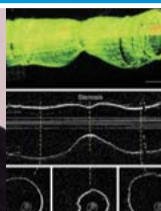
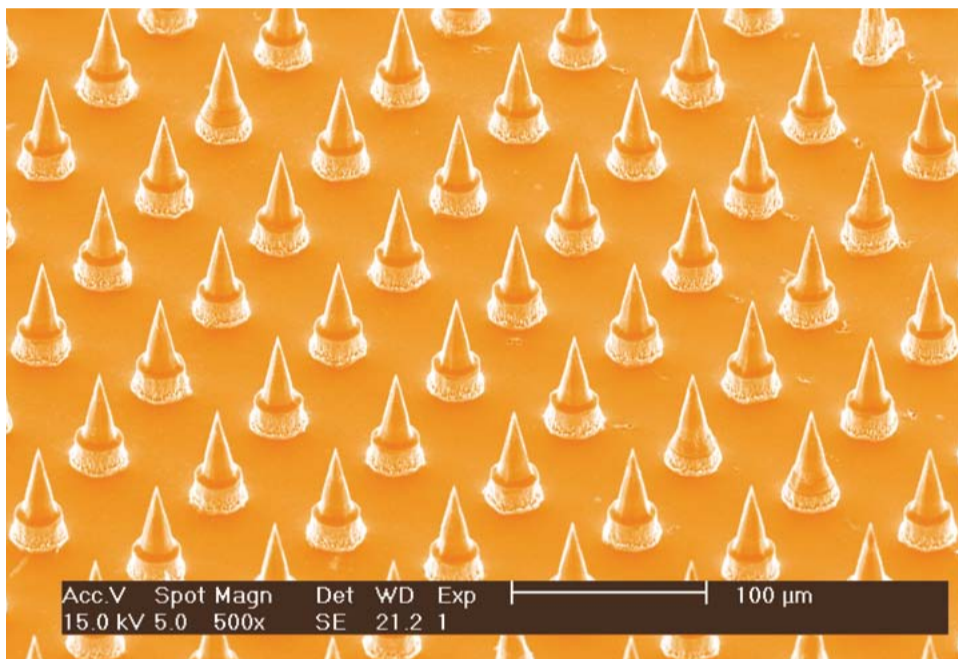


Solar-powered nanosensors
How to make an athlete hungry
In-house characterisation provided to ANFF



Extending capability in WA
Spreading the knowledge
Technique: fringe benefits

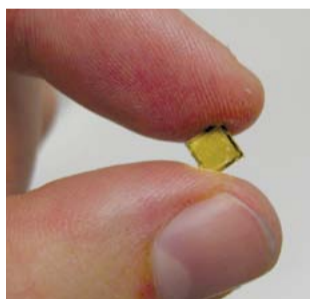
RESEARCH



Major investment for nanopatch vaccine technology

UQ New company Vaxxas Pty Ltd has attracted a \$15 million investment, one of the largest biotech investments in Australia, to enable University of Queensland (UQ) researcher, Prof. Mark Kendall to continue his pioneering research and development of the Nanopatch.

Vaccination is a key preventative medicine strategy essential to reducing, and ultimately eliminating, infectious diseases. Most vaccinations still rely on the needle and syringe but major drawbacks exist with syringe-based vaccination programs, particularly in developing regions. Liquid vaccines need to be kept cold and the lack of reliable refrigeration causes a high percentage of vaccinations to fail. The high risk of needle-stick injuries is also especially problematic where HIV is widespread.



The skin is one of the primary barriers protecting the body and, compared to the muscle, where most vaccines are currently delivered, contains an abundance of specialised antigen-presenting cells (APCs). When foreign substances, including disease-causing viruses or bacteria, do penetrate the skin, the APCs spring into action to establish an immune response. Prof. Kendall and his team are

directly targeting these cells in a completely new approach to vaccination. Their nanopatch is covered with thousands of tiny projections dry-coated with vaccine. The silicon projections are designed to pierce the tough outer layer of cells and enter the skin just far enough to directly target the APCs. When the dried vaccine hits the moist cellular environment it dissolves off the patch right into the clutches of the waiting APCs. The patch only needs to stay on the skin for a minute or less to be effective.

