



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

CREATE CHANGE

CENTRE FOR
MICROSCOPY AND MICROANALYSIS

ANNUAL REPORT 2018

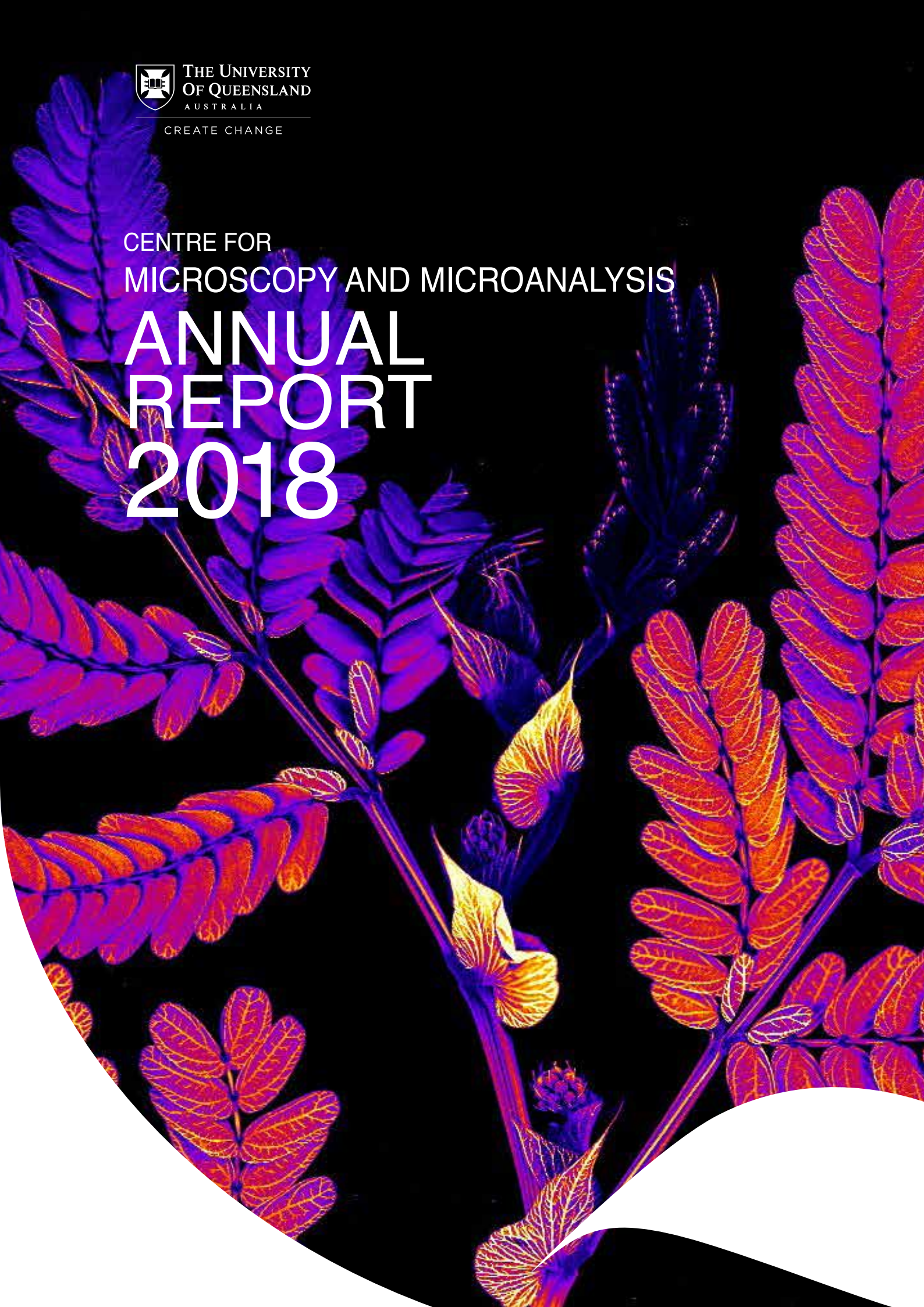
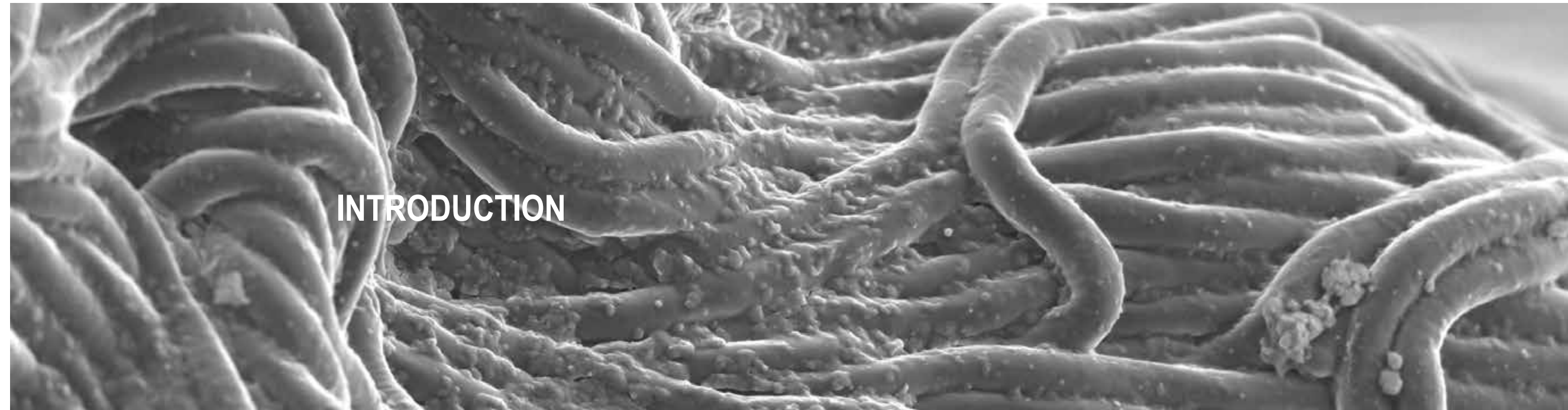




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INTRODUCTION

The Centre for Microscopy and Microanalysis (CMM) is an interdisciplinary research, teaching and service centre. We play an integral role within the research programs of The University of Queensland and participate in both undergraduate and postgraduate education. We provide a comprehensive suite of analytical instrumentation and a high standard of training programs for the research community, including scientists from industry & business, government and not for profit organisations. Our highly experienced, specialist staff are committed to providing a supportive and resourceful working environment where clients receive expert advice and training that equips them to achieve their research goals.

CMM is a foundation member and the Queensland Node of Microscopy Australia (MA - formally AMMRF), which was established in July 2007 under the Commonwealth Government's National Collaborative Infrastructure Strategy (NCRIS).

CMM actively supports and initiates microscopy and microanalysis related research and development projects with the aim to maintain future technological competitiveness for UQ. CMM is also in charge of the renewal of instruments to ensure the optimal balance in instruments dedicated to general education, professional training, service and research and to further enable research projects beyond the current frontiers.

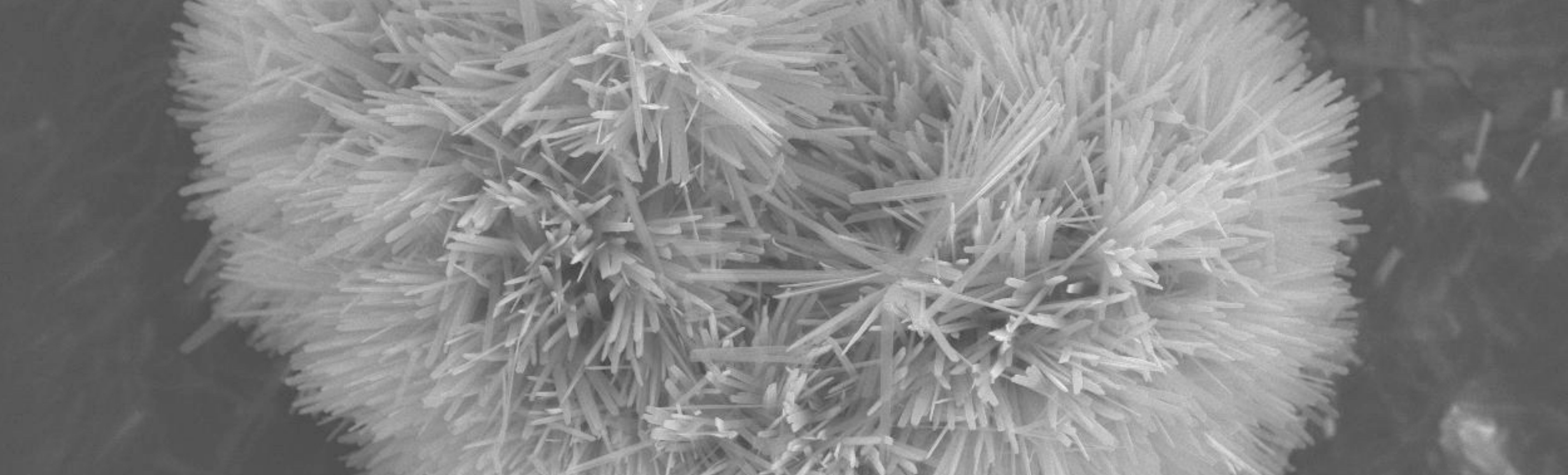
CMM reports directly to the Faculty of Science and is governed by a Director (Roger Wepf), a Deputy Director for scientific services (Kevin Jack) and Deputy Directors for scientific strategy in life-science (Robert Parton) and material science (Jin Zou). They also act as CMM ambassadors in their disciplines. CMM has an independent interdisciplinary Scientific Advisory Board (Head: Robert Parton), representing the different research interests at UQ. An internal Steering Committee acts in an advisory capacity and has final approval authority for all major proposed research and services.

VISION

The Centre for Microscopy and Microanalysis is a research facility dedicated to an understanding of the structure and composition of all natural and fabricated materials across different scales. Our challenge is to meet present needs of researchers and local industry for microstructural characterisation and to equip The University of Queensland to meet new horizons in analysis research.

MISSION

Our service to the research community is provided in three key areas, namely a comprehensive suite of analytical instrumentation, strongly motivated and experienced personnel and a high standard of training programs for our clients. Our highly experienced, specialist staff are committed to providing a supportive and resourceful working environment where clients receive expert consultation, advice and training that equips them to achieve their research goals.



INTRODUCTION

MESSAGE FROM THE DVC (RESEARCH)



It gives me great pleasure to introduce the 2018 Centre for Microscopy and Microanalysis Annual Report.

The release of UQ’s new Strategic Plan 2018-2021 acknowledges the challenges facing society. It is clearly a time when we need to adapt and have a positive impact that will leave a global legacy.

UQ’s vision is to impart **knowledge leadership for a better world**. This is imperative as we strive for greater research endeavours and respond to future global challenges.

As a university in the world’s top 50 universities, we have set ourselves the task of positively influencing society. We do this by engaging in the pursuit of excellence – through the creation, preservation, transfer and application of knowledge. This is UQ’s mission, and through this we will educate and graduate future leaders in their fields.

UQ’s research community is at the forefront of discoveries that impact the challenges facing society. The analytical power and capability of CMM is at the core of many of UQ’s research outcomes. CMM’s reach extends into engineering, science, environmental, biomedical, quantum materials and computation and the list goes on.

Over the last 12 months, CMM has taken exemplary steps to further build its reputation both in Australia and internationally as a leader in microscopy and microanalysis. The arrival in 2018 of new state-of-the-art equipment including the Hitachi HF5000 cs-S/TEM for atomic resolution imaging and characterisation, Electron Beam Lithography systems for quantum computation and nano-patterning research as well as new X-ray scattering systems, represent just a few of the infrastructure changes occurring in CMM.

This investment in infrastructure is an investment in our future. We must provide our researchers with the tools to allow them to continue exploring and finding solutions to societal challenges. We cannot do this without the right tools.

Professor Wepf and his executive team are aware that tools alone are not enough. CMM’s dedicated commitment to training its clients including many early career researchers from UQ and beyond is commendable. Giving the researchers access to tools and the skill sets to successfully operate them lies at the core of CMM’s mission.

2018 represents the last year that CMM will be supported under the Faculty of Science. The establishment of the Central Research Platform (CRP) will see CMM move into this structure

coordinated under the new Pro-Vice Chancellor (Research Infrastructure), Professor Joe Shapter. Through this research facilities initiative, UQ can focus its major infrastructure commitments to ensure we are centrally targeting our investments and outcomes.

On behalf of UQ I extend my thanks to the entire CMM team, as well as their collaborators and partners across UQ and in industry and government, for their vital contributions in 2018.

Professor Bronwyn Harch
*Deputy Vice-Chancellor (Research)
and Vice-President (Research)
The University of Queensland*

INTRODUCTION

MESSAGE FROM THE DIRECTOR

2018 saw tremendous achievements as we continued our journey to improve laboratory facilities, install state of the art equipment and provide our research and industry stakeholders with equipment that meets international analytical trends.



- » The Material Science Hawken Laboratory (p 30) – provided the new home for a cs-S/TEM HF5000 from Hitachi (Inauguration p 58/59), a dedicated clean room suite for two EBL systems from Raith, including a resist sample preparation area, and a small scientific instrument prototyping space to explore future analytical capabilities. This is now complete and the laboratory was again fully operational as of September 2018.
- » The X-ray Material Characterisation Laboratory (p34) – with a larger and dedicated equipment space hosting a new experimental SAXS/WAXS beam-line and scanning XRF tool, an offspring of a collaboration between iXRF and the Novel Imaging Group of CMM, as well as hosting two Faculty of Science X-ray Diffraction tools. This laboratory has been fully operational again since October 2018.

The CMM2.0 strategy introduced in 2016/17 to assess and build on our microscopy infrastructure saw CMM expand its microscopy and microanalysis capacity to a world-class research platform (see laboratory profiles from p26 on). This platform provides cutting-edge micro-, nano- and atomic material characterisation and structuring to allow it to partner UQ researchers, Queensland industry and small to medium enterprises. The arrival of new state-of-the-art equipment for quantum computation, nano-patterning research and new X-ray scattering systems, represent just a few of the infrastructure changes occurring in CMM. You will find more in this annual report and coming up in 2019.

Furthermore the other laboratories explored their own frontiers e.g. in 2018 the 'Life science and Soft Matter Laboratory' at the AIBN (p28) installed its new volume imaging SEM a Thermo/FEI Apreo Volumscope and successfully launched it with the Australian Cancer Research Foundation (ACRF) as part of the joint ARCF Cancer Ultrastructure and Function Facility

with IMB. The QBP and UQ ROCX Laboratory explored the future of a structural biology program for UQ and Queensland and the teams look forward to completely refurbished labs in 2019, hosting three dedicated cryoTEM and other capabilities to come to UQ for a dedicated macromolecular structure research facility – watch this space in 2019.

The investment in infrastructure is a clear statement from UQ into all of our futures as we provide our researchers with the tools to allow them to continue exploring and finding solutions to our world challenges. CMM has taken the first step in this endeavour and for 2019 we foresee a strong focus on maximising the potential, performance, and capabilities of our frontier instruments. We will further consolidate our new laboratories to ensure that we continue to be a strong partner for research undertaken at UQ.

I am aware that tools alone are not enough and we have to invest into exploring know-how, expertise and knowledge of our dedicated expert staff and other people on this journey. Moreover, CMM staff are dedicated to training its clients (from p48 on) from UQ and the private sector, and continually explore new capabilities to provide researchers access to new and old tools with the right skill sets to successfully operate the instruments.

I would like to invite all to take advantage of these impressive resources. Researchers can access each of CMM's laboratories, and help us, as part of this new 'work in progress', to establish a 24/7 access 'modus operandi' from 2019 onward.

UQ's research community is at the forefront of discoveries that impact the challenges facing society and our world. The analytical power and capability of CMM is at the core of many of UQ's research outcomes. CMM's reach extends into engineering cutting-edge materials, basic science,

environmental, biomedical, computational science and the list goes on as you can see from the publication list (p 68...) and some of our impact stories (p 60...).

Last but not least I would like to draw your attention to two new developments at CMM in 2018 – the first are partnerships with scientific instrument builders and suppliers – Scitek and Hitachi/Newspec - which we highlight on page 24/25. More partnerships will commence in 2019.

Secondly, in our new 'work for access' program/partnership, CMM offers leading and selected scientists (p 22/23), with no current access to state-of-the-art equipment at their home institution, the possibility to work in one of the laboratories in exchange for instrument hours.

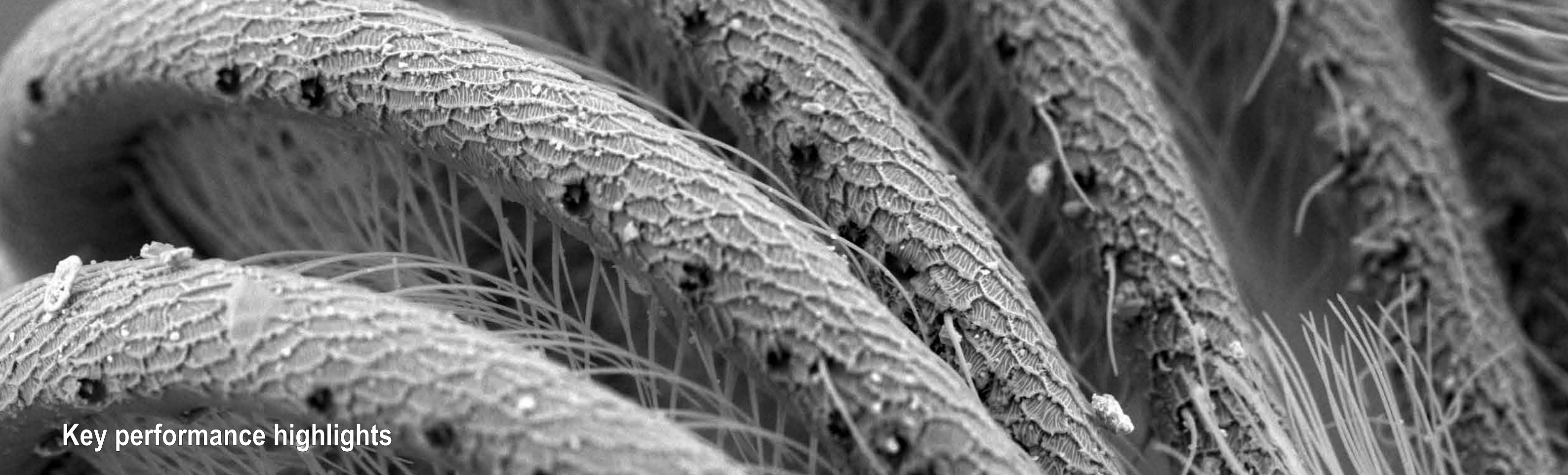
Finally, I would like to thank all centre staff for their excellent and outstanding support and contribution throughout 2018. Without their help these new impressive resources would not exist.

Our 2018 success comes with the strong support of UQ's Faculty of Science. Our special thanks go to the Faculty's Executive Dean Professor Melissa Brown and all of the Faculty of Science management and professional team. This was the last year CMM is under the umbrella of the Faculty of Science. As Professor Bronwyn Harch's noted in her welcome message, CMM moved to the UQ Central Research Platforms at the end of 2018.

I hope you enjoy the 2018 Annual Report and the highlighted research projects.

Professor Roger Wepf

Director CMM - Scientia ac Labore



Key performance highlights

CMM users

50,000+
instrument hours
163% from 2017

4,500+
assisted hours

459
CMM users
132% from 2017

Research output

296
journal articles;
36 published in
journals with an
IF >10

2
book
chapters

5
conference
papers

6
*papers in
the top 1%

34
*papers in
the top 10%

Training

312
attendees at
training courses

48
training
courses

112
clients trained
one on one

499
inductions
across 6
facilities

Outreach

28
invited talks
given by
CMM staff

18
workshops
organised

552
workshop
attendees

3
major public
events

Projects

420
active projects

52
finalised projects

International

48
international
collaborating
organisations

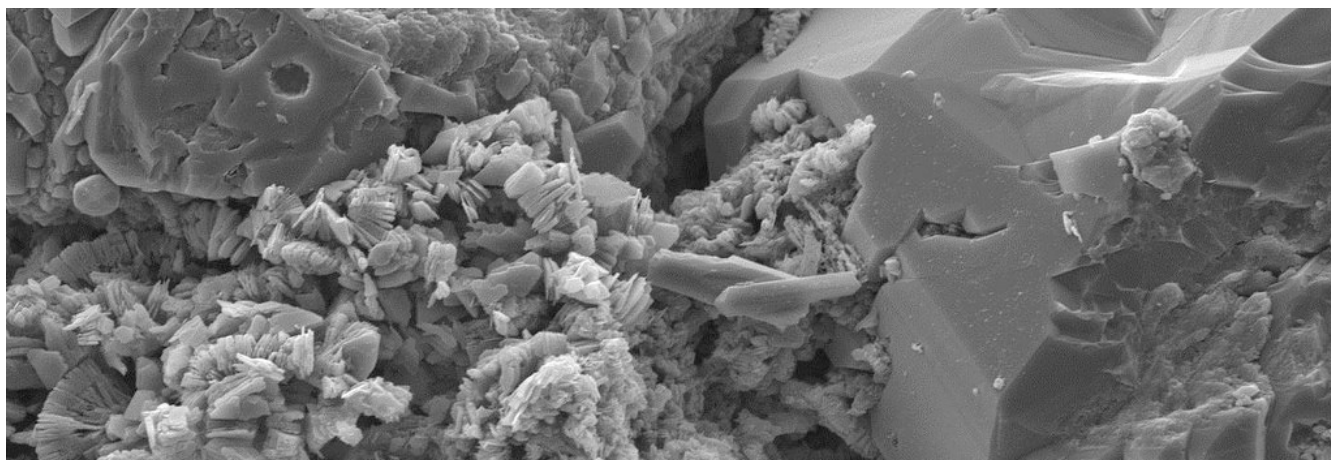
12
international
visitors

12
visits to overseas
institutes

**Worldwide for their subject area and age (Incites, March 2019)*

TEAM

SCIENTIFIC ADVISORY BOARD

**Professor Ian Brereton, UQ**

Professor Ian Brereton, is Director, Research and Technology, at the Centre for Advanced Imaging; Director, Queensland Node, National Imaging Facility and Director, Queensland NMR Network. Professor Brereton is responsible for research infrastructure and facility management at CAI. He has over 30 years' experience in the application of NMR imaging and spectroscopy to the chemical and biomedical sciences. Research activities utilise MR methods for understanding the molecular basis of biological function and disease, informing the development of new diagnostic imaging technologies and approaches to therapy. He teaches the next generation of imaging scientists and technologists, coordinating fundamental MR imaging courses within Master programs in MRT, MI and MR-PET.

