooth enamel using an iron-rich solution treatment and its impact on the enamel resistance to acid attack using SEM microscopy.

Bio

Florant Exertier recently graduated from a master's degree in engineering and material science. After participating to an article on atom probe tomography applied to a geology-based topic, he is working at the Australian Microscopy and Microanalysis Research Facility, focusing on APT work.

In-situ micro-pillar compression of CoCrNi-based medium-entropy alloy

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Medium entropy alloys (MEAs) are an emerging class of multi-component metallic system that offer high strength and ductility compared to conventional metallic materials. In this present study, we have investigated micro-mechanical properties of CoCrNi-based MEA, deposited on steel substrate as 5 um thick coating, with the help in-situ mechanical testing instrument. The morphology of the materials is a face-centred-cubic (FCC) solid-solution with a high density of stacking faults and strongly textured nanometre-sized columnar grains. Micro-pillars with diameters ranging from 2 μm to 300 nm and length to diameter ratio of 2.5:1 were produced by focused ion beam (FIB) milling and in-situ compressed using a flat-punch was carried out with the help of Hysitron nanoindentor. Such in-situ compression shows real time deformation of materials and helps to correlate materials' response with corresponding stress-strain curves. The coatings show extraordinarily high yield strength levels of i.e., 4-4.5 GPa, which is about 3-3.5 times higher than that of their bulk counterpart, considerably improved ductility (compressive plastic strains over 30%) as well as low size dependence. Nanoindentation results show the Hardness and Young's modulus of this coating are 10.4 GPa and 282 GPa, respectively. Such enhanced mechanical properties could be associated with mechanical twinning and staking faults formations in deformed micro-pillars, which in turn increase lattice resistance caused by localized distortion at atomic length scales as well as precipitation strengthening. This was confirmed with transmission electron microscopy investigation on the deformed micro-pillars.

Bio

Currently working as a dual beam (FIB) engineer at Adelaide Microscopy at the University of Adelaide.

Power-free Textile-based Microfluidic Pumps

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In recent decades, microfluidics has had an indisputable impact on the field of public health and medical diagnostics. However their use has been very limited due to their reliance on trained personnel and expensive supporting infrastructure which is not feasible in areas with poverty. Significant research has been carried out to find inexpensive materials for developing low-cost diagnostic devices deliverable to the remote regions of the world. Textiles with their outstanding characteristics have been found to be excellent candidates for making simple, scalable and mass producible microfluidic analytical devices.

In this work, for the first time, 3D textile structures comprising of commercial polyester threads and low-density polyethylene(LDPE)/liquid crystalline graphene oxide (LCGO) composite fibres have been introduced as low-cost power-free textile-based microfluidic pumps.

ANFF fabrication facilities underpinned fabrication of novel 3D textile-based self-wicking microfluidic pumps. LDPE/LCGO composite fibres were made using a twin-screw extruder system to extrude filaments of about 150-200 µm diameters. Subsequently, these spun fibres were converted into 3D tubular knitted structures (Fig. 1a) in parallel with a commercially available polyester thread. The wicking properties of these structures have been investigated by measuring the amount of water displacement between two reservoirs connected with a pre-concentrated textile structure (Fig. 1b) at different times. Fluid moved faster using 3D knitted structure comprised of composite fibres. Moreover, flow rate was proportional to the loading of LCGO into LDPE, i.e. higher the LCGO loadings, higher the flow rate.

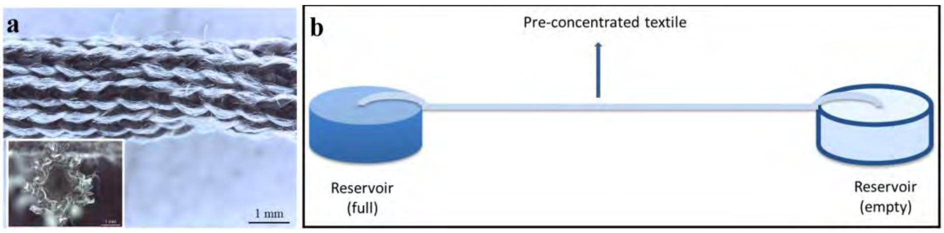

Fig. 1. (a) 3D knitted structure (inset: cross-section view) and (b) schematic of the wicking experiment

Bio

Syamak Farajikhah received his BSc and MSc in Textile Engineering from Amirkabir University of Technology in 2008 and 2010, respectively. Then he joined the Colour Research Group of department of Textile Engineering as a part-time researcher until 2014. Currently, he is studying his PhD at the Intelligent Polymer Research Institute (IPRI) at the University of Wollongong (UOW). His research is focused on development of 3D textile structures for microfluidics to develop low-cost diagnostic devices.

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Highly Sensitive and Wearable E-skin with Ultrathin Gold Nanowires

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Future electronic devices will evolve from current 1st generation rigid system to 2nd generation invisible and stretchable electronics. However, it remains challenging to achieve ultrahigh electrical stretchability, ultrathin device dimensions and optical transparency into a single type of device. One-dimensional (1D) nanomaterials should be a pathway to achieve these unique features simultaneously, owing to their intrinsically high-aspect-ratio that enables the construction of conductive percolation network with small amount of material usage while maintaining high optoelectronic performance. Moreover, 1D nanostructures have better mechanical elasticity than corresponding bulk materials or sphere-like nanoparticles and this is a key requirement for designing electronic skin materials by circumventing material delamination and/or cracking.