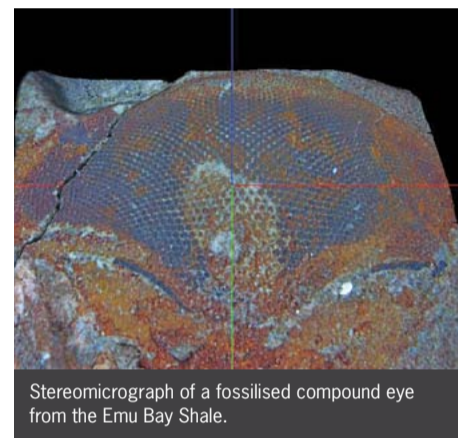
Prof. Kendall's team are regular users of scanning electron microscopy at the AMMRF at UQ and their work has been published widely including recent papers in *PLoS ONE* and *Journal of Controlled Release*.

The nanopatches are painless and, because the vaccine is delivered directly to the APCs, much less is required to give the same level of response, greatly improving efficiency. The dry-coating process ensures that the vaccine-coated patches retain full potency for long periods of time without refrigeration. This feature alone is likely to have a major impact on the effectiveness of mass vaccination programs, especially in developing countries. ■

Ancient insect eyes

SARF Research work published this month in the prestigious journal, *Nature*, by Michael Lee and colleagues, has used microscopy done at the AMMRF, University of Adelaide, to identify the structure of fossilised insect eyes from the early Cambrian period, approximately 515 million years ago. The beautifully preserved fossils were found in the Emu Bay Shale on Kangaroo Island in South Australia and are the oldest and best-preserved non-biomineralised eyes found so far.

Results reveal that these early insects had highly advanced compound eyes, similar in complexity to those of modern insects. Similarly advanced eyes have previously only been found in fossils from 85-million years later. These Emu Bay eyes are likely to have



Stereomicrograph of a fossilised compound eye from the Emu Bay Shale.

belonged to an active predator capable of seeing in low light.

This work provides significant evidence that the development of more highly specialised vision was a driving force for the rapid evolution of many animal groups that occurred during the Cambrian period, the Cambrian explosion. ■

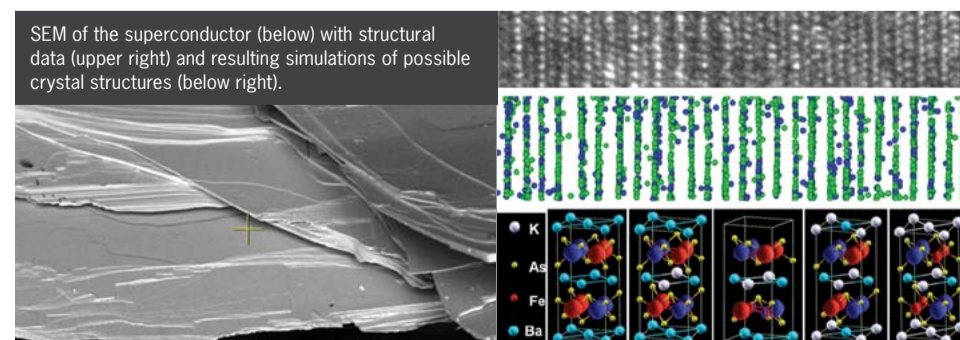
Probing atoms to understand superconductivity

USyd Superconductors are specific materials where electrical currents flow without any energy loss, but only when they are kept below a critical, and usually extremely low, temperature. Mysteriously, some unusual superconductors also appear to exhibit magnetism.

AMMRF scientists, Drs Rongkun Zheng and Waikong Yeoh have led a team investigating this property. Their collaborators are from the AMMRF at the University of Sydney, the University of Wollongong and the Max Planck Institute in Germany. They have recently published their exciting results in *Physical Review Letters*.