**Professor Stephen Blanksby, QUT**

Stephen Blanksby completed his PhD (1999, U. Adelaide) in the field of gas phase ion chemistry before undertaking postdoctoral research in Europe (1999, TU Berlin) and the USA (2000-2002, U. Colorado). He held a faculty position in the School of Chemistry at U. Wollongong (2002-2013) before accepting the position of Director of the Central Analytical Research Facility at the Queensland University of Technology (2014-). Stephen's research is focussed on the structure and reactivity of ions in the gas phase with applications in analytical mass spectrometry. He has published over 150 peer-reviewed articles, serves on the editorial boards of a number of leading journals and is currently secretary of the International Mass Spectrometry Foundation.

**Professor Ian Gentle, UQ**

Professor Ian Gentle joined The University of Queensland in 1993 and is currently Professor of Physical Chemistry in the School of Chemistry and Molecular Biosciences. He has served in a number of leadership roles including Head of Science of the Australian Synchrotron in 2008-2010, Associate Dean (Research) in the Faculty of Science (2013-2018) and Deputy Executive Dean, Faculty of Science (2015-2018).

OVERVIEW SCIENTIFIC ADVISORY BOARD

In 2017 CMM formed a Scientific Advisory Board to guide the future development of the Centre. The Board develops and discusses the future strategic plan and resources for CMM, based on users' future needs. Members of the Board provide scientific and technical guidance in the fields of emerging technology, applications of microscopy and microanalysis, and procedures for each of CMM's facilities. The Board is chaired by CMM's Deputy Director Robert Parton.

**Professor Peter Hayes, UQ**

Professor Hayes is Professor of Metallurgical Engineering within the School of Chemical Engineering. He is currently the Metallurgical Engineering Program leader and is senior researcher in the Pyrometallurgy Research Group (PYROSEARCH). He received his PhD from the University of Strathclyde in Glasgow, Scotland, in 1974.

**Dr Ruth Knibbe, UQ**

Dr Knibbe's research interests are in materials for energy generation and storage with specific interest in electrochemistry and electron microscopy. She received her PhD in Chemical Engineering from UQ in 2007. She then spent four years at DTU-Energy (Danish Technical University) and subsequently five years at the Robinson Research Institute at Victoria University of Wellington. Dr Knibbe's interests are concerned with: in-situ methods for characterising fuel cell and battery materials, the application of machine learning in new material design, development of new materials for Li-S battery systems and understanding degradation mechanisms in fuel cell and battery systems.

**Dr Stephen Love, UQ**

Dr Stephen Love has been Director of Research Infrastructure at UQ for the past 3 years. He has 14 years of research infrastructure and facilities managerial experience, eight of these at UQ. He was a Researcher in the Institute for Molecular Bioscience (IMB), from where he transitioned into management of Research Infrastructure at the Australian Institute for Bioengineering and Nanotechnology (AIBN), and most recently, the Translational Research Institute (TRI). He has been leading laboratory implementation, providing strategic management and advice, in the development of infrastructure systems and services. His knowledge of research facilities and infrastructure in the higher education sector spans three decades and three countries.

**Professor Roland De Marco, USC**

Professor Roland De Marco has been Deputy Vice-Chancellor (Research and Innovation) at The University of the Sunshine Coast (USC) since 2016 after taking up the position of inaugural Pro Vice-Chancellor (Research) at USC in 2011. Prior to his roles at USC, he served as Professor of Chemistry and Associate Deputy Vice-Chancellor (Research Strategy), Dean of Research in Science and Engineering and Head of Chemistry at Curtin University from 2001-2011. Throughout all of his leadership roles, both past and present, he has maintained an active research profile leading a small group focussed on the characterization of electromaterials, especially chemical sensor, fuel cell and electrocatalyst materials. Since 2015, he has held Honorary Professorships in the School of Chemistry and Molecular Biosciences at UQ and the Fuels and Energy Technology Institute at Curtin University.

TEAM

SCIENTIFIC ADVISORY BOARD

***Professor Darren Martin, UQ***

Professor Darren Martin is a global leader in polyurethanes, polymer nanocomposites and renewable nanomaterials, with a proven track record in “end-to-end innovation”. The Martin Group takes fundamental discoveries and learnings in materials science and biology and progresses the science, engineering, regulation and translation of these technologies for the benefit of Queensland and Australia. Current active platforms include the unique cellulose nanofibres from Australian spinifex arid grasses, and organosilicate nano additives being commercialised by the AIBN spin-out company TenasiTech Pty Ltd.

***Professor Fred Meunier, UQ***

Professor Frederic Meunier was the recipient of a European Biotechnology Fellowship and went on to postgraduate work at the Department of Biochemistry at Imperial College (1997-1999) and at Cancer Research UK (2000-2002) in London, UK. After a short sabbatical at the LMB-MRC in Cambridge (UK), he became a group leader at the School of Biomedical Sciences at The University of Queensland in 2003. He joined UQ's Queensland Brain Institute in 2007 and is currently part of the Centre for Ageing Dementia Research.

***Associate Professor Peter Noakes, UQ***

Associate Professor Peter Noakes is investigating the cell and molecular mechanisms that underlie the development and breakdown of the neuro-motor system. His laboratory works on the following: 1) cell and molecular mechanisms surrounding the establishment of neuromuscular and motor neuron (CNS) synapses. 2) The generation and development of motoneurons in health and in disease (e.g. motor neuron disease (ALS)). 3) The role of innate immune system in motor neuron health and disease. His laboratory employs biochemistry, immuno-histology, electrophysiology, live cell imaging, behaviour, cell and molecular biology to study these issues.

***Professor Gordon Southam, UQ***

Professor Gordon Southam received his BSc (Honours) and PhD in Microbiology from the University of Guelph. He joined the Departments of Earth Science and Biology at the University of Western Ontario when he was appointed Canada Research Chair in Geomicrobiology (2001-2011), and Director of the Centre for Environment and Sustainability (2010-2012). In 2012, Professor Southam joined the School of Earth Sciences at The University of Queensland as the Vale-UQ Geomicrobiology Chair.

***Professor Jenny Stow, UQ***

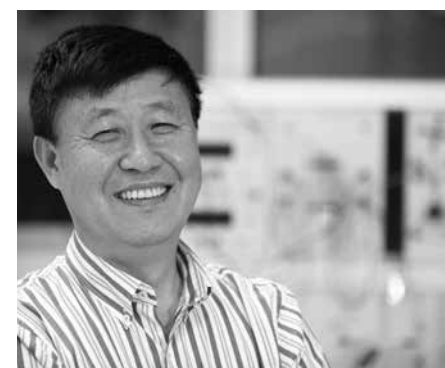
Professor Jenny Stow undertook postdoctoral training at Yale University's School of Medicine as a Fogarty International Fellow. She was soon appointed Assistant Professor in the renal unit at Massachusetts General Hospital, where she established an independent research group in cell biology. She returned to Australia in 1994 as a Wellcome Trust Senior International Fellow to join UQ's Centre for Molecular and Cellular Biology (now IMB). Professor Stow leads her own IMB laboratory.

***Professor Lianzhou Wang, UQ***

Lianzhou Wang is Professor in the School of Chemical Engineering and Director of Nanomaterials Centre, the University of Queensland. His research focuses on the synthesis and application of semiconductor nanomaterials for use in renewable energy conversion/storage systems including photocatalysts, rechargeable batteries and low cost solar cells. Wang received his PhD degree from the Chinese Academy of Sciences in 1999. Before joining UQ in 2004, he worked at two leading national research institutions (NIMS and AIST) of Japan as a research fellow for five years. Since joining UQ, he was an ARC Queen Elizabeth II Fellow (2006), Senior Lecturer (2007), Associate Professor (2010), and since 2012 a Professor in the School of Chemical Engineering, and Senior Group Leader in the Australian Institute for Bioengineering and Nanotechnology, UQ.

***Professor Paul Young, UQ***

Professor Young completed his PhD at the London School of Hygiene and Tropical Medicine and was appointed to a lectureship in the University of London in 1986. He returned to Australia as Senior Research Fellow at the Sir Albert Sakzewski Virus Research Centre in 1989 and joined The University of Queensland as a Senior Lecturer in 1991. He is the current President of the Australian Society for Microbiology and the President of the Asia Pacific Society for Medical Virology.

***Professor Huijun Zhao, GU***

Huijun Zhao is a Professor and the Director of the Centre for Clean Environment and Energy at Griffith University. He has expertise in energy and environmental materials, water source control and management systems, field-based sensing technologies and aquatic environmental quality assessment. One of his current pursuits is to explore new means to unlock the catalytic powers of non-precious materials as high performance catalysts for important catalysis reactions.

TEAM EXECUTIVE

The Executive Committee develops pathways to achieve CMM's strategic goals for the nearby and long term future.

All four members of the Executive sit on the Advisory Board, which is chaired by Robert Parton.



PROFESSOR ROGER WEPF
DIRECTOR

Professor Roger Wepf's research direction leads to developing tools for integrative imaging and spectroscopy to explore new frontiers in structure research. For example, he seeks to develop connectivity between cryo-microscopes and other characterisation tools via cryo- or inert-gas transfer for best sample protection and for correlative imaging and analytics. With his team he explores Imaging Spectroscopy and Mass Spectrometry for cellular biology and 4D STEM for material science and soft matter science applications.



A/ PROFESSOR KEVIN JACK
DEPUTY DIRECTOR OPERATIONS

Associate Professor Kevin Jack's broad research interests are in the understanding of structure-property-performance relationships in a range of materials; that is, the use of molecular level findings and understanding to direct the development of better performing materials, devices or chemical processes.



PROFESSOR ROB PARTON
DEPUTY DIRECTOR LIFE SCIENCES

Professor Parton's research focuses on the cell surface and, in particular, on the structure and function of caveolae. Caveolae are small pits in the plasma membrane which have been linked to tumour formation and muscular dystrophy. He is investigating the role of caveolae in cell physiology and their exploitation by pathogens.



PROFESSOR JIN ZOU
DEPUTY DIRECTOR
MATERIAL SCIENCE

As a Chair in Nanoscience, Professor Zou's research interest has been focused on the understanding of the evolution of advanced, smart and nano-scaled materials and the understanding of fundamental properties of these materials.



TEAM

CMM STAFF

Director

- » Professor Roger Wepf

Deputy Directors

- » Prof Robert Parton
- » Prof Jin Zou
- » A/Prof Kevin Jack

Life Science & Soft Matter
(at AIBN Laboratory)

- » Mr Richard Webb (Manager)
- » Dr Graeme Auchterlonie
- » Ms Robyn Chapman
- » Dr Hui Diao
- » Mr Han Gao
- » Mr Qian Sun
- » Ms Rachel Templin[#]

[#] Received PhD and left CMM for a Postdoc position in February 2018

Material Science Microscopy
(at Hawken Laboratory)

- » Mr Ron Rasch (Manager)
- » Ms Heike Bostelman
- » Dr Elliot Cheng
- » Ms Eunice Grinan
- » Dr Kim Sewell
- » Ms Ying Yu
- » Dr Zibin Chen

Novel Imaging Technologies
(at Hawken Laboratory)

- » Professor Roger Wepf (Manager)
- » Dr Lachlan Casey
- » Dr Elliot Cheng
- » Dr Brett Hamilton

Structural Biology
(at QBP Laboratory)

- » Dr Matthias Floetenmeyer (Manager)
- » Dr Kathryn Green
- » Dr Erica Lovas

UQROCX Crystallography
(at QBP Laboratory)

- » Mr Karl Byriel (Manager)
- » Dr Gordon King

X-ray Material Science & Spectrometry
(at Chemistry Laboratory)

- » A/Prof Kevin Jack (Manager)
- » Dr Lachlan Casey
- » Dr Barry Wood
- » Ms Anya Yago

Service Support Unit

- » Ms Celestien Warnaar-Notschaele (Manager)
- » Dr Rubbiya Ali
- » Ms Wendy Armstrong^{*}
- » Mr Robert Gould
- » Mr Andrew Stark
- » Ms Jennifer Brown
- » Mr Travis Hagstrom

^{*} Retired November 2018

Affiliates

- » Dr Bronwen Cribb
- » Emiritus Professor John Drennan
- » Dr Justin Kimpton
- » Professor Toshiyuki Mori

TEAM

SERVICE SUPPORT UNIT



TEAM

CMM SERVICE SUPPORT UNIT

The brief of the Support Service Unit (SSU) is to ensure that all CMM staff have the resources to complete their work properly. To this end each member of the unit has their own specialty.



CELESTIEN WARNAAR
CENTRE MANAGER

Ms Celestien Warnaar leads the SSU team and assists the Director behind the scenes. Celestien's responsibilities are many and varied, including procurement, maintenance contracts, all HR needs, finance, events, and visitors.

Not surprising then that she names her biggest challenge as juggling each deadline to ensure nothing falls through the cracks. However, it is this constant juggle of a variety of tasks that keeps the job interesting and challenging.

Of top priority to Celestien is the welfare of all staff members, ensuring that they are looked after properly and have the resources they need to work in a pleasant environment.

Celestien graduated with a Masters in Spanish Language and Literature from the University of Leiden. In The Netherlands she taught Spanish for five years until moving to Australia, where she retrained as a business administrator in Melbourne.



RUBBIYA ALI
DATA INFORMATION MANAGER

Dr Rubbiya Ali is CMM's data information manager. She is involved in the development of new data management systems that will assist with the continuous flow of information between the instruments and the client.

Specific duties include image processing and analysis of users' datasets, development and delivery of training modules/ courses and training CMM clients in data management and image processing.

She also regularly engages with NIF and MA, and coordinates the booking and lab management database.

Despite all the challenges that come with a part time position, Rubbiya enjoys the diversity her role brings and helping CMM clients.

Rubbiya completed her PhD at the Institute for Molecular Bioscience, The University of Queensland.



JENNY BROWN
CLIENT LIAISON

Ms Jenny Brown looks after anything to do with clients and client information. As CMM's client liaison officer, Jenny is often the first point of contact for CMM clients.

Her commitment to customer service, aided by excellent organisational and interpersonal skills, gives her the expertise to accurately administer the varied requests that pass over her desk.

Jenny provides financial and administrative support, plus is the contact for clients querying laboratory access and instrument usage. She has responsibility for maintaining the CMM client database, PPMS.

What Jennifer enjoys most about working at CMM is the people contact and overcoming challenges. She enjoys being part of a team that strives for excellence.



ROBERT GOULD
OH&S

As CMM's safety coordinator, Mr Robert Gould's job is to assist and advise CMM staff and clients on all safety issues, ensuring that CMM is compliant to UQ's OH&S policies.

All active users of CMM are contacted by Robert who then assists them with knowledge and skills to work safely within the Centre.

Robert undertakes audits of laboratory areas and focuses on processes to ensure work is conducted safely and meets UQ's safety requirements.

His methodology is to apply risk analysis and to focus on processes that would provide the greatest risks to CMM.

What Robert sees as being most important in his role is that everyone makes it home alive and uninjured.



TRAVIS HAGSTROM
LAB ASSISTANT

Mr Travis Hagstrom is a laboratory assistant at CMM, a role that requires a great diversity of skills including time management and problem solving.

His day could see him undertaking general maintenance in any of the CMM four laboratories, emergency repairs to instrumentation or electrical testing and tagging for new or existing equipment.

Travis also assists the SSU with general administrative support, including PPMS and SiPass card custodian duties to ensure CMM's clients have access to relevant equipment.

Travis most enjoys problem solving at CMM – be they big or small problems in administration, access, maintenance or installation of equipment.



ANDREW STARK
SENIOR TECHNICAL OFFICER

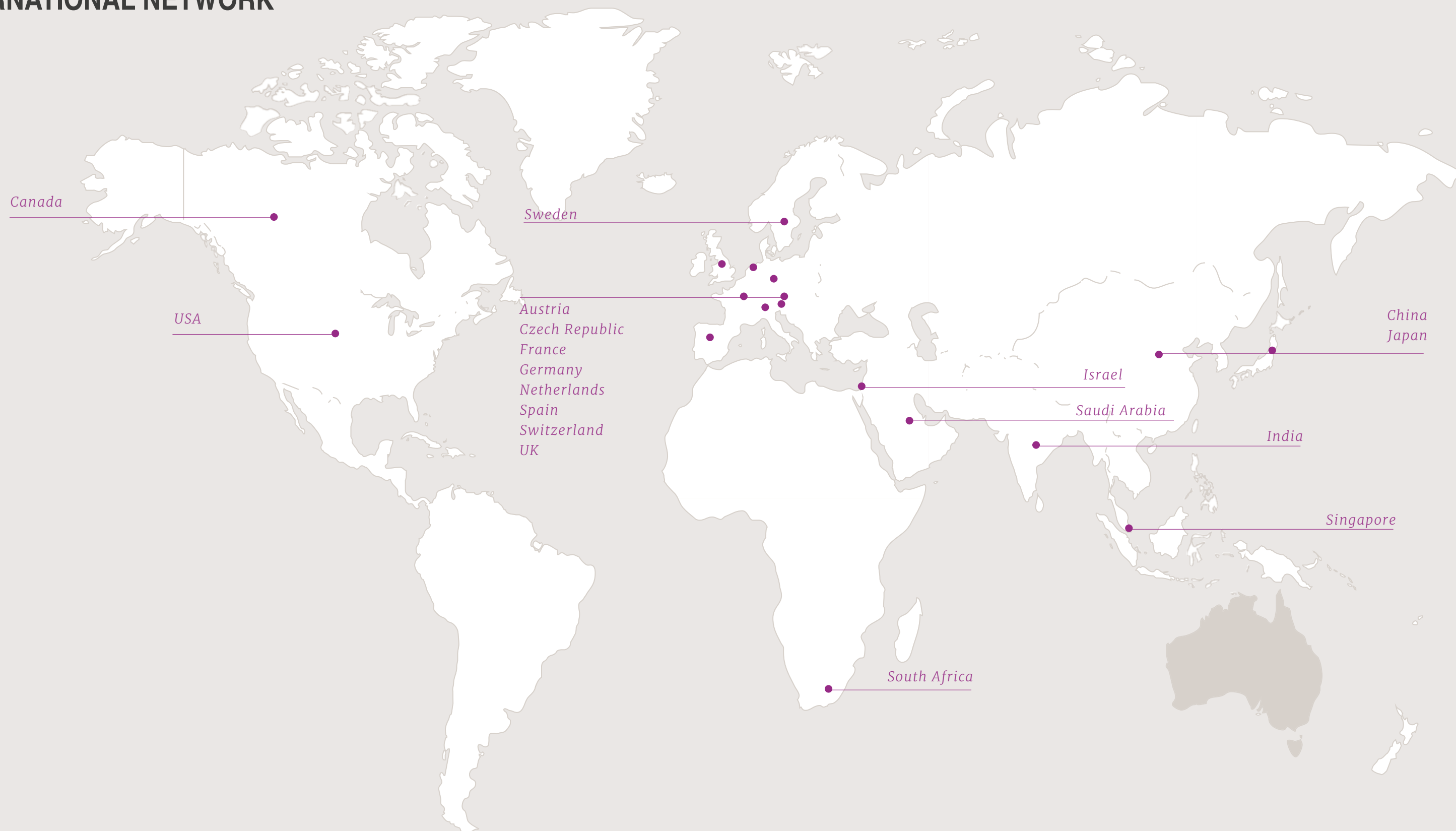
Mr Andrew Stark is a qualified electrical technician and takes care of CMM hardware. He is the first port of call on anything to do with instrument maintenance and instrument related IT issues.

His work involves ensuring the software associated with each instrument is working and clients are able to save data to the data server. He also liaises regularly with other UQ departments including Research Computing, ITS, and ITS Networks.

Andrew cites his biggest challenge as responding to major breakdowns quickly, while continuing to attend to general problems.

Andrew holds a QLD electrical licence, Microsoft, Cisco and instrumentations certification, 3D CAD, and various machining certificates.