Compares to other 1D nanomaterials, which are straight with high persistence length, ultrathin gold nanowires (AuNWs) are serpentine at the nanoscale behaving like "polymer chains" due to their ultrathin nature (2 nm in width, with an aspect ratio of >10 000). Hence, ultrathin Au NWs is intrinsically stretchable thus showing great promise to be used for stretchable and transparent electronic devices. Here, we developed several E-skin devices including wearable pressure sensors, stretchable strain gauge sensors, transparent electrode and supercapacitors based on ultrathin AuNWs, which showed great promise for future invisible and stretchable electronics in bio-monitoring applications.

Bio

Shu Gong is a Research Fellow at Monash University, Australia, under the supervision of Professor Wenlong Cheng. He received his B.S. from Central South University, China, in 2011, and his Ph.D. from Monash University in 2017. At Monash University, his research interests include the development of soft electronics based on nanomaterials.

Stretchable optical and electrical fibres for wearable technology

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Affiliations

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There is a growing need to instantaneously obtain information of one's wellbeing. Wearable technology in the form of accessory devices like smart watches or chest straps is the current status in today's market. However to revolutionise wearable technology for medical health monitoring or measuring performance of elite sportsmen, these sensing devices need to be embedded seamlessly into clothing. They have to withstand the rigors of body movement (stretching, twisting and compression forces), external environment (temperature and moisture) and daily usage (folding and washing). To meet these criteria, we have fabricated optical and electrical fibre sensor made from polyurethane using the scalable process of fibre drawing, to dimensions suitable for weaving into clothing of 150 µm. The mechanical constraints of traditional glass and polymer optical fibre sensors means that they can measure strains of only 1% and 15% respectively. By comparison polyurethane fibre sensors can potentially stretch 600%. Furthermore, they are extremely sensitive to minute perturbations, such as a heartbeat. Simulating the force of a heartbeat using the vibrations of a speaker, we measured the frequency response of these polyurethane fibre sensors optically at 655 nm. A sensitivity of 23.3 dB/N was recorded, making it suitable to detect very small forces of ~ 0.09 N. We have also inserted tungsten wires into the polyurethane fibres to detect compression electrically, measuring a resonant frequency change of 0.56MHz over 1.15mm of deformation. Embedding unique sensing capabilities of polyurethane fibre sensors into clothes will make smart clothing a common part of daily fashion.

Bio

Richard Lwin has researched photonics and optics for 13 years at the University of Sydney. After completing his PhD in 2007 investigating the optimisation of the microstructured polymer optical fibre fabrication process at the Optical Fibre Technology Centre, he continued as the technical officer of specialty optical fibre fabrication at the School of Physics, Institute of Photonics and Optical Science at the University of Sydney. He was also one of the founders of the spin off polymer optical fibre company, Kiriama Pty. Ltd. between 2009-2014. He is currently the facilities manager of the polymer optical fibre fabrication unit for the OptoFab Node of the Australian National Fabrication Facilities. His research includes the fabrication of microstructured optical fibres and metamaterials.

Wearable Smart Textile

Javad Foroughi

Intelligent Polymer Research Institute, ARC Centre of Excellence for Electromaterials Science, University of Wollongong, Wollongong, NSW, 2522, Australia;

Highly stretchable and electrically conductive polyurethane (PU) - multi-walled carbon nanotube (MWNT) composite structures were prepared by developed knitting procedure. The latter involves continues incorporation of MWNT sheets in a set of elastic polyurethane filaments followed by knitting the filaments into three-dimensional (3D) textiles with electrical conductivity of 870 to 7092 S/m that substantially depends on material strain. Mechanical and electrical properties of textiles were found to be highly repeatable for applied strains as large as 100% enabling to achieve the gauge factor in the range 0.61 – 8.8. Dimensional changes of textiles can also be induced by Joule heating with electrical current to provide functionality of knitted artificial muscles. Observed tensile strains up to 30% at work capacity of 2.19 (KJ/Kg) generated by the muscles are highly beneficial for diverse motion control applications. The combination of strain sensing with the ability to control linear dimensions of the material can be used for smart clothing that provides features of monitoring and adjustment to moving structures or human body. Developed procedure is scalable for the fabrication of industrial quantities of smart textiles.

Dr Javad Foroughi received the B.S. and MS degree in textile engineering from Isfahan University of Technology, Isfahan, Iran, in 1997 and the PhD degree in material engineering from University of Wollongong, Australia in 2009. He is currently working as ARC senior research fellow at Intelligent Polymer Research Institute, University of Wollongong, Australia. His research interests include Nanomaterials, Electromechanical actuators ("artificial muscles") using inherently conducting polymers and / or carbon Nanotube, bionics and novel fibres spinning and the use of these in the development of smart materials and electronic-textile.

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