They used atom probe tomography at the AMMRF, Sydney, to look at the 3-D arrangement

of individual atoms in one of these newly discovered superconductors, a potassium-doped BaFe_2As_2 . Their results, and subsequent simulations, showed that the potassium dopant atoms are not uniformly distributed within the material and that the way they are arranged in the crystal lattice determines the relative spin density around the iron atoms and therefore the characteristics of the magnetism. It is also the arrangement of the potassium atoms in the lattice that determines the electronic structure of the material, which is critical for the superconductor's performance. By showing how magnetism and superconductivity can survive harmoniously in these new materials, a very important advance in superconductor science has been made. ■



RESEARCH

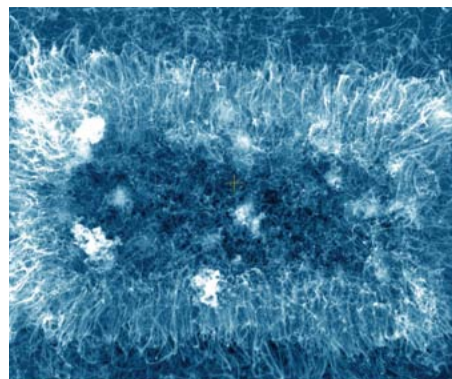
Solar-powered nanosensors

QUT A Queensland University of Technology (QUT) rooftop is the first test site in an international study on solar-powered environmental nano-sensors. The sensor monitors concentrations of three gases responsible for climate change and pollution: ammonia, from fertilisers and cattle manure, nitrogen dioxide from engines and combustion, and nitrous oxide from the ground and fertiliser breakdown and 300 times more potent as a greenhouse gas than carbon dioxide. The sensors will soon be deployed around Queensland.

The project is led by A/Prof. Nunzio Motta from QUT and aims to develop a new class of gas sensors for data collection in remote

areas. The new sensors are cheap, small and require very little energy to work. They achieve this performance through the use of integrated nano-materials and state-of-the-art solar cells using technology from Dyesol.

The sensing materials are nanowires of silicon dioxide and zinc oxide, and carbon nanotubes sensitised with zinc oxide. Their highly active surfaces and large surface-to-volume ratio are ideal for gas sensing. The focused ion beam instrument at the AMMRF Linked Lab at QUT has been used to prepare the sensors, making small holes in silicon and silicon dioxide substrates where catalytic metallic growth seeds collect and direct the



growth of an ordered arrangement of nanotubes and nanowires. This can be seen in the image above.

Once implemented, the system will wirelessly transmit data to collection points so no human intervention will be needed to monitor pollution and greenhouse gases in the environment. ■

How to make an athlete hungry

UWA Many athletes immerse themselves in icy-cold water after exercise to help promote recovery. However, it has now been found that bathing in cold water after exercise increases the appetite. Led by Dr Kym Guelfi, researchers from the University of Western Australia (UWA) studied trained men who completed 40 minutes of treadmill running followed by 20 minutes of either cold water immersion (15°C); neutral water immersion (33°C) or no immersion. The men were then given access to a meal from which they could eat and drink as much

as they liked. It was found that the men consumed more kilojoules following immersion in both cold and neutral water compared to no immersion.

Flow cytometry at the AMMRF, UWA, enabled hormones in the blood of the athletes to be analysed showing that leptin (which signals fullness) was reduced following cold water immersion, while after neutral water immersion, ghrelin (which signals hunger) levels were raised. These changes in appetite are an important consideration for athletes using water immersion as a method of



recovery from exercise both in terms of weight management and optimising post-exercise nutrition. Their work has just been published in *Medicine & Science in Sports & Exercise*. ■

COMMUNITY

In-house characterisation provided to ANFF

The University of Sydney node of the AMMRF has recently located one of its scanning electron microscopes (SEM) within a clean room at Bandwidth Foundry International (BFI) – a facility that forms part of the OptoFab node of the Australian National Fabrication Facility (ANFF).

BFI provides prototyping facilities and services to developers of photonics integrated circuits, MEMS devices, semiconductor development platforms, microfluidic chips and biosensor circuitry. The SEM relocation will enable researchers and BFI staff to characterise sensitive samples within the clean room and comes a time when BFI has added significant capability through the installation



of a new ASML PAS5500/100 i-Line Stepper.

Providing SEM capability to BFI users further highlights the close relationship between fabrication and characterisation and extends the collaborative linkages between the AMMRF and ANFF. This cross-capability initiative will see the AMMRF maintain the instrument and train users in conjunction with BFI staff who will ensure appropriate

procedures for access are maintained.