COLLABORATION INTERNATIONAL NETWORK

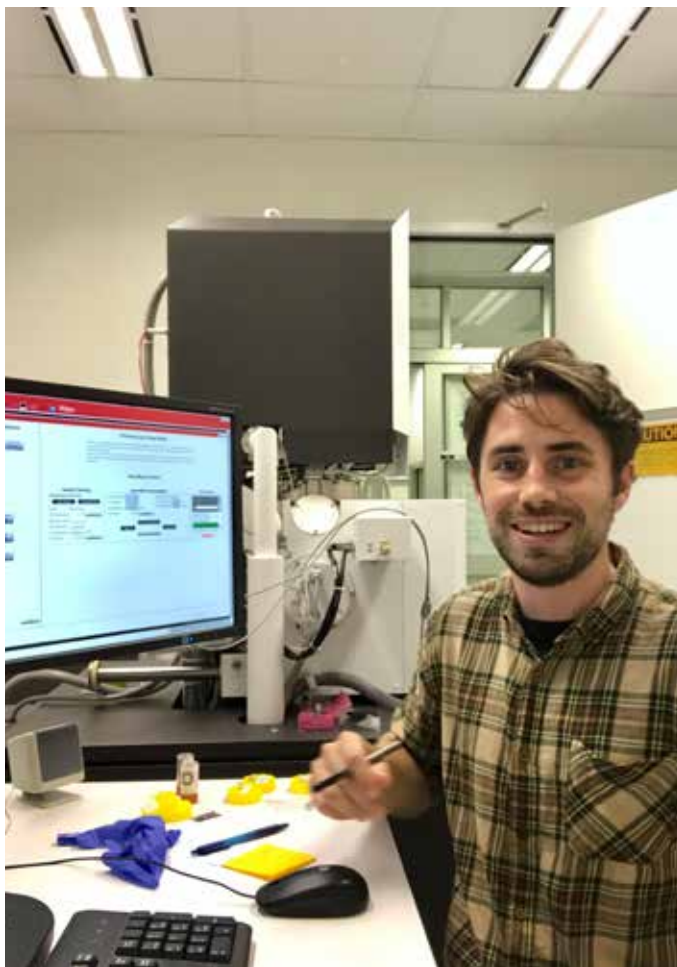


21
National
Collaborators

48
International
collaborators

ACADEMIC COLLABORATION

CMM's work for access program



Visiting Australia from Sweden, Marcel Sayre would argue he is living the perfect life, as he works and studies part time at CMM.

He is part of the CMM 'work for access' program that provides the opportunity of part-time work, plus use of CMM's equipment for individual research.

Marcel says he was attracted to CMM for a number of reasons. Up-front, for every hour he works, he gets an hour of free imaging time for his own research. But it is the state-of-the-art microscopes available to assist clients achieve their imaging goals that was the drawcard.

The same microscopes also provide the imaging data vital to his own research which is aimed at elucidating the functional role of an insect brain region known as the central complex.

At CMM Marcel's focus has been to develop and optimise a workflow for sample preparation, imaging, and image analysis to be applied to serial block-face scanning electron microscopy (SBF-SEM).

His focus has been on developing imaging parameters to optimise data acquisition of large 3D structures using a state of the art SBF-SEM microscope. Marcel works directly with CMM clients to help them obtain data necessary for their research requirements.

Marcel has found that the electron microscopy facility at CMM

has all the necessary resources to fulfil client imaging goals.

"The experienced CMM team go above and beyond to help clients meet all of their imaging needs. Furthermore, CMM's Director, Professor Roger Wepf, was very helpful and flexible when it came to negotiating a work/study agreement that would work for me", Marcel said.

It is this one-on-one relationship that CMM staff nurtures with clients that makes it enjoyable for Marcel.

"One of the most enriching aspects of this experience has been working directly with clients to help them achieve their imaging requirements. This has required me to learn and understand how to operate/troubleshoot these microscopes at a level that most students do not get to experience. It has also enabled me to build a larger network of colleagues, not just within CMM, but with the clients and scientists that I have had the opportunity to work with", he said.

Marcel started his PhD journey with dual enrolments at Sweden's Lund University and Australia's Macquarie University. His vision from the start was to participate in research that is part of a broader collaborative project between research groups. His CMM experience will add to the adventure, while continuing his personal research in insects' brains and examination of their central complex (CX) neuroarchitecture.

Marcel's research aims to reveal the role of specific neural elements in the CX, which can lead the way in understanding how sensory information is transformed into behavioural decisions within the context of navigation.



Long term collaboration with NIMS, Japan

In 2018 CMM continued to strengthen its relationship with Japan's National Institute of Materials Science (NIMS).

Back in 2005 NIMS signed an agreement with five main Australian universities, including UQ, to undertake international cooperation among graduate schools in the field of materials sciences. It was then UQ Deputy Vice-Chancellor (Research), Professor David Siddle who ratified the agreement and established a specific NIMS/UQ Memorandum of Understanding (MoU).

The MoU brought together a decades long relationship between NIMS and CMM, where researchers have been mutually visiting and collaborating. This included CMM's inaugural Director, Professor John Drennan who commenced visiting NIMS in the mid-1980s working on fuel cell applications, and collaborating with NIMS research scientist Dr Toshiyuki Mori.

The collaboration between CMM and Dr Mori continues to this day, and CMM was honoured to welcome him again during 2018, along with colleagues Prof Shigeharo Ito and Prof Takaya Sato from the National Institute of Technology at Tsuruoka. Dr Mori is the Green Leader for the Global Research Centre for Environment and Energy based on Nanomaterials Science, as well as a group leader of the Fuel Cell Materials Group within NIMS. Having spent the earlier part of his career in the corporate sector, Dr Mori brings his industrial experience into his research collaborations, with an eye to applying this knowledge to practical challenges.

The collaboration between CMM and NIMS through Dr Mori's group has resulted in over 60 journal publications and regular visits from Dr Mori and members of his research group.

Also during the year, CMM was pleased to welcome Dr Auchi Mitsunari who visited under a MoU between Microscopy Australia and the Japanese Nanocharacterisation Network, signed in April 2018 and also part of the NIMS network.

The aim of this MoU is to facilitate staff exchanges for training purposes. Dr Mitsunari spent two weeks in October at CMM to work on TEM and FIB.

Prof Takeguchi, a NIMS Group Leader and Station Director, accompanied Dr Mitsunari for a short stay.

About NIMS

NIMS has as its mission to carry out fundamental research and generic/infrastructural technology research and development in the field of materials science, and with improving the level of materials science and technology.

In the 60+ years of its establishment, it remains a world leading research organisation, and its most recent strategic plan positions NIMS to be a leader in addressing socio-economic challenges and services as a core R&D organisation for the "super-smart society" initiative.

To meet this and other goals, NIMS recently established the Program for Strengthening Innovative Materials Development (M3)- through which NIMS will serve as a global hub for promoting open innovation in collaboration with industry and universities.

Top of page: photo by Vanessa Bucci on Unsplash

Industry collaboration

CMM closely collaborates with microscope and instrument suppliers around the world to ensure our client base receives access to cutting-edge microscopy and analytical instruments and/or best possible service. We currently work with several companies on the improvement and development of new products, which we hope to present in the foreseeable future. However, in 2018 the collaborations with Scitek and Hitachi/NewSpec went a step further and are therefore presented here.

SciTek & CMM collaboration

Dr Zibin Chen is an application scientist with Scitek Australia Pty Ltd, a world leader in vacuum technology and surface science technology. His current role bases Zibin at CMM, where he acts at the connection between industry and CMM.

Scitek is an Australian company providing instrumentation and service support for customers working in science and engineering. Zibin contributes to Scitek's surface science portfolio and vacuum/pump technologies.

Zibin is responsible for science and application support to existing Scitek product users. This requires him to work closely with the Scitek team to support their efforts by undertaking presentations, demonstrations and assisting with product recommendations. Zibin travels to provide technical recommendations and support for customers working in science and engineering. He also undertakes lectures for Australian and New Zealand universities on various technologies.

His second role is within CMM where he provides advice, performs technical training for CMM clients, and maintains instruments.

Zibin has come to this position after completing a degree in Biomedical Engineering at South China University of Technology, China, followed by MPhil and a PhD at the University of Sydney. He joined Scitek Australia in December 2017.



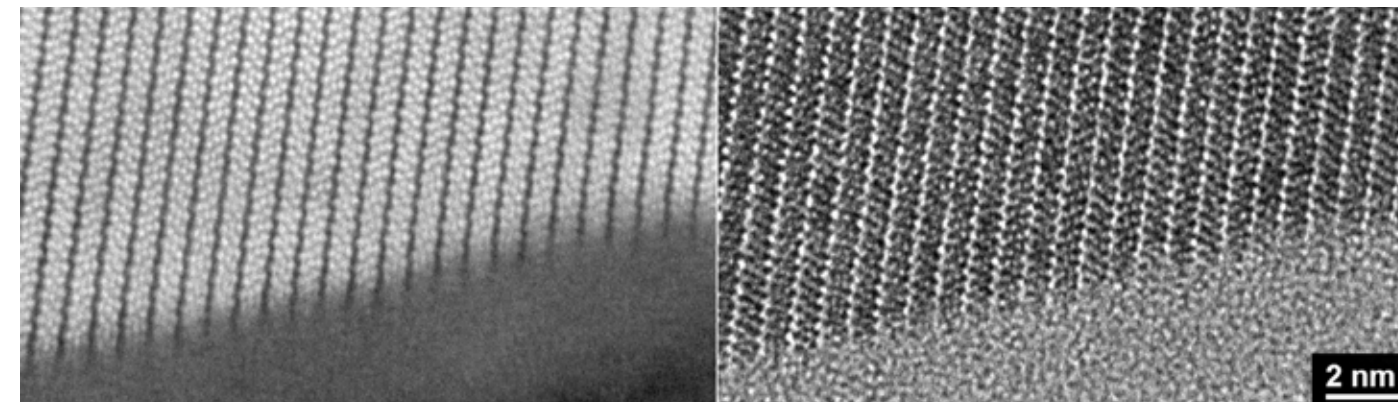
Zibin has extensive experience in materials research using various advanced transmission electron microscopy, scanning electron microscopy, and scanning transmission electron microscopy techniques including TEM, SEM, STEM, XRD, OM, FIB, APT, AFM, PL, CL, XPS, and XRF.

His own research focuses on the applications of advanced electron microscopy techniques to investigate structures and structure-property relationships of advanced materials including semiconductors and ferroelectric materials.

The collaborative relationship between CMM and Scitek has operated for just under a year, with benefits to both organisations.

Zibin provides professional help for CMM instrumentation maintenance and service. He helps train CMM customers using different instruments, including FIB and TEM and also helps develop the material preparation techniques in CMM.

Conversely, CMM provides an excellent platform to demonstrate SciTek products and product lines. The exposure at CMM also builds SciTek's scientific reputation.



Hitachi engineer will join CMM in new collaboration

A unique multidimensional agreement between CMM, Hitachi, and NewSpec Pty Ltd, will commence in 2019, providing CMM and its users with enhanced maintenance, product development and professional development opportunities.

Through this agreement, CMM's Hitachi equipment will be covered by an extended maintenance support contract, which will include the placement of a Hitachi engineer within CMM for a 6 to 12 month assignment, commencing October 2019. The engineer will assist with the maintenance of CMM's current Hitachi instruments, including the recently installed and custom made HF5000.

The HF5000 is a new 200kV Transmission Electron Microscope, combining both Hitachi HighTech's TEM and Scanning Transmission Electron Microscope (STEM) technologies to achieve spatial resolution at the sub-angstrom (Sub-Å, 0.1 nm or less) level.

The CMM Hitachi agreement includes training of CMM staff and clients on all Hitachi instruments. This specialised training will provide users maximum benefits from the instruments, and the relationship will result in users experiencing better operational capabilities from instruments.



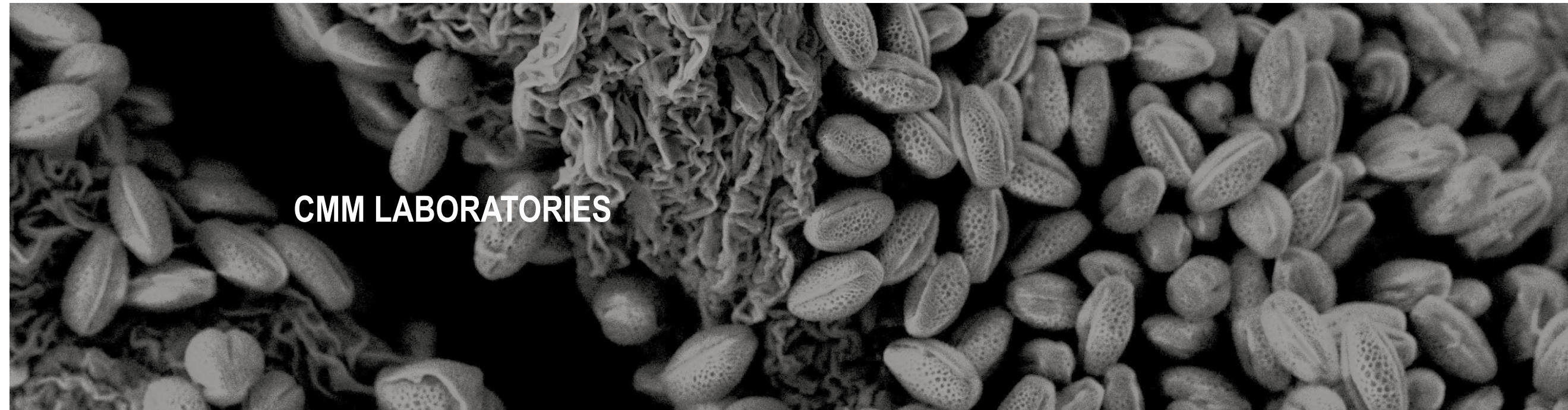
The CMM Hitachi agreement provides exceptional opportunities for CMM staff and users to challenge scientific boundaries and seek new discoveries.

CMM's Director, Professor Roger Wepf, will have a special role in the agreement and will collaborate with Hitachi on R&D projects on a consultancy basis.

The agreement also allows for the establishment of a three-year Hitachi scholarship aimed at professional development. Under this scholarship, CMM postgraduate student and postdoctoral fellows will have the opportunity to seek financial support towards travel to selected conferences, at which they present research generated on Hitachi instruments.

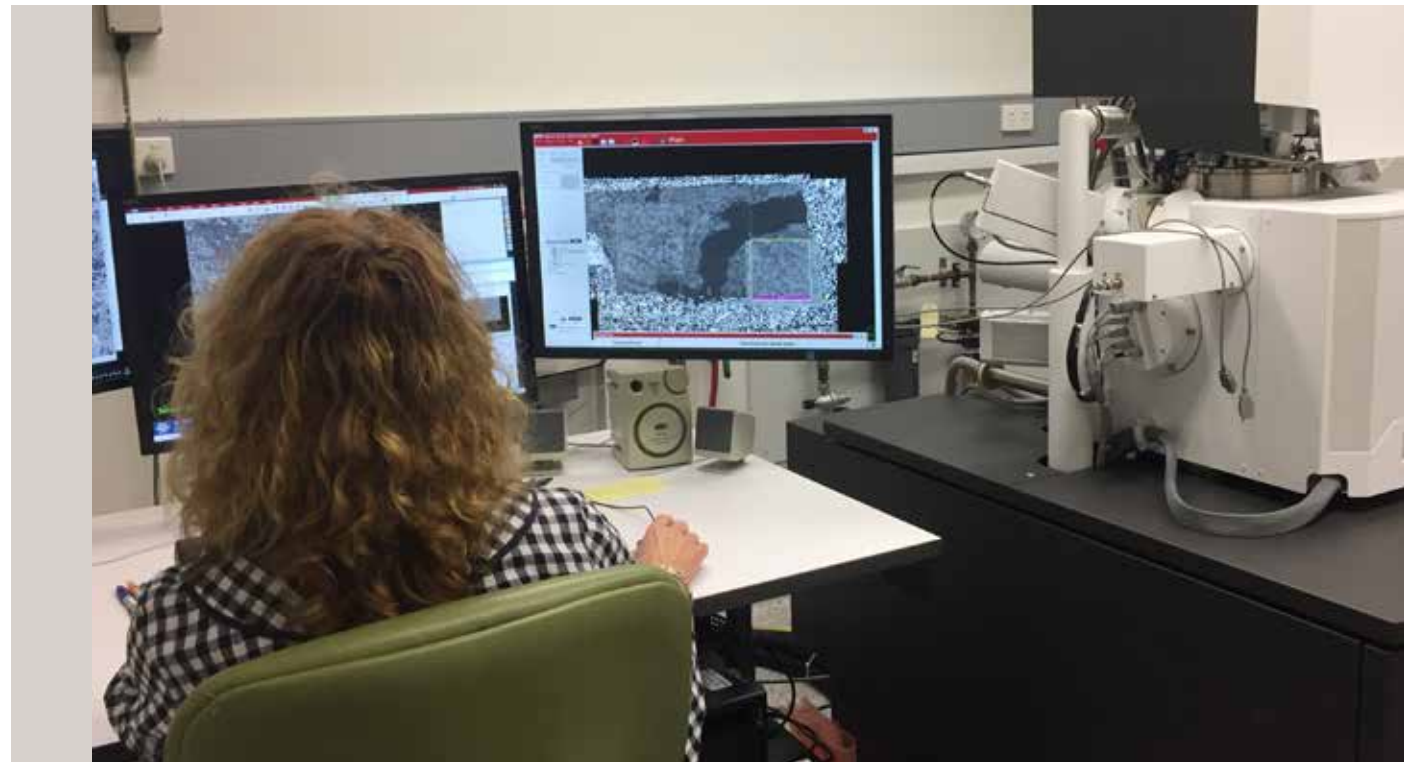
The CMM and Hitachi agreement builds on the strong relationship over a number of years. In 2018 CMM, in conjunction with NewSpec & Hitachi, commenced the STEAM program, which brings an Hitachi TM4000 microscope into Queensland schools and tertiary education facilities. This gives students a unique opportunity to undertake a real analysis using world class equipment. Further information on this program is on page 54 of this Annual Report.

CMM and Hitachi also partnered for a two-day workshop at UQ in September to celebrate the re-opening of CMM's Hawken Laboratory and the inauguration of the HF5000. Over the two-day program an outstanding list of international speakers presented their findings and shared their experiences. Further information on the inauguration of the HF5000 can be found on page 58.



CMM has six laboratories across four sites at UQ. In 2018 there were many highlights in our laboratories, including major infrastructure upgrades and new industry collaborations.

The Centre provides a comprehensive suite of analytical instrumentation and a high standard of training programs for researchers.



FACILITIES

AIBN LABORATORY

Life science & soft matter

Following new instrument installations in 2017 of two Hitachi HT7700 TEMs, staff at the AIBN laboratory trained 65 new clients on the use of these microscopes to a level where they could carry out independent research.

In 2018 the laboratory acquired the Thermo Fisher Apreo SEM with VolumeScope. This instrument was purchased from an Australian Cancer Research Foundation (ACRF) grant as part of a big package to setup the \$2.3 million ACRF Cancer Ultrastructure and Function Facility. This facility also involves the Institute for Molecular Biosciences, where they have installed state of the art light microscopes, including a Lattice Light Sheet microscope.

The facility was opened at a ceremony in April where the Acting Chief Scientist, Dr Christine Williams, and the ACRF CEO Professor Ian Brown were present. The installation of the Apreo was a long process, but by late 2018 it was up and running with good results.

Marcel Sayre joined the AIBN laboratory as a visiting PhD student. Marcel is a student from Lund University in Sweden and has come to the CMM to use the Volume SEM instruments, the Thermo fisher Apreo/VolumeScopoe and the

Zeiss Sigma/3View for his research. During his visit he is also working with CMM to help develop these instruments. He has been a great addition to the laboratory and a huge help in this work (see page 22 for more on Marcel).

With the imminent refurbishment of the QBP laboratory it was decided to combine the operations of that laboratory with the AIBN during this time. In late 2018 the JEOL 1011 TEM was moved into the AIBN, which brought the total number of TEMs to four. When the QBP closes in 2019, its staff and more of its instrumentation will be relocated into the AIBN space temporarily.



LAB OVERVIEW

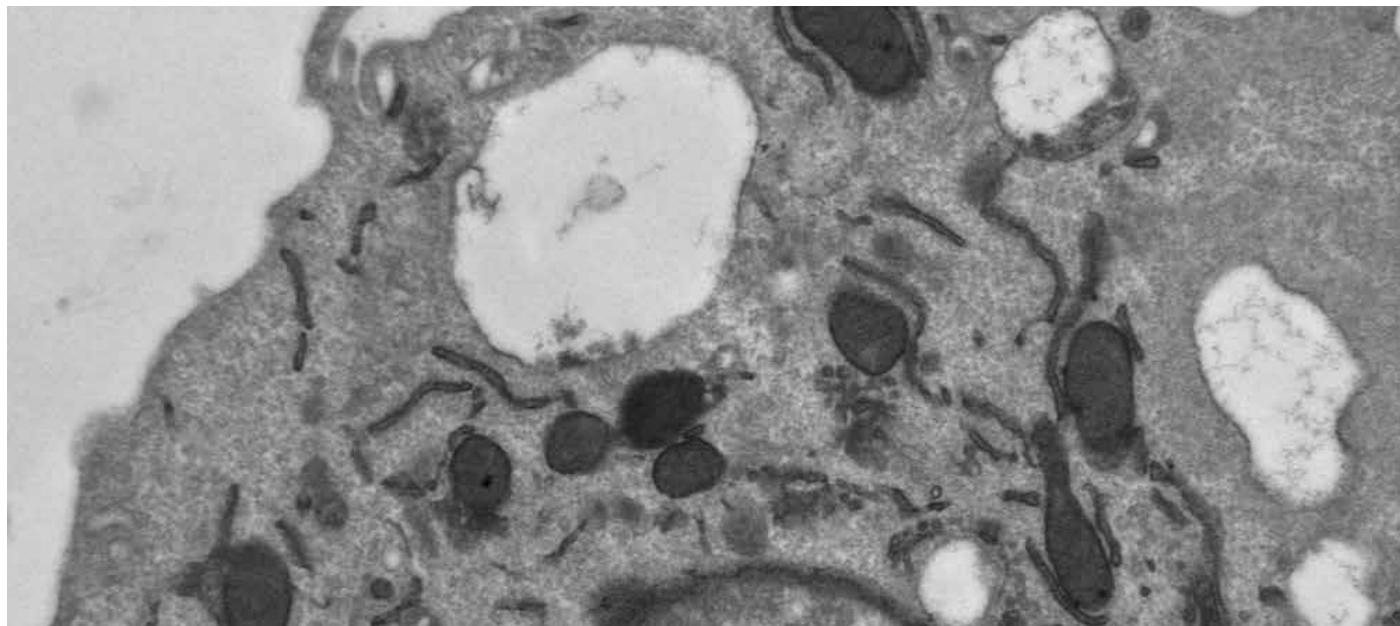
CMM facilities are located on the ground floor of the Australian Institute for Bioengineering and Nanotechnology building. These purpose built laboratories house four state of the art transmission electron microscopes and four scanning electron microscopes plus a range of sample preparation facilities. In addition the laboratory is equipped with a sophisticated optical microscopy suite with three optical microscopes in various configurations.

TEAM

- » Mr Richard Webb, Laboratory Manager
- » Dr Graeme Auchterlonie, Research Officer
- » Ms Robyn Chapman, Scientific Officer
- » Dr Hui Diao, Dual Beam FIB/SEM Engineer
- » Mr Han Gao, Casual Research Officer
- » Mr Qiang Sun, Casual Research Officer
- » Ms Rachel Templin, Research Assistant
- » Mr Marcel Sayre, Visiting student

INSTRUMENTS

- » Hitachi HT7700 with Bruker EDS
- » Hitachi HT7700 Exalens
- » Tecnai F20 200 kV TEM/STEM with Oxford EDS, STEM BF/DF/HAADF, Gatan OneView Camera, Gatan High Temperature D/T Holder (1000°), Nanofactory 30997 D/T STM Holder, GIF EELS/EFTEM/STEM-EELS 2002CCD camera
- » Zeiss Sigma SEM with Gatan 3View
- » FEI Scios FIB with Oxford EDS, Oxford EBSD, Easy Lift Micromanipulator, Gas Injection system with platinum, tungsten, silicon and selective carbon etching
- » Thermo Fisher Apreo SEM with VolumeScope



FACILITIES

HAWKEN LABORATORIES

Material sciences

The year-long refurbishment of the Hawken laboratory has now been completed, with a significant improvement to the operational environment of the material science electron microscopes (EM), biomolecule imaging mass spectrometers (MS), and nanoscale fabrication electron beam lithography (EBL) instruments that operate within the laboratory.

All existing electron microscopes and imaging mass spectrometer equipment have been returned to the laboratory and recommissioned into full operational order. New state-of-the-art equipment has been installed into specially built dedicated research spaces. This includes a new atomic resolution Hitachi HF5000 Cs corrected STEM in a vibration isolated, magnetically shielded, thermally controlled room. The Cs-STEM has multiple analytical detectors for EDS and EELS, and is soon to be fitted with a high speed pixelated detector for scanning diffraction (ptychography) and *in-situ* holders for real-time experiments under the beam.

The other dedicated research space built in the new Hawken lab was a clean room for electron beam lithography. This purpose built space is now home to two RAITH EBL's and a special sample preparation area that will allow sample preparation, e-beam writing and final specimen processing in the same clean room area. Significant research results have already been produced from the new EBL systems with the Warwick Bowen Quantum Optics Laboratory producing quantum electro-optomechanical devices (see separate research story by Christiaan Bekker) as well as photonic/quantum sensing devices to help develop the next generation of medical diagnostic sensors.

The refurbished Hawken laboratory and the new Cs-STEM was inaugurated in September 2018 with a two day seminar that featured invited guests from around the world. Many world leaders in aberration corrected Scanning Transmission Electron Microscopy (STEM) travelled from Europe and North America, as well as many local Australian experts, to deliver an excellent series of talks to an assembled audience of UQ researchers. Many then travelled to the 19th International Microscopy Conference in Sydney the following week to present research results from the new world-class infrastructure situated in the Hawken laboratory.

Novel imaging

In 2018, the imaging mass spectrometry facility moved into the newly refurbished Hawken laboratories. A number of publications emanated from the facility; a particular highlight was published in *Cellular and Molecular Life Sciences* by Dr Eivind Undheim's group, and titled *PHAB toxins: a unique family of predatory sea anemone toxins evolving via intra-gene concerted evolution defines a new peptide fold (doi: 10.1007/s00018-018-2897-6)*. This paper combined high speed MALDI-TOF mass spectrometry imaging with high mass resolution MALDI-FT-ICR mass spectrometry imaging to unambiguously show the presence of new toxin in the tentacles of Sea Anemone. The paper represents a combination of two of the three important pillars in mass spectrometry imaging (high speed, high mass resolution, and high spatial resolution). The Centre recently received funding to replace one of its aging MALDI-TOF systems, and is looking forward to selecting and purchasing the new instrument, which will keep the facility at the forefront of mass spectrometry imaging in the country.

TEAMS

Material sciences

- » Mr Ron Rasch, Laboratory Manager
- » Ms Heike Bostelmann, Scientific Officer
- » Dr Zibin Chen, Application Scientist
- » Ms Eunice Grinan, Scientific Officer
- » Dr Kim Sewell, Scientific Officer
- » Ms Ying Yu, Scientific Officer
- » Dr Elliot Cheng, Nanolith Specialist Engineer

Novel imaging

- » Professor Roger Wepf, Laboratory Manager
- » Dr Brett Hamilton, Imaging Mass Spectrometry Specialist
- » Dr Elliot Cheng, Nanolith Specialist Engineer
- » Dr Lachlan Casey, Analytical X-ray Specialist

INSTRUMENTS

Scanning Electron Microscopes

- » Hitachi SU3500 with Oxford Xmax SDD EDS elemental analysis
- » JEOL JSM6610 with combined Oxford Xmax SDD EDS and Nordlys EBSD detectors
- » Philips(FEI) XL30 with cryo shuttle transfer system
- » JEOL JSM7001F with JEOL minicup EDS detector
- » JEOL JSM7100F with Gatan Alto Cryo system and JEOL SDD EDS detector
- » JEOL JSM7800F with two in-lens detectors
- » JEOL JXA8200 EPMA with 5 WDS detectors and John Donovan PfEPMA software

Imaging Mass Spectrometry

- » Bruker Amazon Speed iontrap with ETD - coupled to AP-MALDI
- » Bruker Ultraflex III - MALDI-TOF/TOF (x2)
- » Bruker MicroTOF Q II (QqTOF) – coupled to AP-MALDI

Electron Beam Lithography

- » RAITH EBPG 5150 EBL
- » RAITH e-Line Plus SEM and EBL
- » Bruker Dektak XT Stylus Profiler

Material Sciences

Novel Imaging Technologies



LABORATORY OVERVIEW

The newly refurbished and expanded Hawken laboratory houses advanced instrumentation in the form of material science electron microscopes (EM), biomolecule imaging mass spectrometers (MS), and nanoscale fabrication electron beam lithography (EBL). The improved environment has created dedicated research spaces in the form of an isolated and shielded room for a newly installed HF5000 Cs corrected STEM with atomic resolution, plus a dedicated clean room for two newly installed fully automated RAITH EBL e-beam writers for large scale patterns at nanometre accuracy.

FACILITIES

QBP LABORATORIES

Structural biology

Good things take time, and this includes refurbishments of advanced laboratories. Although we expected to finalise the procurement of two next generation automated cryo electron microscopes by the end of 2018, the planning of a new CryoEM facility that will house these high end instruments has taken longer than expected.

Following visits to the factories of the two main competitors in the field – JEOL in Tokyo, Japan, and Thermo Fisher Scientific in Eindhoven, The Netherlands – we finally decided on JEOL as the preferred supplier. Soon CMM clients will have access to a 300kV JEOL Cryo ARM300 and a 200kV JEOL Cryo ARM200.

Both electron microscopes will have a cold FEG electron source, an omega energy filter and direct electron detectors from Gatan, a K2 summit and its latest iteration the Gatan K3. The ARM300 will also have a phase plate for near focus imaging at high contrast.

To guarantee the optimal performance of these sensitive instruments the existing CryoEM facility at the Queensland Bioscience Precinct (QBP) needs to undergo an extensive refurbishment, which commenced in early December with the closing down of the facility, and will hopefully be finished in early May 2019.

The delivery of the first microscope, the Cryo ARM-300 is expected for May/June and the delivery of the Cryo ARM-200 in September 2019

UQROCX crystallography

2018 was a year of transition for UQ ROCX with the move to join CMM from the 1st January. There were enquiries from two Pharmaceutical companies regarding contract work; one of which shows promise for future collaboration. A further highlight for the laboratory in 2018 was the publication of an article in *The Journal of Natural Products* co-authored by both UQ ROCX staff. The publication resulted from a collaboration between researchers from Saõ Paulo State University-UNESP, Brazil and UQ.



TEAMS

Structural biology

- » Dr Matthias Floetenmeyer, Laboratory Manager
- » Dr Kathryn Green, Scientific Officer
- » Dr Erica Lovas, Scientific Officer

UQROCX crystallography

- » Mr Karl Byriel, Technical Manager
- » Dr Gordon King, Research Officer

INSTRUMENTS

Cryo TEM instruments

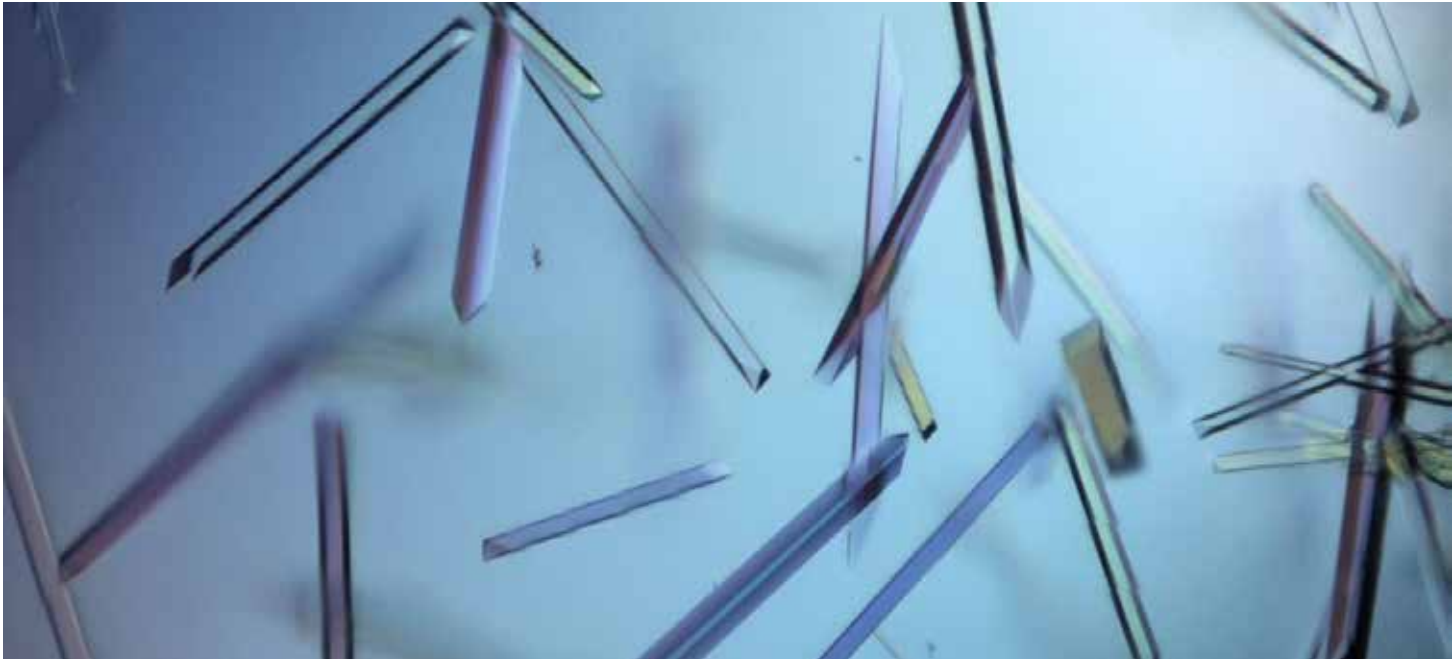
- » Tecnai F30 G2 TEM
- » Tecnai T12 G2 TEM
- » JEOL JEM-1011 TEM
- » JEOL JSM-5000 Neoscope
- » Leica EM AFS2, Automatic Freeze-Substitution Unit (x2)
- » FEI Vitrobot Mark 2, Automatic Plunge-Freezer
- » Baltec HPM-010, High Pressure Freezer
- » Leica EMPact2, High Pressure Freezer
- » Leica UC6-FCS Cryo-Ultramicrotome (x2)
- » Leica Ultracut UC6 Ultramicrotome (x2)
- » Baltec MED-020, Carbon Coater/Glow Discharge Unit
- » Quorum 150TE Carbon Coater

UQROCX instruments

- » Rigaku FR-E+ SuperBright X-ray Generator
- » Rigaku Saturn 944 CCD area detector
- » ACTOR
- » Rock Imager
- » Tecan liquid handling robot
- » Mosquito Crystal & Mosquito LCP
- » Rigaku R-Axis IV++ area detector
- » Viscotek TDA 305

Structural Biology

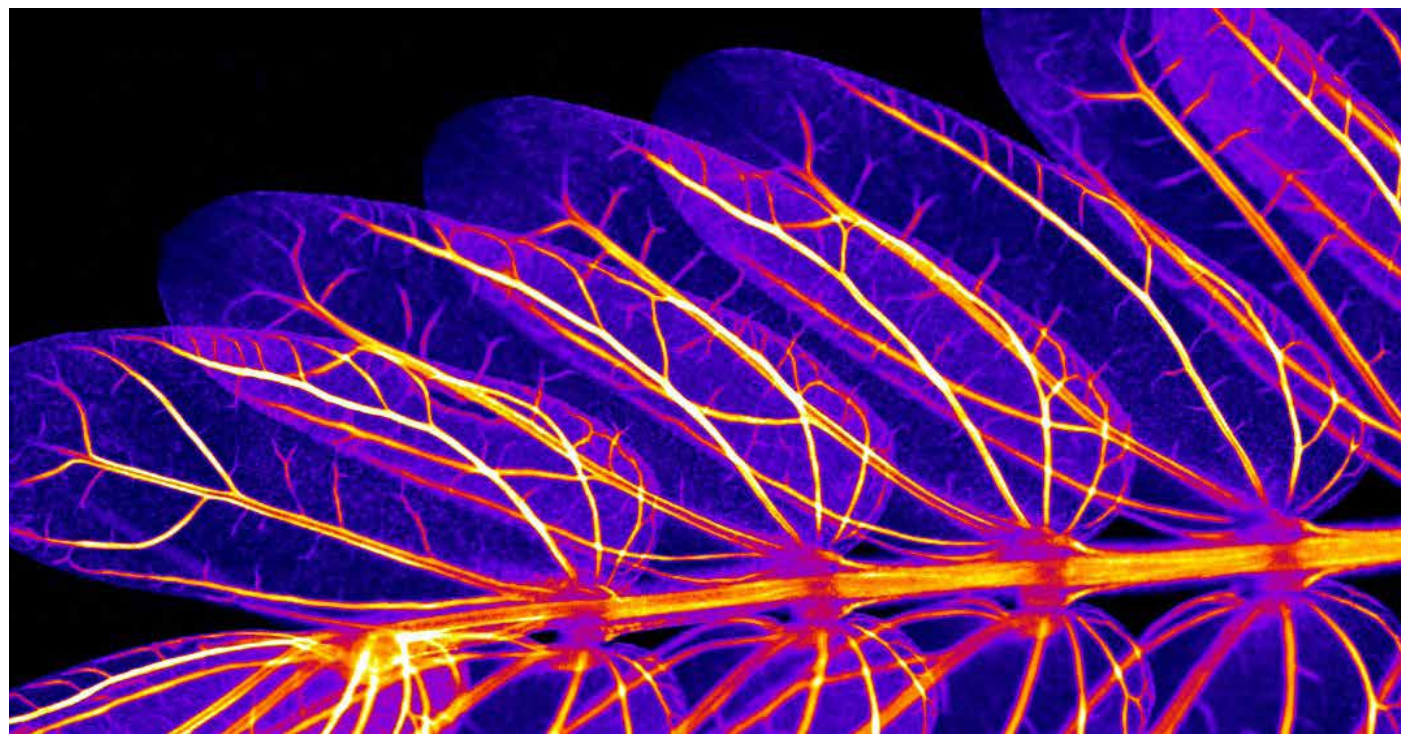
UQROCX Crystallography
(QBP)



LABORATORY OVERVIEW

Located in the Queensland Bioscience Precinct at The University of Queensland, the Cryo-Transmission Electron Microscopy (TEM) Facility is a laboratory that was purpose-built for standard and cryo-TEM sample preparation and analysis, as well as electron tomography of both resin-embedded and cryo-samples (for three-dimensional analysis).

The Remote operation crystallization and X-ray diffraction facility (UQ ROCX) provides access to world class equipment for protein crystallization, crystal imaging and X-ray diffraction. UQROCX coordinates the Australian Synchrotron Collaborative Access Program (CAP) for South East Queensland Protein Crystallography.



FACILITIES

X-RAY LABORATORY

X-ray material science & spectrometry

The CMM X-ray laboratories underwent a significant modernisation and enhancement of the functionality of the space in the second half of 2018 and is now fully functioning. The new environment includes redesigned and more efficient use of space, more suitable climate control and provision of instrument services as well as a significant reduction in ambient noise.

The rejuvenated laboratory space was completed in time for the installation of a Xenocs Xeuss 2.0 Small- and Wide-Angle X-ray Scattering System and an iXRF AtlasX scanning X-ray Fluorescence Mapping instrument. Both systems are fully commissioned and are being used by researchers. In addition the ongoing collaboration with the School of Chemistry and

Molecular Biosciences has also seen the installation of two new X-ray diffraction instruments into this area; these are a Rigaku Synergy single crystal diffractometer and a Rigaku SmartLab SE powder diffractometer.

The surface analysis capabilities within UQ were given a boost by funding secured through the ARC-LIEF scheme in 2018. The funding will support the procurement of new instrumentation that will succeed the existing aged XPS instrument and will provide modern high performance XPS with *in-situ* and *in-operando* attachments as well as allied imaging and spectroscopies such as scanning Auger microscopy, ultra-violet photoemission spectroscopy and electron-energy loss spectroscopy.



LABORATORY OVERVIEW

The X-ray analysis laboratory at CMM is based on level two of the Chemistry building and provides a range of X-ray techniques, including diffraction, scattering, spectroscopy and imaging, for studying chemical composition, nano-scale size and crystalline phases in a range of materials.

The facility provides complementary techniques to the electron-based methods afforded by the AIBN, QBP and Hawken Laboratories and to the macromolecular diffraction facilities in the QBP laboratories through small-angle scattering and small-molecule diffraction techniques.

TEAM

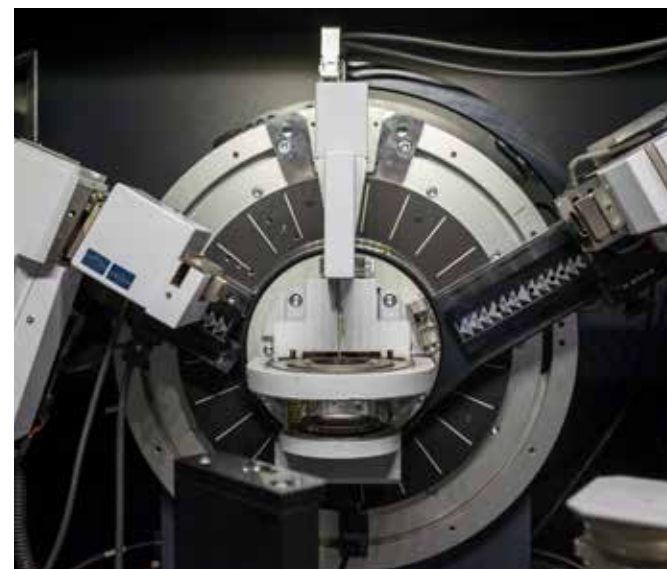
- » A/Prof Kevin Jack, Laboratory Manager
- » Ms Anya Yago, X-ray Diffraction Scientist
- » Dr Lachlan Casey, X-ray Scattering and Spectroscopy Scientist
- » Dr Barry Wood, X-ray Spectroscopy Scientist

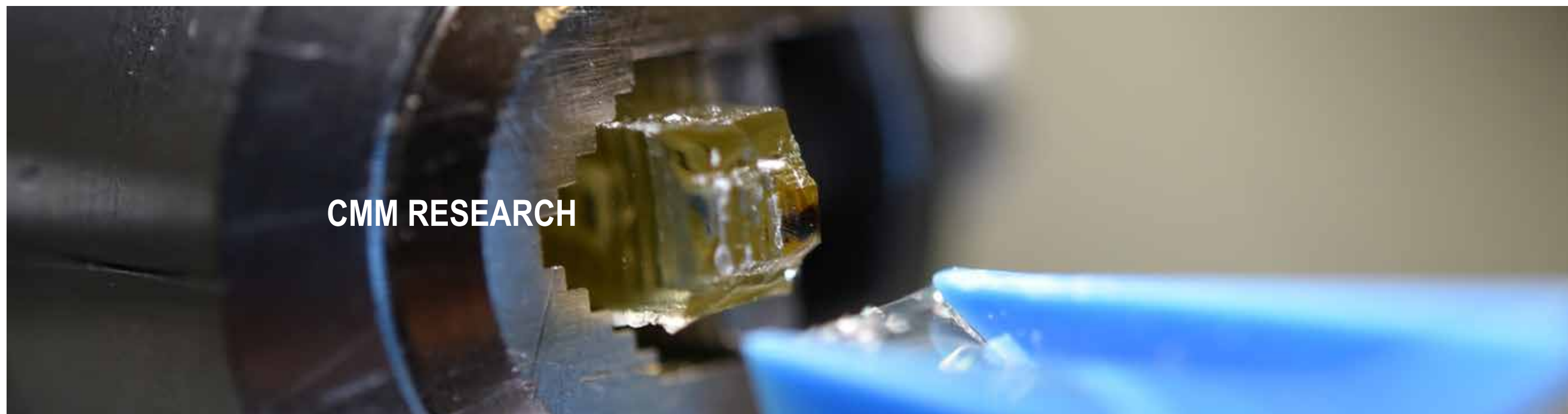
INSTRUMENTS

- » Xenocs Xeuss 2.0 Small-Angle X-ray Scattering
- » Bruker D8 Advance Powder X-ray Diffractometer
- » Rigaku SmartLab Thin-Film and Micro-Diffraction X-ray Diffractometer
- » Kratos Axis Ultra X-ray Photoelectron Spectrometer
- » iXRF AtlasX X-ray Fluorescence Spectrometer

Hosted:

- » Oxford Diffraction Single Crystal X-ray Diffractometer
- » Rigaku Synergy Single Crystal X-ray Diffractometer
- » Rigaku SmartLab SE Powder X-ray Diffractometer





CMM is an interdisciplinary research centre that plays an integral role within the research programs of UQ.