"Characterisation – and especially microscopy, is emerging as the critical metrology for many fabrication processes. I am delighted that we are able to work with the BFI and the broader ANFF team to enable this approach for better photolithography fabrication" says AMMRF Executive Director, Prof. Simon Ringer. ■

AMMRF meets parliament

Prof. Simon Ringer, Executive Director and CEO of the AMMRF and Prof. Martin Saunders, Deputy Director of the University of Western Australia node, recently went to Canberra for Science Meets Parliament. Convened by

Science and Technology Australia, (previously FASTS), this activity provides an opportunity for members of parliament (MPs) and scientists to talk directly to each other.

Prof. Ringer and Saunders found the event

extremely valuable with excellent networking opportunities. High-profile research outcomes, the importance of research infrastructure and the benefits of collaborative research networks were highlighted to MPs and delegates. ■

EXECUTIVE DIRECTOR'S COLUMN

The AMMRF team is strongly committed to partnerships and this is evident throughout this issue. In many respects, the success of the AMMRF is directly related to our capacity to forge successful strategic partnerships and I'd like to highlight several recent initiatives.

We are all delighted that David Sampson and his colleagues from the AMMRF at UWA have forged a unique link between our facility and the National Imaging Facility (NIF) based around micro-magnetic resonance imaging and X-ray tomography – areas of clear synergy between microscopy and imaging. In Sydney, further connections between the Australian National Fabrication Facility and the AMMRF are shaping up in the form of a joint laboratory at the Bandwidth Foundry International (BFI). We have installed a scanning electron microscope that will double as an electron beam lithography tool and a metrology tool for users and customers of the BFI. We have also initiated a project with the Multi-modal Australian ScienceS Imaging and Visualisation Environment (MASSIVE). Based at Monash University it aspires to be the primary Australian high performance computing facility for computational imaging and visualisation. A project around atomic-resolution microscopy using the flagship atom probe capability is also underway.

More broadly, the characterisation community continues to collaborate on delivering the 2011 national characterisation roadshows during the week of October 24. This brings together the AMMRF, Australian Synchrotron, National Deuteration Facility and NIF to promote our capabilities to the national research community. For the first time, the roadshows will focus on Sydney and Canberra, hosted by the University of Western Sydney, and the Australian National University, respectively, so keep an eye on ammrf.org.au for precise dates.

Inter-facility collaboration is also apparent in the National Characterisation Council submission to the DIISR research infrastructure roadmap. It is pleasing to see that the exposure draft, recently released by DIISR, identifies eResearch and Characterisation as the two capability areas where there are clear connections with each of the national research priorities. The AMMRF strongly endorses this view and we look forward to the roadmap providing enhanced opportunities to better connect our people and instruments to the leading research projects of the nation.

Simon Ringer Executive Director & CEO

COMMUNITY

Extending capability in WA



The AMMRF node at the University of Western Australia (UWA), the Centre for Microscopy, Characterisation and Analysis (CMCA), has recently expanded to include a number of additional characterisation facilities around the university. This has boosted the range of instrumentation and expertise offered through the node to include nuclear magnetic resonance (NMR), X-ray diffraction and mass spectroscopy.

The incorporation of the three facilities, and associated staff members, into the AMMRF extends and complements existing characterisation capabilities at the node in a way that benefits all Australian researchers.

The ten instruments include four high-field NMR spectrometers that provide the

capability to study the structure, dynamics and interactions between organic molecules. Two diffractometers enable single-crystal structure determination, with the more powerful instrument enabling the structure of very small crystals and poorly diffracting materials to be elucidated. Four mass spectrometers make it possible to analyse complex chemical mixtures where only a limited amount of sample is available.

With the instruments we are delighted to welcome to the AMMRF the three existing facility managers, Drs Lindsay Byrne, Tony Reeder and Brian Skelton who together bring over 60 years experience in the characterisation of molecular compounds. You can read more about each of them on the back page. ■



Spreading the knowledge

Two workshops in very different areas have recently helped AMMRF staff and users to extend and transmit their expertise.