CMM's comprehensive suite of analytical instrumentation provides researchers with the resources to achieve their research goals. In this section, we share just some of the research stories that CMM has been a part of in 2018.

Journey to the centre of a cell

Robyn Chapman, Richard Webb, James Rae, Charles Ferguson, Robert Parton, Angus Johnston John McGhee, Nick Ariotti

The ‘Journey to the centre of a cell’ project is a unique, multi-disciplinary collaborative initiative exploring the visualisation of nanotechnology. Using actual cancer cell data and Serial Block Face Scanning Electron Microscopy, a unique collaboration between arts and science has resulted in a 3D Virtual Reality tool that allows the user to ‘walk’ over the surface of the cancer cell and then to explore inside the cell.

Rob Parton’s group used their expertise in cell biology to grow migrating human cancer cells in a matrix. James Rae and Charles Ferguson then processed the cells for electron microscopy. With Richard Webb and Robyn Chapman, these cells were then cut into thousands of slices in the serial blockface scanning electron microscope in the CMM. Subsequently images of these slices were coloured by Nick Ariotti to highlight the different structures and used to create a 3D reconstruction of the cell. In consultation with Rob and Angus Johnston, (Monash Institute of Pharmaceutical Sciences) John McGhee then used his experience as a practicing 3D CGI artist, animator and researcher at the College for Fine Arts, University of New South Wales to create a Virtual Reality (VR) ‘trip’ through a human cell.

The prototype has demonstrated how virtual reality headsets can be used to interact with cell image data in an immersive way to provide invaluable insight for scientific discovery and science education. In pilot tests, Angus Johnston showed that the VR experience increased students’ understanding of cell biology.

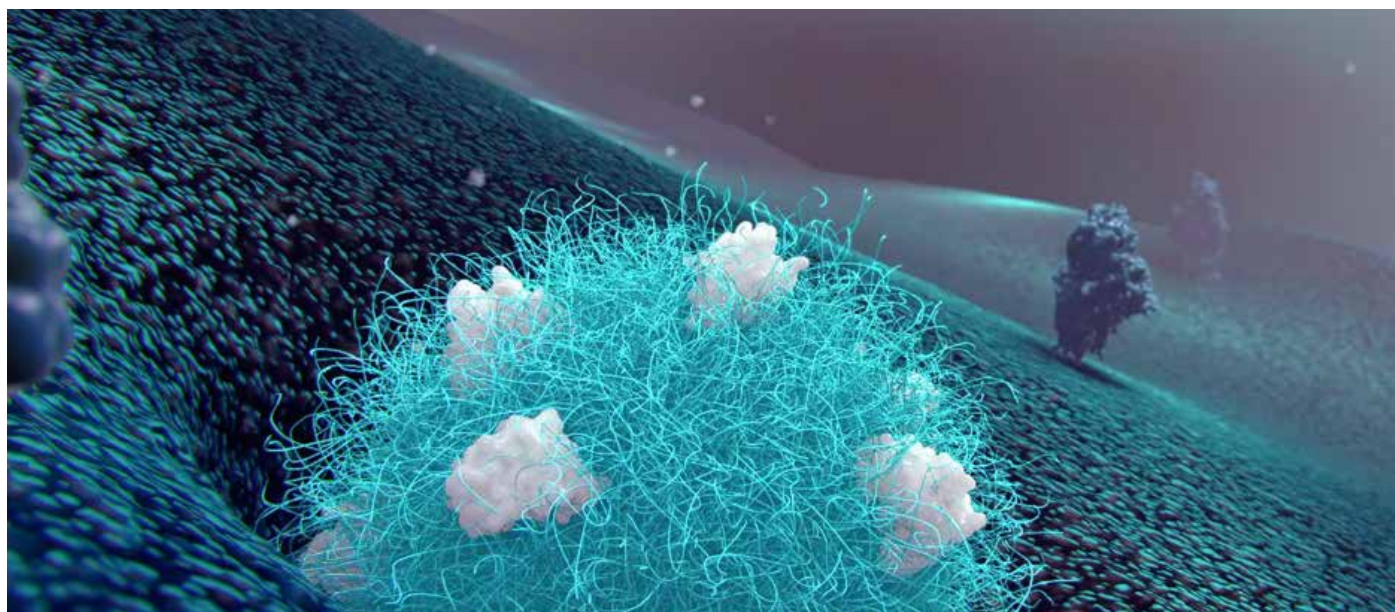
Being able to experience the cell like this gives a glimpse of new ways in which we can interact with microscopic data.

We envisage that these techniques will become a crucial research tool in biology. In addition, *Journey to the centre of a cell* is an incredibly beautiful immersive experience, which can introduce non-scientists to the inner world of the cell. It has now been experienced by hundreds of users in schools, in public demonstrations, on TV (e.g., ABC’s *Catalyst*), and by visitors to UQ, UNSW, and Monash. The work describing *Journey to the centre of a cell* was published in 2018 (Johnston et al, *Traffic*, 2018).

Future plans/goals

A major aim of future work is to map key proteins into the 3D VR models to understand how these proteins work together in healthy cells and what goes wrong in diseases such as cancer.

Still image of nanoparticles entering a cell based on a video from the ‘Journey to the centre of the cell’ project.



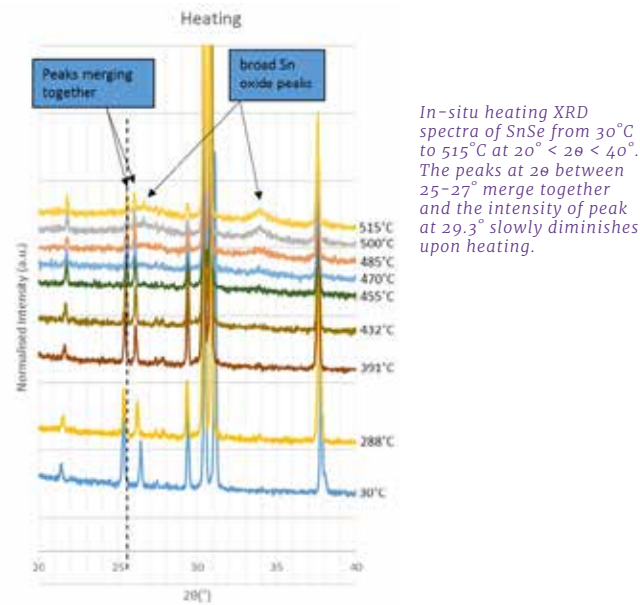
In-situ heating XRD observation of thermally-induced phase transformations in advanced materials

Xin Tan

This collaboration project between CMM and the Centre for Advanced Materials Processing and Manufacturing (AMPAM) aims to study the phase transformation mechanisms in a wide range of materials from titanium alloys through to functional materials. Some systems being investigated include phase changes in GeTe-based and SnSe-based materials, at elevated temperatures. Both systems are promising candidates for various functional applications, particularly in relation to their polymorphic phase transformation in their crystalline forms.

The real-time observations of thermally-induced crystallographic transformations were conducted using the Rigaku SmartLab system housed in the CMM X-ray Facility. The system is equipped with a 9kW rotating Cu anode. The experiments began at room temperature and the temperature was ramped up to certain pre-set values. The Rigaku SmartLab system self-align at each temperature step, taking into account the thermal expansion of the sample. XRD data was collected *in-situ*.

The results obtained from these experiments showed the onset temperatures of phase transformations and provided real-time crystallographic information of the samples during the thermally-induced transformations, providing better understanding of the transformation mechanisms of these materials.



In-situ heating XRD spectra of SnSe from 30°C to 515°C at 20° < 2θ < 40°. The peaks at 2θ between 25–27° merge together and the intensity of peak at 29.3° slowly diminishes upon heating.

Efficient solar-driven water splitting

Songcan Wang, Peng Chen, Yang Bai, Jung-Ho Yun, Gang Liu, Lianzhou Wang

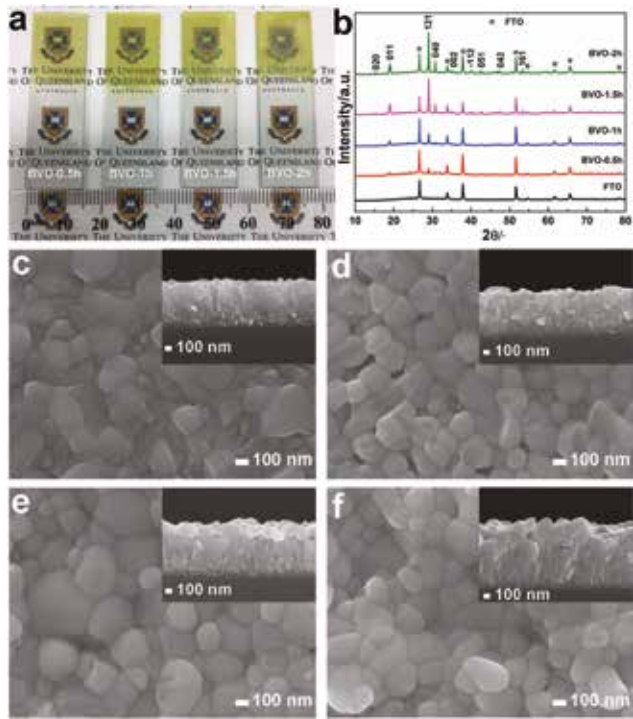
CMM user Professor Lianzhou Wang and his colleagues have published research that examines Bismuth vanadate (BiVO₄) and its potential in water splitting technology.

BiVO₄ is a promising photoanode material for photoelectrochemical (PEC) water splitting. However, owing to the short carrier diffusion length, the trade-off between sufficient light absorption and efficient charge separation often leads to poor PEC performance.

In their research, the group developed a new electrodeposition process to prepare bismuth oxide precursor films, which can be converted to transparent BiVO₄ films with well-controlled oxygen vacancies via a mild thermal treatment process.

The optimized BiVO₄ film exhibited excellent back illumination charge separation efficiency mainly due to the presence of enriched oxygen vacancies which act as shallow donors.

By loading FeOOH/NiOOH as the cocatalysts, the BiVO₄ dual photoanodes exhibit a remarkable and highly stable photocurrent density of 5.87 mA cm⁻² at 1.23 V versus the reversible hydrogen electrode under AM 1.5 G illumination. An artificial leaf composed of the BiVO₄/FeOOH/NiOOH dual photoanodes and a single sealed perovskite solar cell delivers a solar-to-hydrogen conversion efficiency as high as 6.5% for unbiased water splitting.



a) Digital images and b) XRD patterns of BVO-0.5h, BVO-1h, BVO-1.5h, and BVO-2h. SEM images of c) BVO-0.5h, d) BVO-1h, e) BVO-1.5h, and f) BVO-2h. Insets: the corresponding cross-sectional views.

The pathogenesis of insulin-induced laminitis in horses

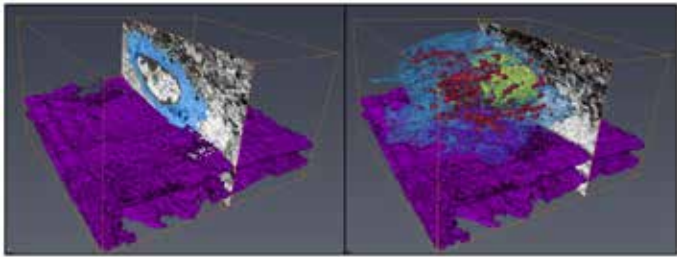
Simon Stokes, Kathryn Green, Robyn Chapman, Andrew van Eps

Endocrinopathic laminitis is a disease of the horse foot associated with high blood insulin. This form of laminitis is typically chronic, slowly progressive and often subclinical, although recurrent acute episodes are also common, particularly after access to pasture high in non-structural carbohydrate. Despite identification of some key events in recent studies, understanding of how excess insulin causes laminitis is unclear.

Continuous digital hypothermia (cooling the feet) is an effective preventative and therapy for a different form of laminitis (sepsis-associated) and has been widely adopted in clinical practice. In addition, evaluation of digital hypothermia in experimental sepsis-associated laminitis has led to a better understanding of the pathophysiology of that form of the disease.

The first objective of this project was to determine if continuous digital hypothermia is a rational first aid therapy for an acute bout of endocrinopathic laminitis. It was found that continuous digital hypothermia provides a protective effect against the development of laminitis induced by high blood insulin: the first evidence to support a clinically-applicable first aid treatment for endocrinopathic laminitis.

CMM's Gatan 3View system was used to investigate laminitis lesions that develop in response to high blood insulin. Cellular and extracellular lesions were detected in 2018 using this technique, and in 2019 our aim is to investigate if these lesions were prevented by digital hypothermia, in order to determine how hypothermia exerted its protective effect.



3D visualisation of a lamellar epidermal basal cell from a horse with laminitis. Segmentation was performed using Amira.

How ‘sticky’ are nanowires?

Hui Diao, James Mead , Han Huang, Shiliang Wang, Hongtao Xie

The aim of this project was to develop an experimental technique to study the adhesive behaviour of nanowires, and ultimately, to quantify their adhesive strength.

Significant research effort has been spent on trying to develop synthetic adhesive materials that can rival the incredible adhesion behaviour exhibited by the toe pad of the humble gecko. The secret behind the gecko's ‘stickiness’ can only be uncovered by examination at the nanoscale.

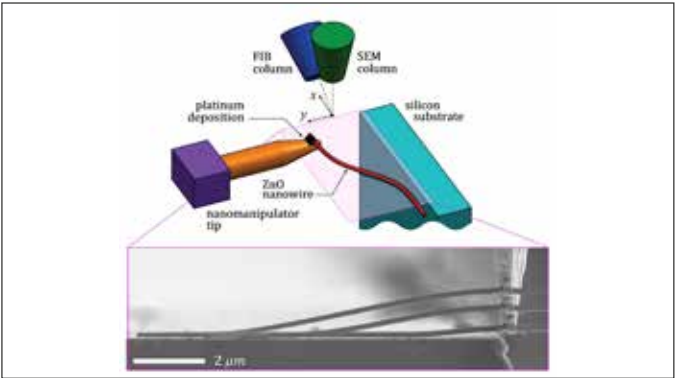
The toe pad contains an intricate array of stiff one-dimensional structures, and it is their distinctively large surface area combined with their structural rigidity that allows them to generate such impressive adhesion forces. Similar, but synthetic one-dimensional nanostructures, classified as nanowires, can now be simply synthesised. Yet, no experimental techniques previously existed for studying their adhesive behaviour.

The team developed an experimental technique for studying the adhesive behaviour of nanowires. Using one of CMM's scanning electron microscopes equipped with a nanomanipulator, we were able to observe the bent shape of nanowires as they were peeled from a surface with nanoscale precision. To do this, the free end of a nanowire was first fastened to the nanomanipulator using electron beam deposited platinum. From micrographs of nanowire's bent shape as it was being peeled, we were able to determine how much energy was transferred from the strained nanowire into separation of the two surfaces, and ultimately to determine the adhesive strength of the nanowire.

Highlights of the research include:

- » Demonstrated initial feasibility of the technique.
- » Collected data to quantify the adhesive strength of a set of nanowire samples.
- » Published the research DOI: 10.1039/c7nr09423j

Moving forward, the team aims to replicate the technique under an optical microscope. Nanoscale adhesion inside an electron microscope can be different to when in air. While an optical technique will have lower imaging resolution, peeling can be conducted in air, and simpler equipment can be used.





Identifying artist's pigment from Australia's earliest known rock art

Recent Scanning Electron Microscope analyses conducted at CMM's Hawken laboratory has shed new light on the pigments used by Australia's first artists. Chemical and morphological investigations showed that the c.28,000 year-old motif, the earliest known rock art in Australia, was made using specially prepared wood charcoal.

The tiny 3 x 3 cm slab of quartzite with a delicate black drawing was unearthed during the 2010 excavations at the famed Nawarla Gabarnmang rockshelter in Jawoyn Country, Southwest Arnhem Land. Previous work at the Australian Synchrotron co-ordinated by Dr Jillian Huntley (PERAHU, Griffith) had shown that the black pigment contained bromine.

Jillian explains, "Part of the fun of science is unexpected results. While X-ray fluorescence microscopy would not have been our first choice, when the opportunity arose we jumped at the chance to see what we might find. Assuming the motif was charcoal, whose main chemistry is carbon and below the detectability of XFM (even with a synchrotron), we had hoped to characterise environmental chemistry and understand where on the rock shelter surface the tiny slab might have come from. Instead we found the pigment contained bromine, but were still no closer to knowing what the main pigment composition was".

To resolve the matter, working in partnership with Professor Bruno David from Monash University and the ARC Centre of Excellence for Australian Biodiversity and Heritage, the archaeologists brought the tiny rock slab to CMM's Hawken laboratory and placed it into the Hitachi SU3500 variable pressure SEM.

"Coating the sample was not an option, as it could not be damaged" Jillian said.

The back-scattered electron micrographs showed the pigment was pushed into the micro-crevices of the stone surface, indicating the motif was drawn with dry pigment.

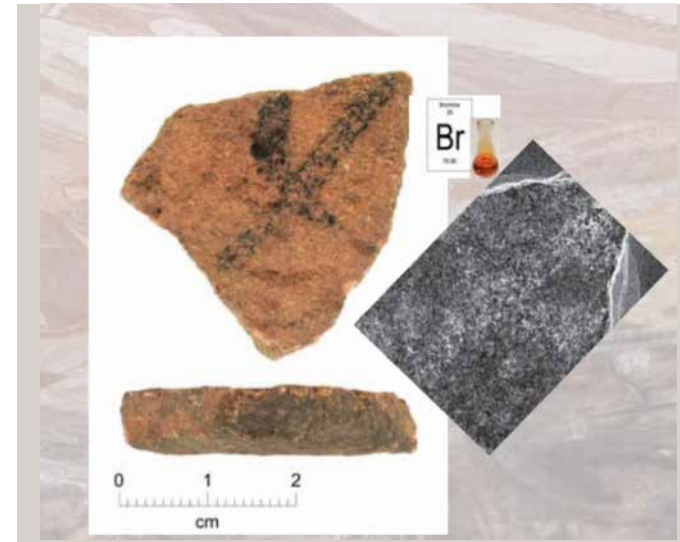
Anna Florin, a PhD candidate in UQ's School of Social Science, interpreted the charcoal morphology.

"The artists prepared the black pigment using charcoal made from burnt wood," she said.

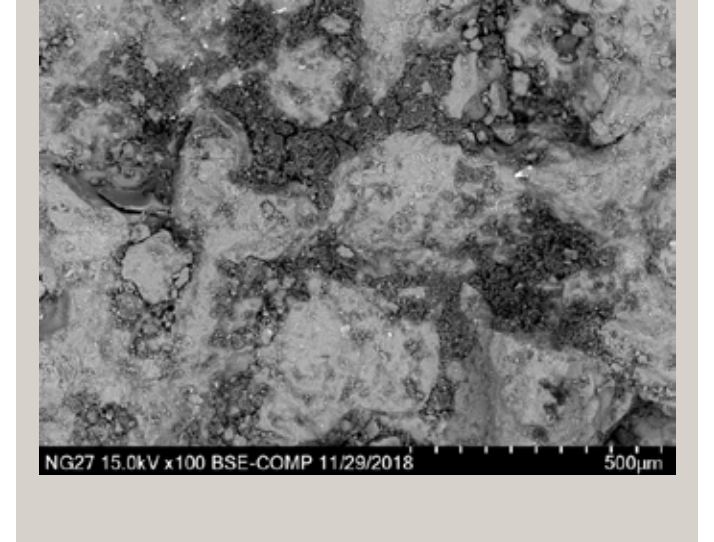
An expert in archaeobotany, Anna's PhD research explores the diets of Australia's earliest colonists by identifying the remains of charred plant foods in the more than 65,000 years of charcoal remains found at Madjedbebe, the earliest known occupation site in Australia, located in Mirarr Country, western Arnhem Land.

Having used several analytic techniques including pXRF, FTIR (David et al. 2013) and synchrotron XFM to determine what the pigment was not – Dr Huntley said it was satisfying to definitively show with the SEM that the motif was made using specially prepared plant charcoal.

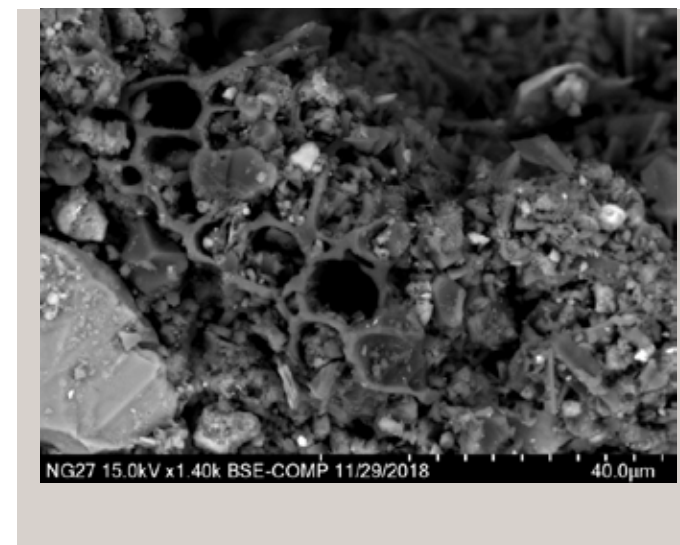
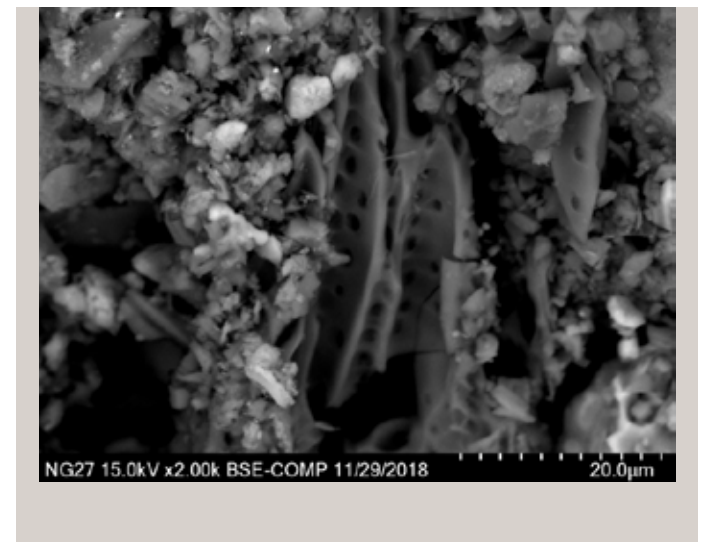
"The detailed wood anatomy was more than we hoped to see. I can't believe it has preserved for some 28,000 years".



The c.28,000 year-old rock art found in the sediments at Nawarla Gabarnmang showing the Br element map produced by synchrotron XFM.



The surface of the black motif from Nawarla Gabarnmang showing the lighter high points of the stone with the dark charcoal lying in the depressions.



Structural elements of the charcoal used to draw the c.28,000 year-old motif from Nawarla Gabarnmang, including xylary elements indicative of wood charcoal.

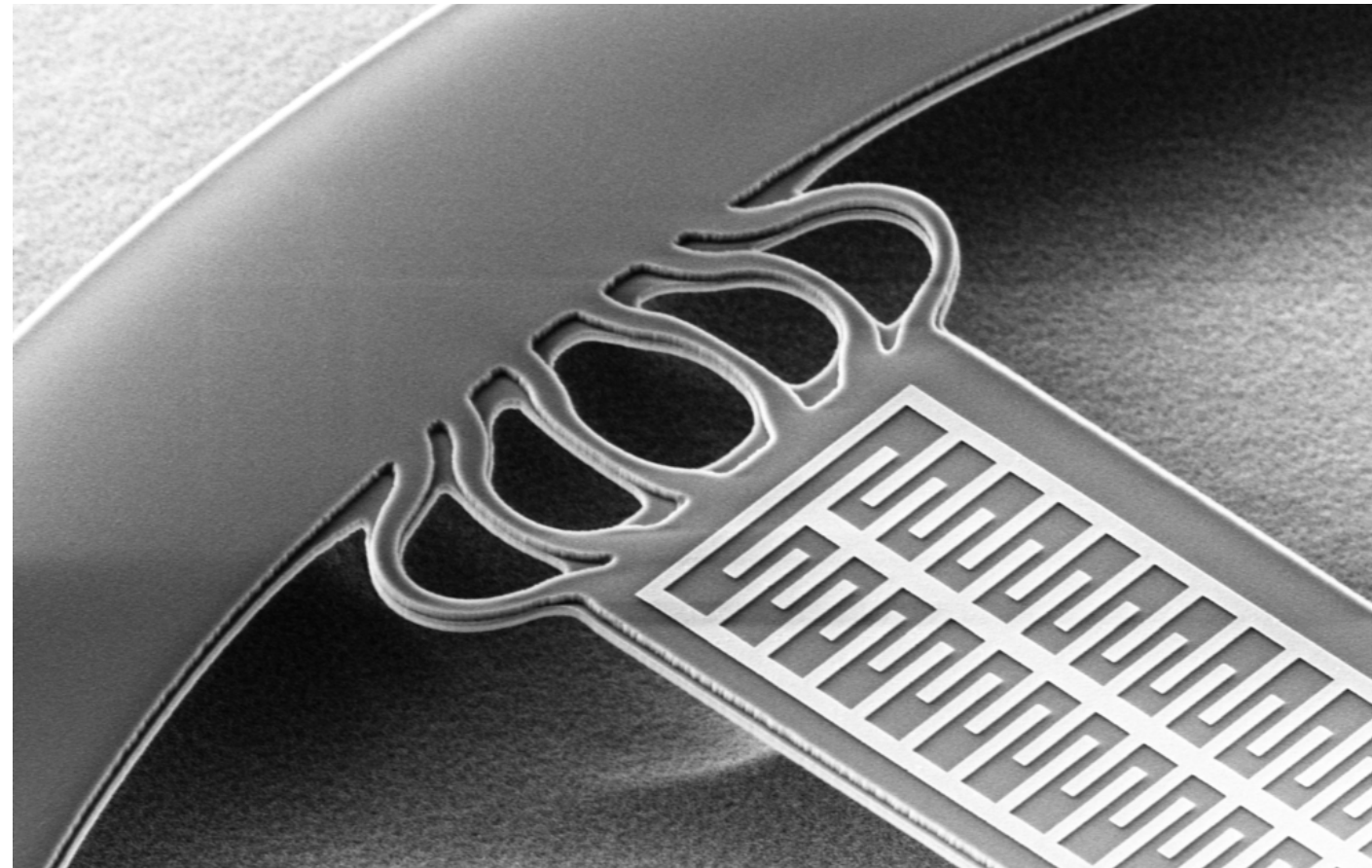
Acknowledgements:

This work is a collaboration between the archaeologists at the Place Evolution and Rock Art Heritage Unit at Griffith University, Professor Bruno David of the Monash Indigenous Studies Centre at Monash University, Professor Bryce Barker of the University of Southern Queensland, the Jawoyn Association and the School of Social Science at UQ. We thank Ron Rasch for access to the CMM facility and assistance with SEM analysis.

Further reading:

David, B., Barker, B., Petchey, F., Delannoy, J.J., Geneste, J.M., Rowe, C., Eccleston, M., Lamb, L. and Whear, R., 2013. A 28,000 year old excavated painted rock from Nawarla Gabarnmang, northern Australia. Journal of Archaeological Science 40(5):2493–2501.

Chalmin, E. and Huntley, J., 2017. Characterizing Rock Art Pigments. In The Oxford Handbook of the Archaeology and Anthropology of Rock Art. <http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780190607357.001.0001/oxfordhb-9780190607357-e-48>



Down with double disks

Christiaan Bekker

Free Spectral Range Tuning of an On-Chip Microcavity through a Nanofabricated Integrated Capacitor

At the Queensland Quantum Optics Lab, headed by Professor Warwick Bowen at UQ, much work has gone into developing devices at scales of tens to hundreds of microns (smaller than the width of a human hair) for ultrasensitive sensing, control and transduction between different types of signals. The group has recently started developing a double-disk resonator.

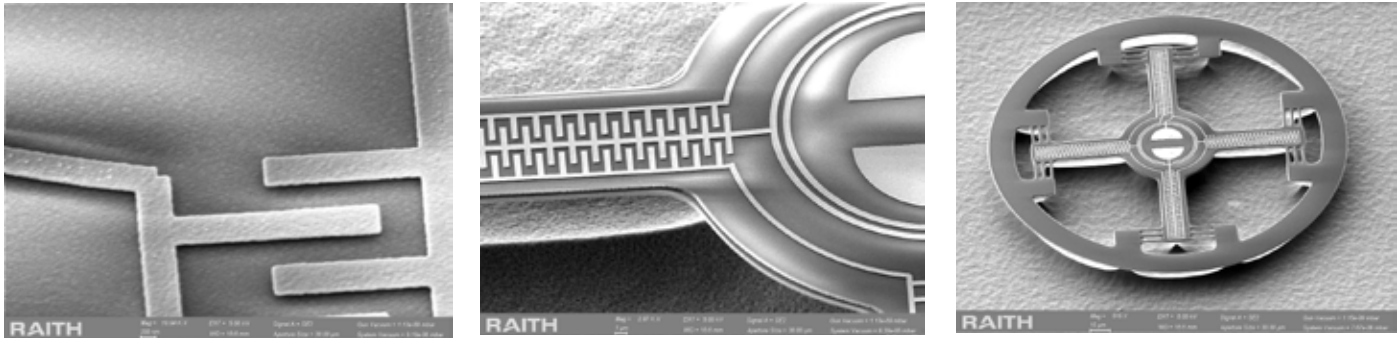
Unsurprisingly, this consists of two very thin disks stacked on top of each other on a pedestal – so close, in fact, that the spacing between the disks is only a fraction of the wavelength of the light used to probe the devices. Although the light can't clearly 'see' each disk separately, the light that can exist in the device is extremely sensitive to any changes in the gap between the disks.

These double disks need to be defined with high resolution, as we wish to maximise the smoothness of the disks' outer perimeter to optimise the confinement of light. In addition, projects are underway to control the devices electrically through gold capacitors (as in the figures below), or to use the response of magnetostrictive material on the double disks to sense magnetic fields. This requires the use of the EBL lithography systems in CMM, which have no trouble defining features at sub-micrometer scales. The coating, patterning and fabrication of the devices were performed jointly in the CMM

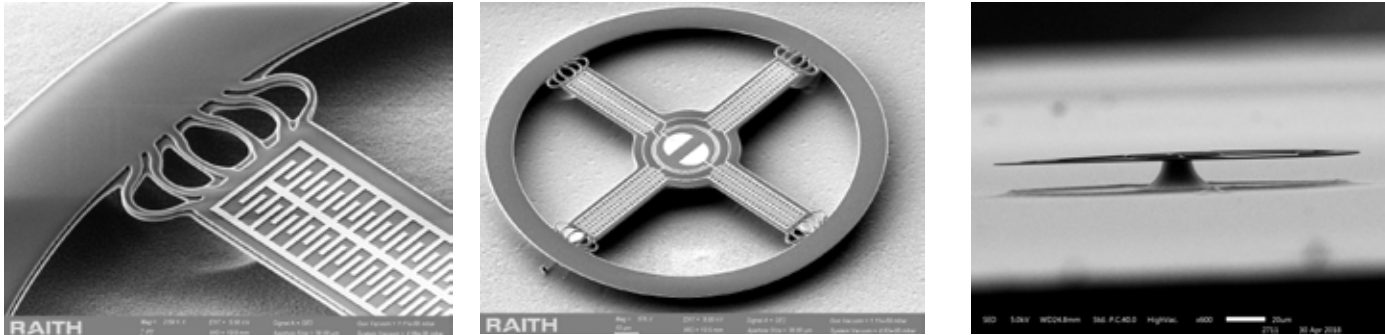
EBL cleanroom and the ANFF cleanroom in the neighbouring ANFF building.

With these devices, we have been able to demonstrate free spectral range tuning, which means that in practice, the device can be set on resonance with an arbitrary frequency (colour) of light. In photonic circuits, this corresponds to a switch which can rout optical signals between paths for a wide range of operational bands, using the same device. This can open up the possibility of parallel reconfigurable circuits on a single chip, complex photonic networks for computers based on light, or on-chip spectrometers for measuring the intensity of light at specific frequencies.

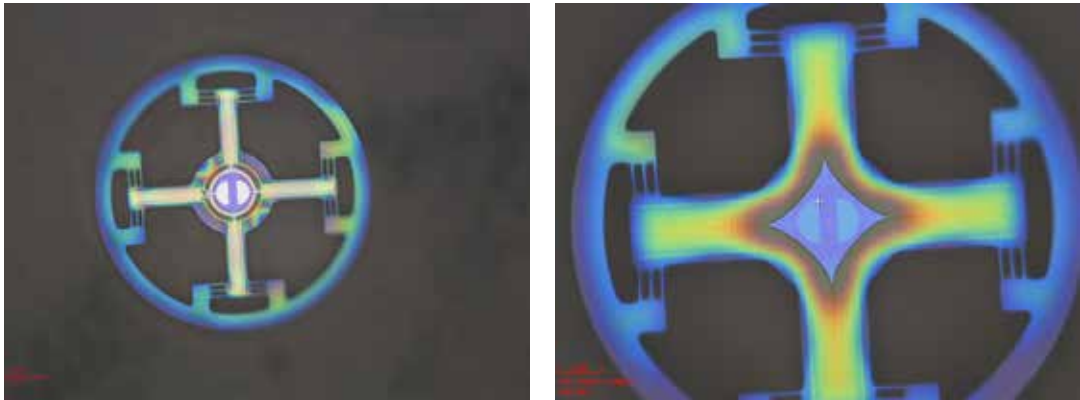
In an extension of this project, the group are currently working on creating an on-chip laser using these devices, which can be widely tuned *in-situ* on a chip. This could provide compact, flexible light sources for applications ranging from signal generation and on-chip spectroscopic characterization to labs-on-a-chip, where the source, experiment and detector are all fabricated lithographically.



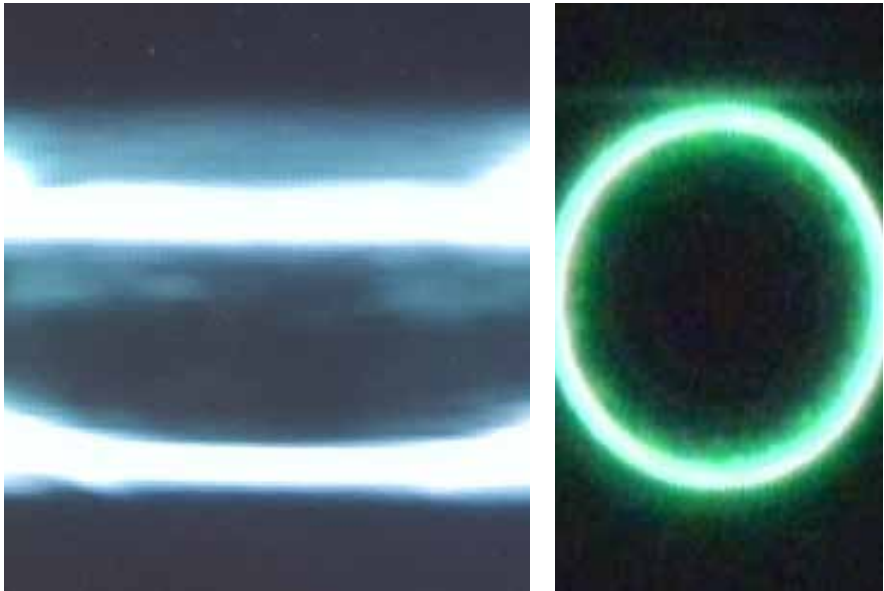
SEM Images taken with E-Line SEM of FSR-tuneable double disk devices. The first device is designed to release stress in the disks through lateral anchor points. Closer inspections of the electrodes were made to evaluate their deposition process.



The second device uses curved anchors to similarly release stress.



Zeta top-view images of Erbium-implanted tuneable double-disks, used in the on-chip laser project.



Green lasing observed in experimental setup

A sphere-to-polyhedron shape transformation

Chin Ken Wong, Adam D. Martin, Matthias Floetenmeyer, Robert G. Parton, Martina H. Stenzel and Pall Thordarson

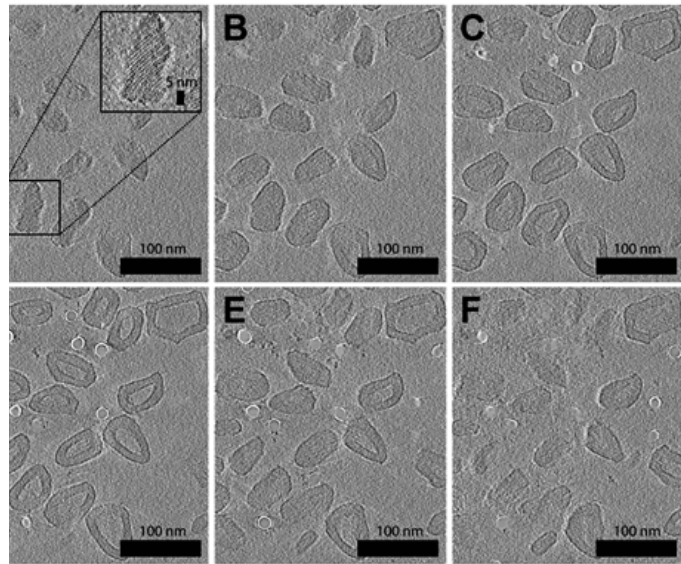
The creation of ‘soft’ deformable hollow polymeric nanoparticles with complex non-spherical shapes via block copolymer self-assembly remains a challenge.

In this work, the team shows that a perylene-bearing block copolymer can self-assemble into polymeric membrane sacs (polymersomes) that not only possess uncommonly faceted polyhedral shapes but are also intrinsically fluorescent.

The researchers further reveal for the first time an experimental visualization of the entire polymersome faceting process. They uncover how polymersomes facet through a sphere-to-polyhedron shape transformation pathway that is driven by perylene aggregation confined within a topologically spherical polymersome shell.

Finally, they illustrate the importance in understanding this shape transformation process by demonstrating our ability to controllably isolate different intermediate polymersome morphologies.

Their findings should provide opportunities for those who utilize non-spherical polymersomes for drug delivery, nanoreactor or templating applications, and those who are interested in the fundamental aspects of polymersome self-assembly.



Cryo-ET images of (65% THF/water) faceted polymersomes. (A–F) Six top-to-bottom x,y-slices through the tomographic reconstruction. Shown inset in A is a higher magnification image that highlights the existence of smectic layers on the polymersome surface.

Autotransport process of a trimeric autotransporter

Nandini Chauhan, Daniel Hatlem, Marcella Orwick-Rydmark, Kenneth Schneider, Matthias Floetenmeyer, Barth van Rossum, Jack C. Leo, Dirk Linke

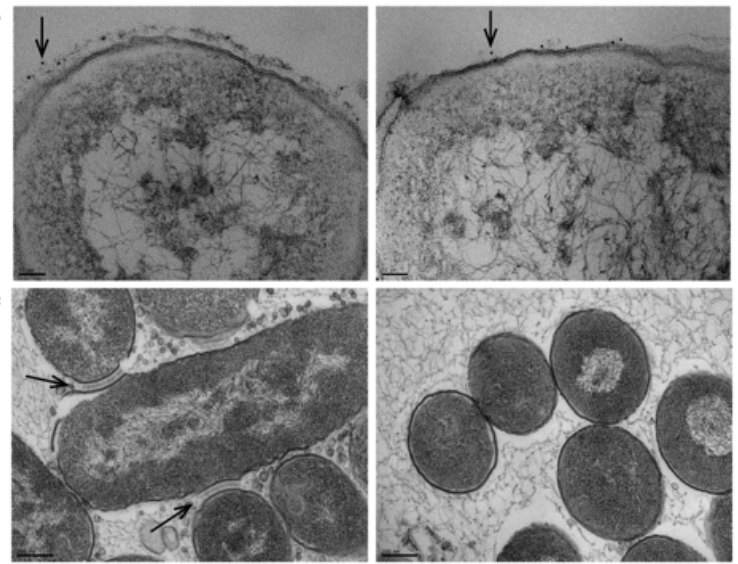
Trimeric autotransporter adhesins (TAAs) are a subset of a larger protein family called the type V secretion systems. They are localized on the cell surface of Gram-negative bacteria, function as mediators of attachment to inorganic surfaces and host cells, and thus include important virulence factors. Yersinia adhesin A (YadA) from *Yersinia enterocolitica* is a prototypical TAA that is used extensively to study the structure and function of the type Vc secretion system.

A solid-state NMR study of the membrane anchor domain of YadA previously revealed a flexible stretch of small residues, termed the ASSA region, that links the membrane anchor to the stalk domain.