An AMMRF masterclass workshop on Non-Destructive High Resolution X-Ray Microtomography and Live Animal Imaging was held at the AMMRF, University of Adelaide, in May. It was organised by Adelaide Microscopy and the invited speakers, including AMMRF staff, A/Prof. Allan Jones and Dr. Agatha Labrinidis (whose work appears on the cover below), provided comprehensive coverage of the theory and practice of X-ray microtomography, including in-vivo and in-vitro applications, standards, parameters, analysis, 3-D rendering, 3-D visualisation software, and live-animal biophotonic imaging.

The Workshop facilitated discussion between researchers and was a unique opportunity for the Australian community of

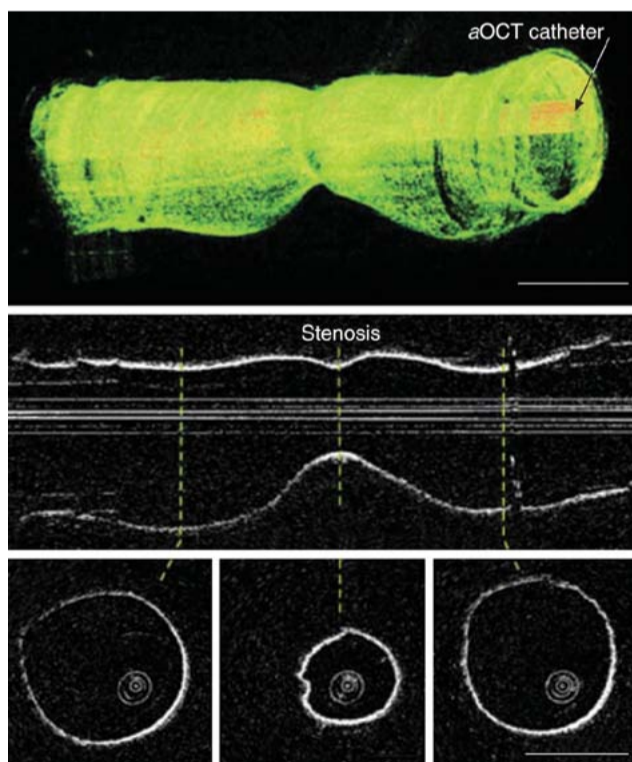
X-ray microtomographers to share their ideas, problems and approaches to varied samples.

The other significant workshop was the recent EELS School, the first of its kind to be held in Australia. The event was hosted by the AMMRF Linked Laboratory at RMIT University (RMITU) and run by Gatan. It attracted approximately 20 participants, including staff and students from all the AMMRF nodes and several other universities. The workshop covered practical and theoretical aspects of electron energy-loss spectroscopy and energy-filtered TEM, with lectures, microscope sessions and computer laboratories spread over three days.

Prof. Martin Saunders from the AMMRF at the University of Western Australia and Prof. Dougal McCulloch from the AMMRF at RMITU contributed through lectures and discussions on applications of this technique in the physical and biological sciences. ■



TECHNIQUE



Fringe benefits

Microscopy and microanalysis are characterisation methods directed largely to imaging and the determination of positionally specific information from samples at the sub-centimetre scale. However, those in the field tend to have their own assumptions about what is and is not

microscopy or microanalysis. There are many techniques being developed that sometimes fit and sometimes don't fit within the assumed definition of 'microscopy and microanalysis'. However, it is interesting to consider peripheral, but related and potentially useful, additions to the characterisation arsenal.

One such technique is optical coherence tomography (OCT). Used widely in ophthalmology, it relies on differential reflection of near-infrared radiation from the surface 1–2mm of tissue providing much higher resolution than ultrasound techniques. A team from the Optical + Biomedical Engineering Laboratory (OBEL)

at the University of Western Australia have extended the range of applications for this technique by developing an endoscopic optical scan head that enables long-range OCT scanning to map internal anatomy of hollow organs such as the airways. The probe head is encased in a 2.2mm catheter that can be inserted into

a patient's lower airway. The head can rotate within the catheter to give a full view of the anatomy without being detectable by the patient during the period of evaluation, even when that is during sleep. This feature has enabled the team to image the airways of sleeping patients with sleep apnoea.