In this work the researchers presented evidence that single amino acid proline substitutions produce two different conformers of the membrane anchor domain of YadA; one with the N-termini facing the extracellular surface, and a second with the N-termini located in the periplasm.

The team propose that TAAs adopt a hairpin intermediate during secretion, as has been shown before for other subtypes of the type V secretion system.

As the YadA transition state intermediate can be isolated from the outer membrane, future structural studies should be possible to further unravel details of the autotransport process.



Electron micrographs of cross-sections of immunogold-labelled YadAwt (A) and YadAA354P (B) expressed in *E. coli*. Lollipop-shaped surface projections are seen on the surface of wild-type expressing cells, but are missing in the cells expressing the proline mutant, while the gold labelling is present in both (indicated by black arrows). ‘Zipper-like’ formations promoting autoaggregation are observed in *E.coli* expressing YadAwt (C) (indicated by a black arrows) but missing in *E.coli* expressing YadAA354P (D).

Understanding human disease

Project 1

WooRam Jung, James Rae, Charles Ferguson
Nick Ariotti,
Collaborators: Kirill Alexandrov, Yann Gambin

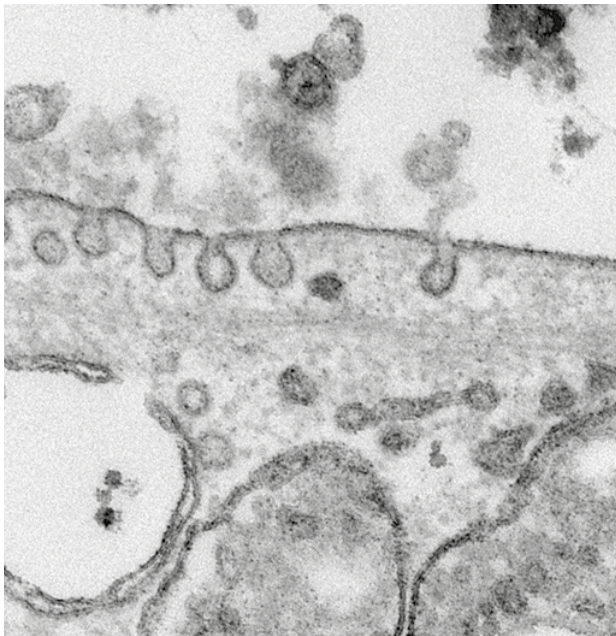
The cell is the fundamental unit of life. The human body contains approximately 200 different types of cells. These cells have different molecules, structures, and functions that are essential for the organs of the body to function. This work involves using electron microscopy to explore the cell and to determine what goes wrong in human disease. In particular, the team have focussed on the plasma membrane that encloses the cell and forms a crucial barrier between the cell and the outside world.

The plasma membrane is a mosaic of specialised regions with specific functions. The overall aim of the research is to dissect the structure, function, and composition of specific plasma membrane microdomains and to understand how microdomain dysfunction leads to disease. Electron microscopy, including electron tomography, serial blockface scanning electron microscopy (SEM), focussed ion beam SEM, and cryoelectron microscopy, is a vital technique in these studies.

The work has implications for diverse cellular processes and disease conditions including muscular dystrophy, liver regeneration, and cancer.

Future plans

To dissect the molecular mechanisms involved in the formation and function of caveolae and to understand how dysfunction of caveolae contributes to human disease.



Caveolae, small pits of the adipocyte (fat cell) surface, as seen by transmission electron microscopy.

Project 2

Tom Hall, James Rae, Charles Ferguson, Nick Ariotti
Collaborators: Yann Gambin

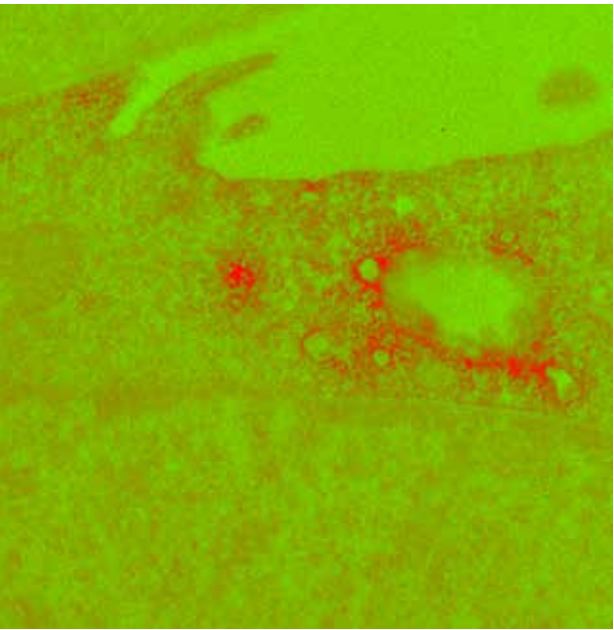
A crucial aspect of cell biological research involves the localisation of a protein within individual cells in tissues and whole organisms. The conventional approaches to finding out where a protein is located in the cell are based on antibodies; these methods are laborious and generally not applicable to modern methods of 3D electron microscopy. The team developed novel high throughput methods for localisation of proteins in cells and tissues.

These methods used small antibody fragments, termed nanobodies, that recognise either green or red fluorescent proteins, that are fused to an enzyme called APEX that can be detected by electron microscopy.

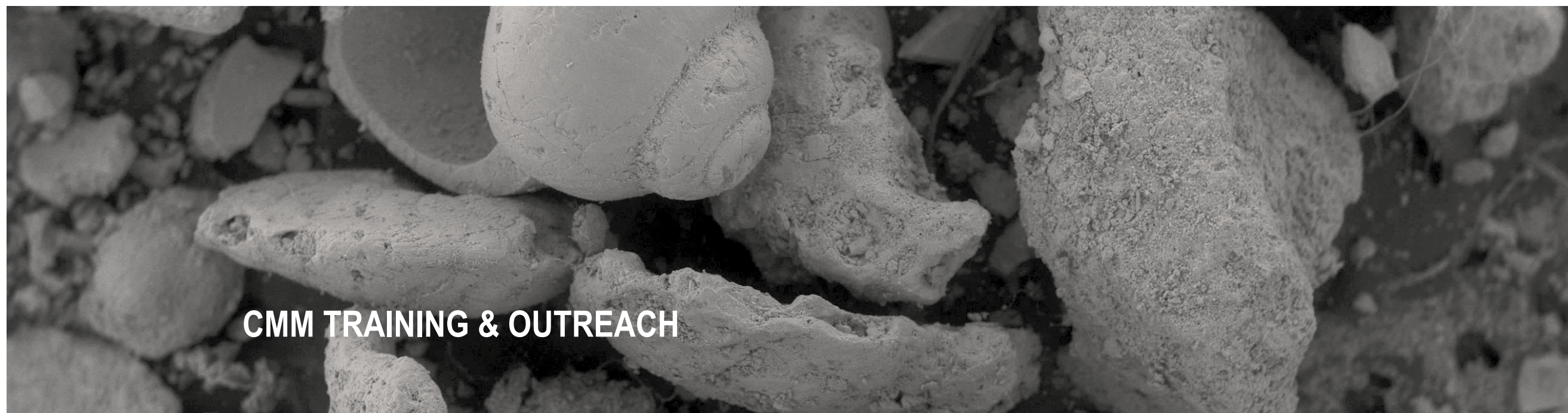
The team further modified this method to allow detection of low abundance proteins; the engineered nanobodies and the attached APEX enzyme are broken down unless they bind to their target proteins. Moreover this method could be used to specifically detect protein complexes. This work was published in PLoS Biology in 2018.

Future plans

As these new methods are compatible with 3D electron microscopy the team is in the process of optimising conditions for APEX-based localisation of proteins using serial blockface and focussed ion beam SEM. This would allow localisation of proteins in the context of a whole organism for the first time.



APEX localisation of protein of the endosome and cell surface; the electron dense marker has been pseudocoloured red.



CMM TRAINING & OUTREACH

In addition to its comprehensive instrument training timetable, both one-on-one and courses, CMM is committed to sharing its expertise via seminars, workshops, networking events and outreach activities.

Highlights in 2018 included participation at the World Science Festival, the CMM User Assembly, and the Microscopes in Schools program.

Highly experienced, specialist staff are committed to providing a supportive and resourceful working environment for clients helping them to achieve their research goals through expert advice and training.

CMM training

To assist in the use of CMM's extensive range of advanced microscopy and microanalysis equipment, the Centre offers education and training that enables clients to reach a level of proficiency where they can operate independently. The majority of clients accessing the Centre participate in educational instruction.

Each user is assessed for existing competency during an interview process. Classes for some equipment are provided *ad hoc* (arranged one-on-one) whereas other training occurs in course blocks at fixed times.

Upgrade training to more advanced equipment and techniques is possible after preliminary training has been undertaken and is available upon application

Occupational health and safety

The CMM performed strongly in the Annual HSW inspection of centre facilities and services, achieving a 96% rating. It is a credit to all staff and clients that a high rating was achieved during changes in University and Safety systems, and the expansion of CMM facilities and capabilities.

- » The reopening of the Hawken and Chemistry facilities following refurbishments resulted in another record number of inductions (499).
- » The refurbishment of Hawken and Chemistry facilities addressed long term safety issues in these areas.
- » Only 1 Lost Time Injury (LTI) was reported across all CMM sites in 2018.
- » The departure of Wendy Armstrong in 2018 was a loss to the Safety Team but her diligent work in developing safety systems, procedures and culture will have a lasting impact on CMM safety.

48

Training courses

312

Course attendees

112

Users trained one on one

294

Individual users

499

Inductions across 6 facilities

134

Active risk assessments from CMM staff

User Group Forum

The breadth of research undertaken at CMM was showcased at the 2018 User Group Forum.

Organised by CMM Deputy Director, Associate Professor Kevin Jack and hosted by CMM Director, Professor Roger Wepf, the December 2018 Forum highlighted the interdisciplinary research capabilities facilitated by CMM with the aim to maintain future technological competitiveness.

The audience of close to 100 attendees heard how CMM instrumentation is vital for the continuing dedication to general education, services and research, and importantly to push research projects beyond the current frontiers.

Speakers and topics addressed at the Forum included:

Research program:

- » Designing next generation solar driven biotechnologies. A multi scale approach. Ben Hankamer (IMB, UQ)
- » Advances in mass spectrometry for molecular structure elucidation with spatial context. Stephen Blanksby (CARF, QUT)

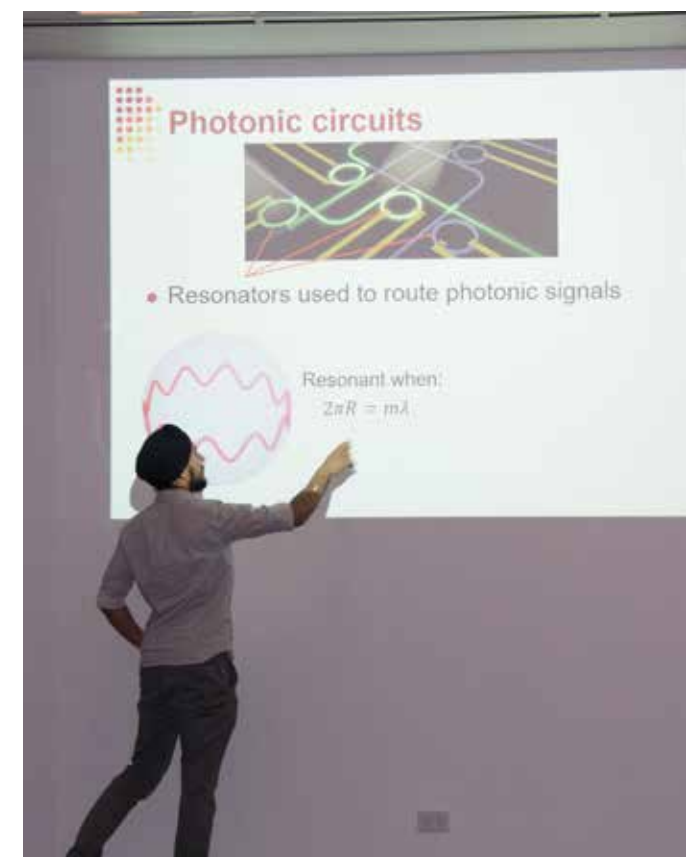
CMM client project presentations:

- » Eivind Undheim (CAI) Mass spectrometry as a tool for understanding venom biology
- » Nasim Amiralian (AIBN) Different approaches to producing cellulose nanofiber
- » Stuart Nicol (SCE) Controlled solidification of synthetic iron ore sinter melts
- » Alison White (AIBN) Optimisation of Impermeable Gold Microcapsules
- » Sarah Piper (IMB) Cryo-EM structures of YenTc: new clues to the molecular mechanisms of pore-forming ABC toxins
- » Antony Van der Ent (SMI) MicroXRF mapping of plant material samples
- » Emily Furlong (IMB) Studies of the trimeric disulfide isomerase PmScsC and its redox partner PmScsBa
- » Yuzhe Yang (SMME) Growth mechanism of single-crystalline layered nanostructures grown by salt-assisted atmospheric pressure chemical vapour deposition
- » Rachpon Kalra (SMP) From optomechanics to phononic circuits

The User Group Forum also provided the opportunity for CMM staff to keep clients updated of new infrastructure and capabilities.

The completed upgrade of both the Hawken and X-ray Laboratories has evoked great interest in CMM's users as additional world-class capacity has been added to CMM's instrumentation portfolio, including the much-anticipated Hitachi HF5000 cs-S/TEM for atomic resolution imaging and characterisation, and two Raith Electron Beam Lithography systems (EBL's) – a 100kV EBLPG5150 and the 1-30kV eLine which added quantum computation and nano-patterning capacity. Meanwhile the X-ray Laboratory now hosts a new dedicated *in-situ* small-angle X-ray scattering system (SAXS/WAXS) and a unique scanning XRF systems as well as two new installed instruments (XRD and X-ray diffractometer).

The User Group Forum concluded with a networking event allowing attendees to network with CMM's specialist staff.



World Science Festival

Visitors to the World Science Festival held in Brisbane in March 2018 experienced the excitement of scientific discovery with real-world light and electron microscopy samples and activities using specialist tools that will ‘make the invisible visible’.

The Centre for Microscopy and Microanalysis (CMM) presented a highly engaging interactive microscopy exploration booth titled ‘Microscopy & MyScope™’ during the 2018 World Science Festival (WSF) program at the Queensland Museum (QM). Over the weekend in March, the official attendance figure for the WSF event at the QM was more than 40,000 visitors.

The CMM microscopy booth had more than 600 enthusiastic visitors who made discoveries with our amazing free online microscopy outreach tool MyScope Outreach™, under the expert guidance of CMM (including UQROCX) staff.

Visitors to the booth stations were able to try out real light microscopes ranging from inexpensive USB tools through to traditional laboratory standard stereo light microscopes.

The average visitor time was around 15 minutes. Activities included high magnification viewing of biological samples such as food mould, native bees, butterfly wings, mother-of-pearl and gecko feet, and the use of X-ray microanalysis (EDS) to quickly and safely determine the elements in gold, fool’s gold and meteorite samples. Younger visitors were particularly keen to investigate and capture images of their own skin, hair and clothing using the hand held USB microscopes.

The booth had seven computers running the free online MyScope Outreach™ website developed by the Microscopy Australia and FEI company, which is an amazing SEM simulator. Computer technical aspects of the display were expertly organised and monitored by Andrew Stark.



Taking CMM into the classroom

CMM has been turning their laboratories into classrooms for a number of years, allowing primary and high schools a greater hands-on experience of science and the power of big microscopes.

In 2018 CMM in conjunction with NewSpec, changed the rules. Rather than bringing students to the CMM labs – CMM and NewSpec are taking microscopes to schools.

Schools in and around Brisbane are given the opportunity to host a Hitachi TM4000 microscope for a week and incorporate the use of the microscope into their STEM activities.

It is a passion that CMM and scientific equipment distributor NewSpec hold close – to inspire the next generation of scientists by providing access to the actual tools research scientists and engineers use to make discoveries.

In a welcome expansion to the program, CMM and NewSpec have added arts to the initiative, creating STEAM activities (science, technology, education, art, and mathematics).

Before the microscope can be brought into the classroom, the teacher needs to undertake a training workshop in CMM’s labs. This training provides guidance on the operation of the machine and sample preparation. CMM staff also assist teachers with advice on setting up their specific projects.

The program commenced in 2018 and already several schools have taken up the offer, with one Brisbane school submitting images produced on the TM4000 to CMM’s ‘image of the month’ competition, where they won special recognition.

CMM’s Director, Professor Roger Wepf, says the CMM/ NewSpec STEM and STEAM program is a hands on teaching resource that encourages students to consider a career in STEM.

‘Exploded bug’ taken by Ms Evelin Li from IES (International Education Services) received a special acknowledgement in our ‘Image of the month’ competition

“CMM is looking forward to taking the Hitachi TM4000 into more schools in 2019”, Professor Wepf said.

“UQ recently approved funding for CMM to appoint a part-time outreach officer. This person will have the responsibility to encourage more teachers to be trained and therefore provide more students with the opportunity to prepare their own samples and examine them using this marvellous microscope,” he said.

“Ideally CMM would like to develop some ‘ready to go’ projects and/or samples that would be in line with the Queensland curriculum”, he said.

CMM are also exploring options for students and teachers who want to expand their knowledge to undertake in-house experience or training at CMM.

The TM4000 is a Hitachi scanning electron microscope that has been made available free of charge by NewSpec to undertake this activity. The portability and compactness of the machine makes it the perfect microscope to be taken from school to school.

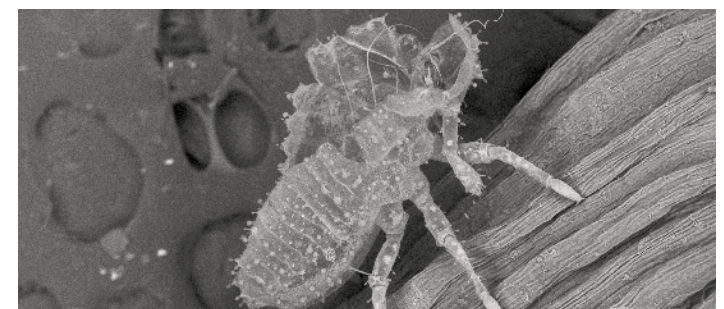
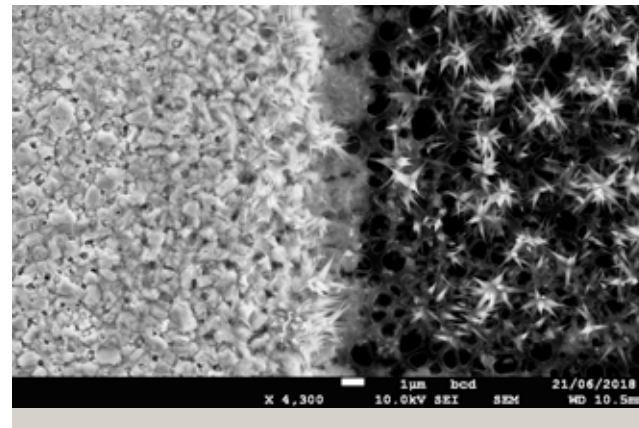
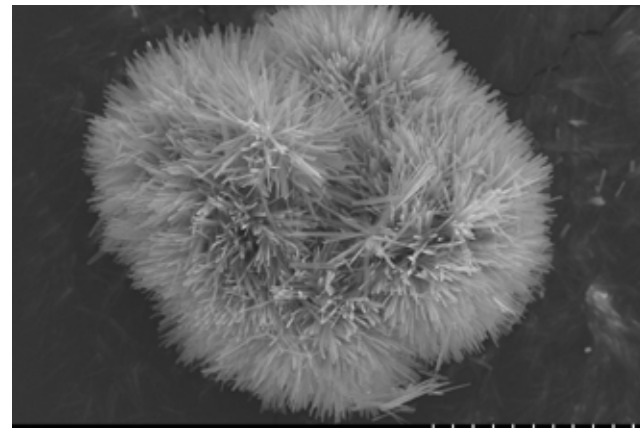
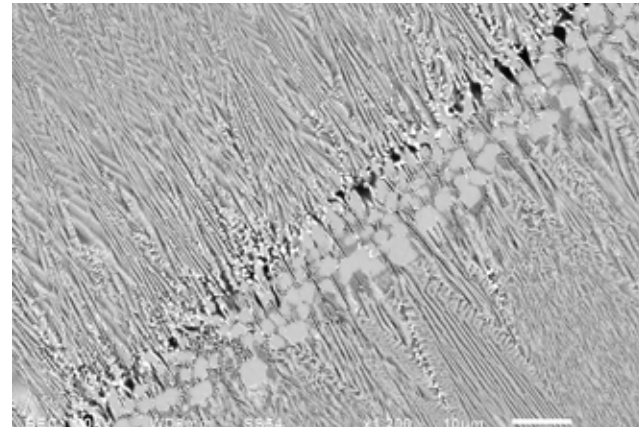
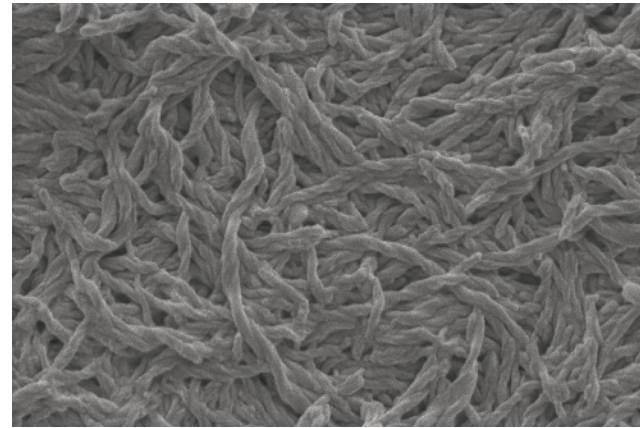
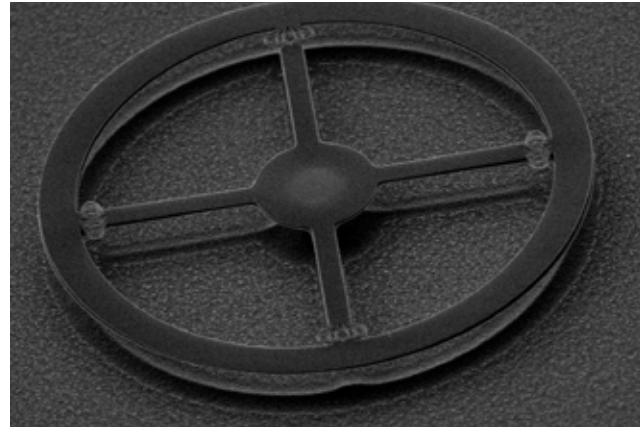