The UWA group have used what they have called anatomical OCT (aOCT) to measure the diameter of airways in 43 human volunteers. The subjects included both healthy controls and patients with a range of pathologies including asthma, chronic obstructive pulmonary disease (COPD) and bronchiectasis. By varying the air pressure delivered to the anaesthetised subjects, they were able to quantify the change in airway size and then estimate compliance of the airway walls. This work was recently published (with cover and editorial) in the *American Journal of Respiratory and Critical Care Medicine*.

Prof. David Sampson, Director of the AMMRF node at UWA and Head of OBEL, said "We're very proud of this work. It's been great to see the team take it from initial design of the scanner, through development of a prototype system, to performing clinical trials, and finally to get recognition in the leading journal in this field." ■

The DMS has arrived

Data storage has progressed from the days of photography when negatives were stored in cupboard to the digital age when we become ever more connected. Data in the cupboard is being replaced by data in the cloud. The recently completed Data Management System (DMS) will help put it there in a meaningful form.

To make microscope data useful it has to be described and catalogued so it can be searched and understood – it has to have metadata stored with it. The AMMRF in collaboration with Intersect, has completed a NeAT-funded project that resulted in the deployment of the DMS on its micro-CT and atom probe platforms at the University of Sydney node.

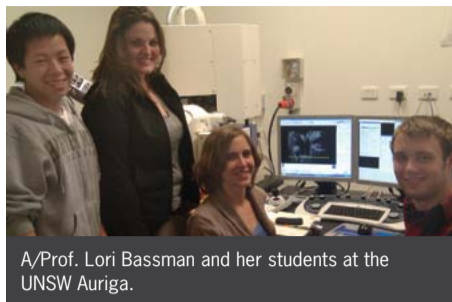
The DMS automatically collects the instrument metadata, combines it with provenance data from the instrument booking system and creates a searchable catalogue that other researchers can access. It moves the raw data to secure storage and can even publish the data in national searchable archives. An ANDS-funded project is currently adding advanced light microscopy platforms to the DMS. Opportunities to deploy the DMS to other nodes are being investigated. ■

COMMUNITY

AMMRF in India

The Electron Microscopy Society of India this year celebrates its 50th anniversary. To mark the occasion, the Society organised its largest-ever conference in Hyderabad from July 6–8. 20 invited international delegates joined 500 local participants and addressed the conference. Prof. Martin Saunders, Deputy Director of the AMMRF at UWA gave a plenary lecture on ‘Structural and chemical analysis at the nano-bio interface’, which showcased his projects that apply advanced TEM techniques to biological research.

He then visited the Indian Institute of Science (IISc) in Bangalore presenting a seminar and discussing the development of research collaborations between UWA and IISc including a scheme to establish PhD projects where IISc students can do part of their project at the AMMRF’s UWA node. ■



A/Prof. Lori Bassman and her students at the UNSW Auriga.

New FIBs in focus

AMMRF nodes at the University of Sydney and the University of New South Wales (UNSW) have each recently installed new, high-powered focused ion beam instruments as a result of a successful joint LIEF grant in 2010. The New Auriga instruments are proving very popular with users due, at least in part, to their improved performance. They are very high-resolution instruments both for imaging and for milling, where a precision down to a few nanometres can be achieved. This is especially true at lower ion beam energies allowing users to gently shape and clean samples for TEM or atom probe applications without inducing any damage. The better ion beam also makes it possible to mill away material at faster rates than other instruments, resulting in increased throughput.

The new instruments can automate many procedures, including TEM sample

EVENTS

Microscopy exhibition @ Questacon

The AMMRF presents *Incredible Inner Space*, an exhibition of stunning micrographs in Australia’s premier science venue. The exhibition will run from November to late January with an expected audience of about 150,000 people. It aims to arouse curiosity and wonder

in viewers of all ages, encouraging them to find out more about the stories behind the images.

This exhibition also supports the federal government’s Inspiring Australia initiative to increase and improve the public’s engagement with science.

ACMM22, ICONN2012 and APMC10 join forces

This combined conference will take place in the Perth Convention & Exhibition Centre, WA, 5–9 February 2012. More info and registration at: microscopy.org.au/ACMM-22



preparation, allowing the system to work during the night, running through routine tasks without the need for an operator. Many tomographic options exist producing image stacks using the standard ‘slice and view’ routines and analysis of crystallographic and chemical variations in 3-D using the electron backscatter diffraction (EBSD) and energy dispersive spectroscopy capabilities.

The UNSW instrument has been an attraction for a visiting academic within the School of Materials Science and Engineering at UNSW. A/Prof. Lori Bassman, was awarded, jointly with Prof. Michael Ferry and Dr. M. Zakaria Quadir, a National Science Foundation grant

to bring her engineering students from Harvey Mudd College, California to Sydney to use 3-D EBSD on the new instrument in order to investigate aluminum and nickel materials following their deformation and recrystallisation. ■

The AMMRF is funded by



An Australian Government Initiative
National Collaborative Research
Infrastructure Strategy



STAFF NEWS

Ms Aoife McFadden has joined the team at Adelaide Microscopy as a scanning electron microscopist, solution ICPMS and BET surface area analyst. She graduated from Flinders University with a BTech in Forensic and Analytical Chemistry and an Honours degree in Chemistry. Since then she has acquired knowledge and experience while working in the minerals group at the SA Museum.

Dr Agatha Labrinidis is the newest member to join Adelaide Microscopy. She has come from a research position within the University of Adelaide investigating new agents against bone cancer using animal models and the micro-CT and fluorescence/bioluminescence imager. Her recent appointment as microscopist will see her working in fluorescence, confocal and multiphoton microscopy and small animal imaging.

Dr Hongwei Liu received his PhD and did postdoctoral work at Nanjing University in China characterising thin films and nanomaterials. After teaching at Guangxi University, Hongwei joined the Queensland University of Technology as a research fellow. In late 2010, he visited the Australian Centre for Microscopy & Microanalysis (ACMM) to make use of the transmission electron microscopy (TEM)

facilities. In April, Hongwei started as TEM Specialist to support and train users.

Dr Takanori Sato graduated from the University of Canterbury (UC), Christchurch, with a BE(Mech) 2004 and a PhD in 2009 on light alloys. Before joining the ACMM in May this year, he lectured at UC and kept the electron microscopes running. He will soon be putting his skills in teaching and microscopy to good use as he trains users in atom probe tomography.

Dr Tony Reeder graduated with a BSc(Hons) in synthetic organic chemistry from UNSW. After a stint in the paint and mining industries, he completed a PhD in pharmacy at the University of Sydney followed by a postdoc in the Biochemistry Department, Royal Prince Alfred Hospital, Sydney. Tony has run UWA’s mass spectrometry facility since 1994 and his recent research interests focus on human and animal metabolomics.

Dr Lindsay Byrne completed his PhD at UWA and has managed their NMR facility for over 30 years. In addition to NMR studies in organic and organometallic chemistry, his research interests cover NMR applications in a wide range of disciplines including biochemistry, engineering, soil science, botany, medicine and marine archaeology.

Dr Brian Skelton completed a PhD at The University of Auckland, NZ before taking a postdoctoral position at UWA. Following a stint at the University of Sussex he returned to UWA in his current role as manager of crystallography facilities. Brian has published more than 1200 scientific papers and is a highly cited researcher. His major research focuses are in small molecule crystallography and X-ray diffraction.

Dr Dave Adams has an MSc in igneous petrology and volcanology from Baylor College, Texas and a PhD in geology from Oregon State University. Dave became familiar with electron microprobe analysis during his studies, bringing back to life Baylor College’s old AMRAY AMR-1000. Prior to joining CMCA, Dave worked with the US Geological Survey in Denver, Colorado in the Denver Microbeam Laboratory. He is also knowledgeable on SEMs and FIBs.

Dr Lecia Khor joins the CMCA as a post-doctoral research fellow, having graduated from UWA in 1998 with a PhD in geochemistry. Lecia was then employed at Cirrus Logic in the USA where she managed the electron and focused ion beam laboratories. She then worked as a product development scientist for PharmaForm LLC but now returns to UWA to investigate solid state and structural chemistry.

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