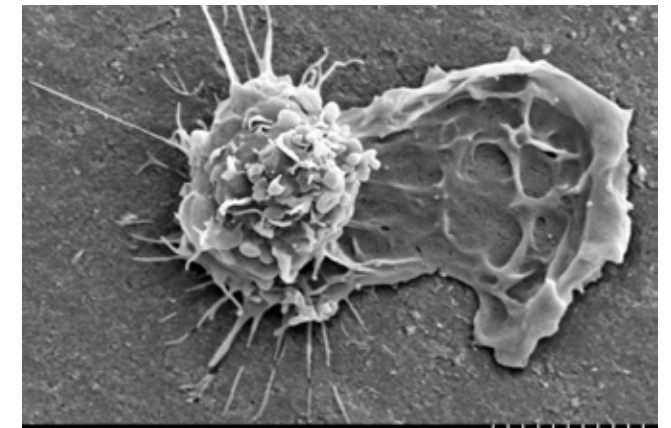
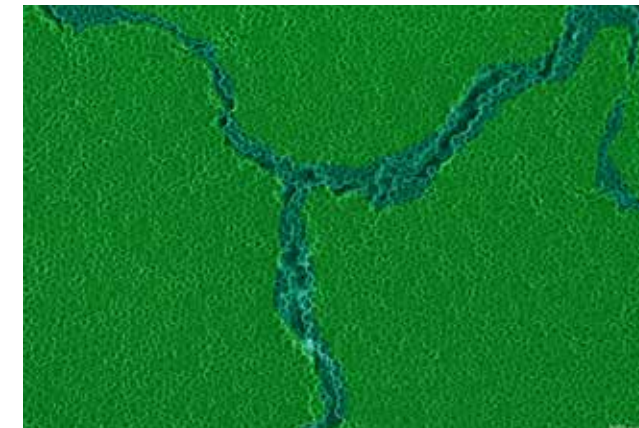
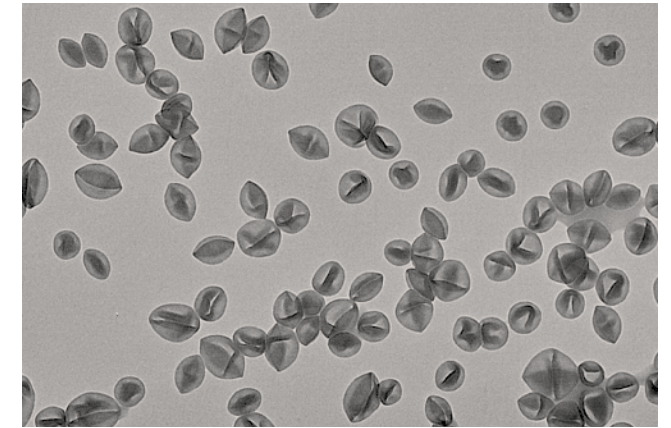
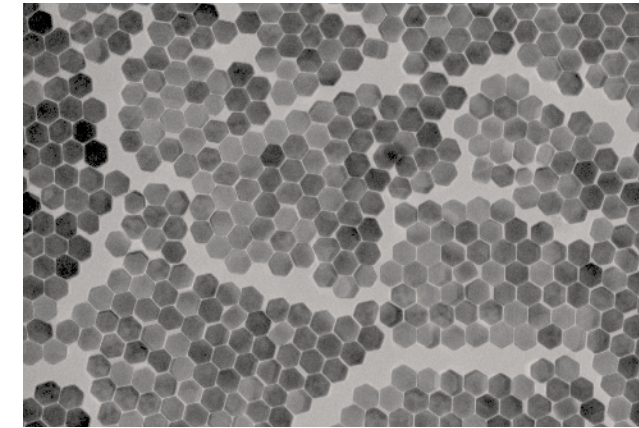
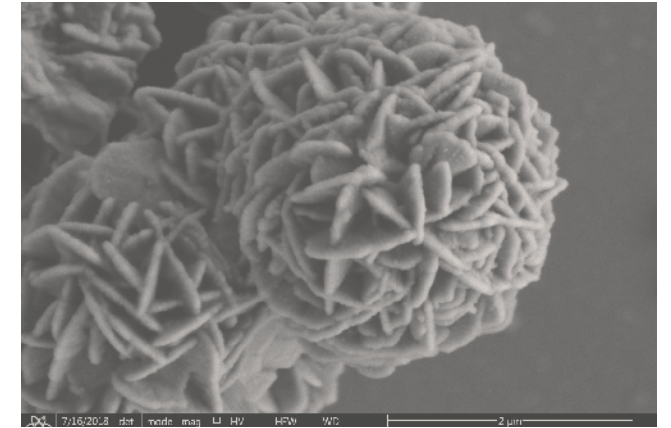
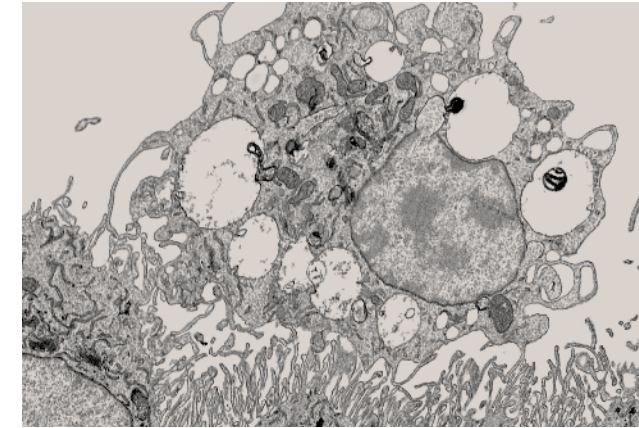
Image of the month



FROM TOP, LEFT TO RIGHT: Christiaan Bekker, These are double-disk optomechanical resonators, JEOL IT300 SEM; Miaoqiang Lyu, electron-beam lithography (RAITH ElinePlus in CMM), etching PMMA/Si substrate into PMMA nanorod arrays with different length; Jenny Lin, lithium based metal stearate (=soap) thickener, JSM 7001F SEM at 30000X 3KV Aperture 4 WD 6.5mm Spot 3; Franky Zhiqi Fan three types of ceramic oxides phases, JEOL JSM-6610 at BEC mode; Yilan Wu, urchin-like niobium pentoxide particle fabricated from hydrothermal synthesis, Hitachi SU3500 at SE mode; Dr Bogdan Donose, border between a TEM Copper grid coated with silica nanoparticles and a zone with carbonate/bicarbonate crystals, JEOL 7001F

In 2018 CMM continued its Image of the Month competition. CMM clients enter the competition by submitting an image that they have taken on one of the instruments. The monthly winner has their image displayed on the banner of CMM's website and included in the online gallery. This is a great way to exhibit the images taken on CMM instruments and it continues to build the connection between staff and clients.

View our full gallery on <https://www.flickr.com/photos/cmmatuq>



FROM TOP, LEFT TO RIGHT: Michael Hodges-Langford, epilexus cell (macrophage), with a highly vacuolated cytoplasm, patrolling along the microvilli of the choroid plexus epithelium within the embryonic mouse brain, Hitachi HT 7700 at 80kV; Dr Hong Peng, flakes of sodalite crystal, FEI Scios FIB-dual Beam SEM; Zhiqing Wu, NaLnF_4 (Ln=Yb, Tm) nanocrystals, Hitachi HT7700B at 80 kV; Russell Wilson, soft silica nanocapsules synthesised by peptide mediated biosilification on an oil-in-water emulsion template, Hitachi HT7700 at 80kV; Dr Chun Xu, Silica nanoparticles without any coating, JEOL 7800 at a very low voltage and coloured with photoshop; Nendar Herdianto, single-nucleated osteoclast (spherical) with its extended pseudopodia on the surface of Sr-substituted hydroxyapatite, Hitachi SU3500

Seminar series

The Frontiers in Microscopy and Microanalysis seminar series introduces the student and staff to advances in microscopy and nanoscopy with an emphasis on light microscopy, electron microscopy and analysis as well as X-ray microscopy and X-ray analytical methods. Both methodological and technological progress as well as applications in various scientific fields are discussed.

Highlights of the 2018 series include:

- » Dr Patrick Woo, Hitachi High Technology and NewSpec Pty Ltd
Advances in imaging and analytical techniques in scanning electron microscopy
- » Presentations from Zeiss, Raith and Witec on multimodal and multiscale electronic and light microscopy as well as new frontiers in correlative techniques
Supporting materials research to manufacture the future
- » Mr Jaap Brink, JEOL USA & Mr S Motoki, JEOL Ltd
JEOL and the occurrence of the next Ice Age
- » Dr Hongyi (Justin) Xu, Department of Materials and Environmental Chemistry, Stockholm University
Fundamentals of electron crystallography and its application in structure determination
- » Dr James Sagar, Oxford Instruments NanoAnalysis, UK
Three advanced & extreme EDX training lectures for SEM and STEM
- » Christopher Baker, Daniel Szombati, Idriss Blakey, Rachpon Kaira, Christiaan Bekker, UQ, Zibin Chen, Scitek Australia Pty Ltd and Nit Taksatorn, GenISYS GmbH
Electron beam lithography workshop
- » Dr Tadateru Nishikawa San, JEOL Ltd
Frontiers in spectroscopy – Introduction of the latest JEOL NMR
- » Dr William Rickard, John de Laeter Centre, Curtin University
Application of FIB-SEM based Time of Flight Secondary Ion Spectrometry.
- » Professor Richard Tilley, University of New South Wales
Solution synthesis and electron microscopy of nanoparticle catalysts

21
seminars

400+
participants



ConQEST Gatton

In July 2018 Roger Wepf presented the keynote address at the 2018 annual ConQEST conference held at the Gatton, UQ campus to some 130 delegates.

QEST is the association of Queensland Education Science Technicians: a non-profit professional association for laboratory staff in Queensland educational facilities.

ConQEST is the annual conference of QEST focusing on Professional Development workshops and information sessions.

The theme of ConQEST 2018 was “Game changers and change makers” with practical experiences in line with the Australian curriculum and new senior science syllabus being of key interest.

Roger’s keynote address tied into this theme as he discussed STEM (Science Technology Engineering and Mathematics) microscopy-related options that UQ/CMM could provide. These were: (1) Real active STEM in the Class Rooms; (2) Tele-SEM Course at CMM (“CyberSTEM”); (3) Virtual tools from Microscopy Australia (Scanning Electron Microscope [SEM]

Simulator and MyScope™); and (4) Newspec/Hitachi TM4000 plus Tabletop SEM “Inspire STEM Education” initiative for schools.

The application of microscopy to the Art curriculum was illustrated with colourful examples of indigenous art inspired by electron microscope images and the possible acronym STEAM was suggested to include Art into STEM.

There was also a practical component that involved a demonstration of the Tabletop Scanning Electron Microscope by Andrew Gibson-White from NewSpec using a range of interesting biological and physical science samples at magnifications well above that possible with a light microscope.

After only minimal instruction delegates were able to operate the SEM very effectively themselves, which highlighted the potential application for schools. At the conclusion a request was made to ConQEST to consider possible school curriculum applications for school students and to provide feedback to CMM on the four options.





Advanced health tools, battery technology and nanomaterials are all potential developments that could flow from a new microscope at The University of Queensland.

A \$5 million Hitachi HF5000 200kV Transmission Electron Microscope, which can see objects smaller than the very smallest atom – a hydrogen atom – was launched in 2018 during a two day workshop.

CMM hosted the event in September to open its newly refurbished Hawken Laboratories, which include a room purpose built to locate the HF5000. The festive launch was attended by representatives from Hitachi and CMM's extended research community.

Centre Director Professor Roger Wepf said the new technology would help bring together researchers from quantum physics to molecular biology, potentially leading to ground-breaking technologies.

"This microscope has enough power to see to a millionth the diameter of a human hair, which means you can see even small variations in the spacing between atom lattices in metals and semiconductors," he said.

"Getting down to this infinitesimally microscopic level is going to open up discoveries in the fields of health, synthetic biology, advanced materials and unique electronic devices."

"Imagine being able to manipulate ultrathin electronic or magnetic materials in real time, test nanoscale battery models, or see how a drug is delivered to a cell on a molecular or atomic scale."

Professor Wepf said the microscope provided a unique research platform.

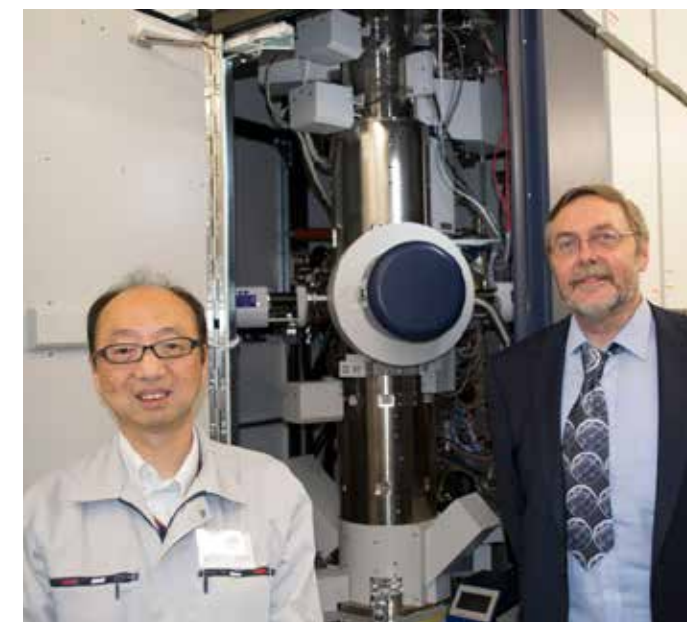
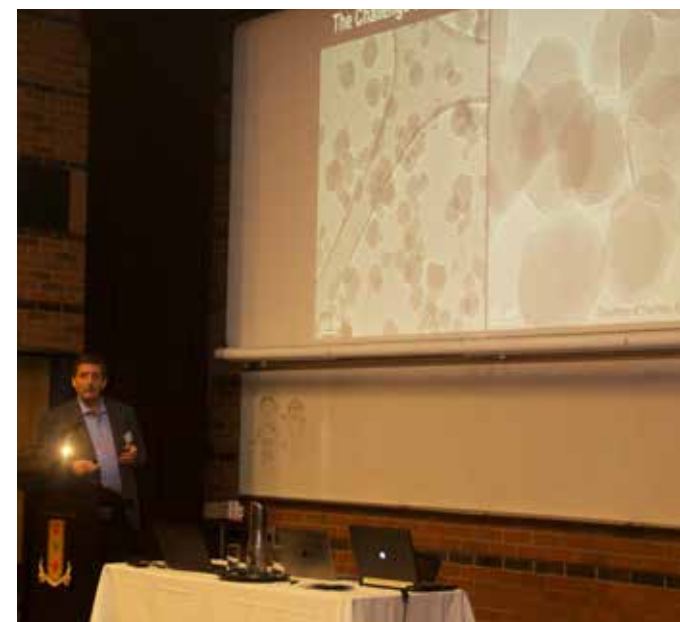
He said Hitachi, along with other partners, including scientific equipment specialists NewSpec, were keen to push technological boundaries in efforts that would help position Queensland at the centre of a sixth technological wave, the so-called sustainable 'green wave'.

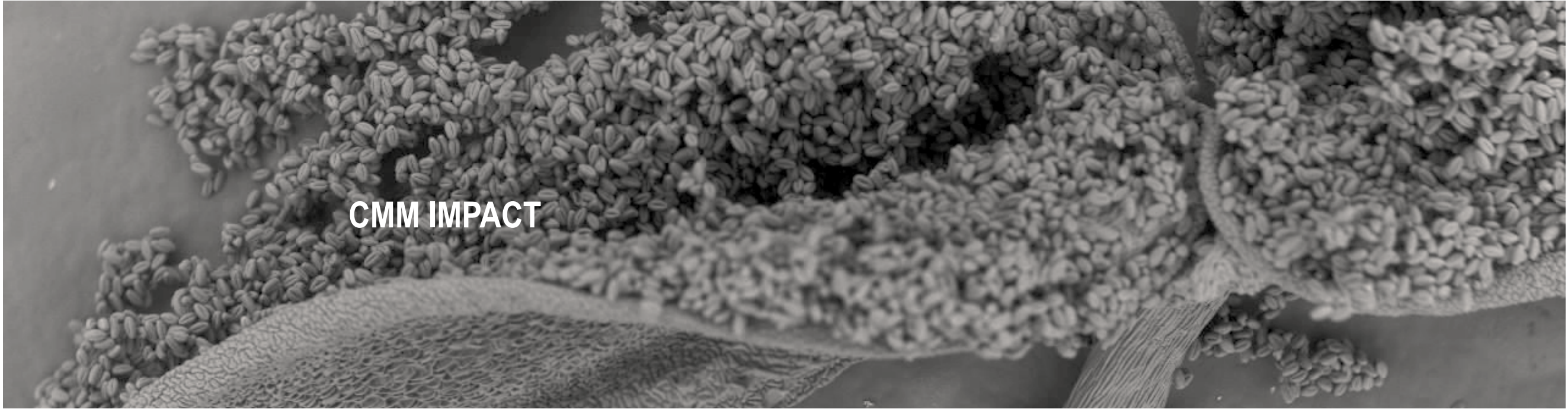
Professor Wepf was joined at the launch by Hitachi Vice President and Executive Officer Mikio Takagi, Member for Redlands Ms Kim Richards MP, UQ Provost Professor Aidan Byrne and NewSpec CEO Mr Graeme Jones.

The infrastructure is part of a raft of investments in microscopy at UQ, which includes \$5.5 million for the Hawken facility's refurbishment and \$4.5 million for a nanolithography suite as part of the Australian Research Council's Centre of Excellence for Engineered Quantum Systems (EQUS).



Adapted from UQ News September 2018: <https://www.uq.edu.au/news/article/2018/09/microscopic-innovation-reap-big-rewards>





CMM is committed to working with industry and research partners in their quest to improve and develop new designs, processes, and technologies. CMM provides the tools, training and professional expertise through access to the world’s best analytical instrumentation to facilitate this change.

*CMM is committed to
working with industry
and research partners to
create change*

What is our impact?

As researchers ourselves, and research facilitators to the broader Queensland community, we are always driven by the thought that our efforts will make a difference. That the results of our work contribute to creating a healthier, sustainable and more equitable society.

The business of scientific endeavour means that impact may be immediate and foreseeable. But more likely, the beginning of an impact journey will be difficult to define. The research will take years, and be based on the inspiration of a scientist decades ago, who worked tirelessly, along with many students and colleagues from successive generations. All of which will eventually lead to a breakthrough that has a measurable impact. Quite often serendipity is part of this journey and scientists have to be open for such ‘fortune incidents’. This is science, this is how it works, and as a modern society we are the beneficiaries of this process.

The research infrastructure at CMM (the advancements of which are an impact in itself) is at the disposal of the whole Queensland research community. As outlined in this report, we have capacity to host hundreds of users working 24/7 per week all year long on the instruments, and provide them with adequate training and safety instruction, such that they can work independently in the laboratories. We also have the scientific capacity to help them interpret their results and consult them on their endeavours.

Microscopy and microanalysis facilities allow Queensland researchers to understand and quantify the micro- and nano-structures and compositions of diverse systems, from engineering materials to biological organisms, which was hitherto impossible. Many advances in medical treatment and diagnostics, engineering, communications, agriculture, defence materials, minerals, energy and environmental management depend on microscopy investigations as an ‘eye opener’. Research and innovation in these critical areas underpin diverse industries that not only sustain the economy but improve quality of life.

The research section of this report highlights just some of the outcomes from CMM laboratories, in particular, *Journey to the centre of the cell*, which uses cancer cell data to create a 3D virtual reality tool to explore inside a cell. This will have a significant impact on the way biologists can understand microscopic data.

Further, the incredible application of SEM in archaeology proved that charcoal was used in the oldest rock art in Australia, thus contributing to understanding the world’s oldest culture and its very early achievements.

Also, earlier in the report, we highlighted the unique opportunity we provided to Queensland schools, in partnership with our close industry collaborator Hitachi, by taking an advanced scanning electron microscope into the classroom giving young Queenslanders skills, advanced education and training, and an insight into a potential future career in STEAM. This program adds to our existing outreach initiatives, built over

a number of years in collaboration with Microscopy Australia, including Incredible Inner Space, Stories and Structures – New Connections, MyScope™, MyScope Outreach™ and the Inspire STEM Education project.

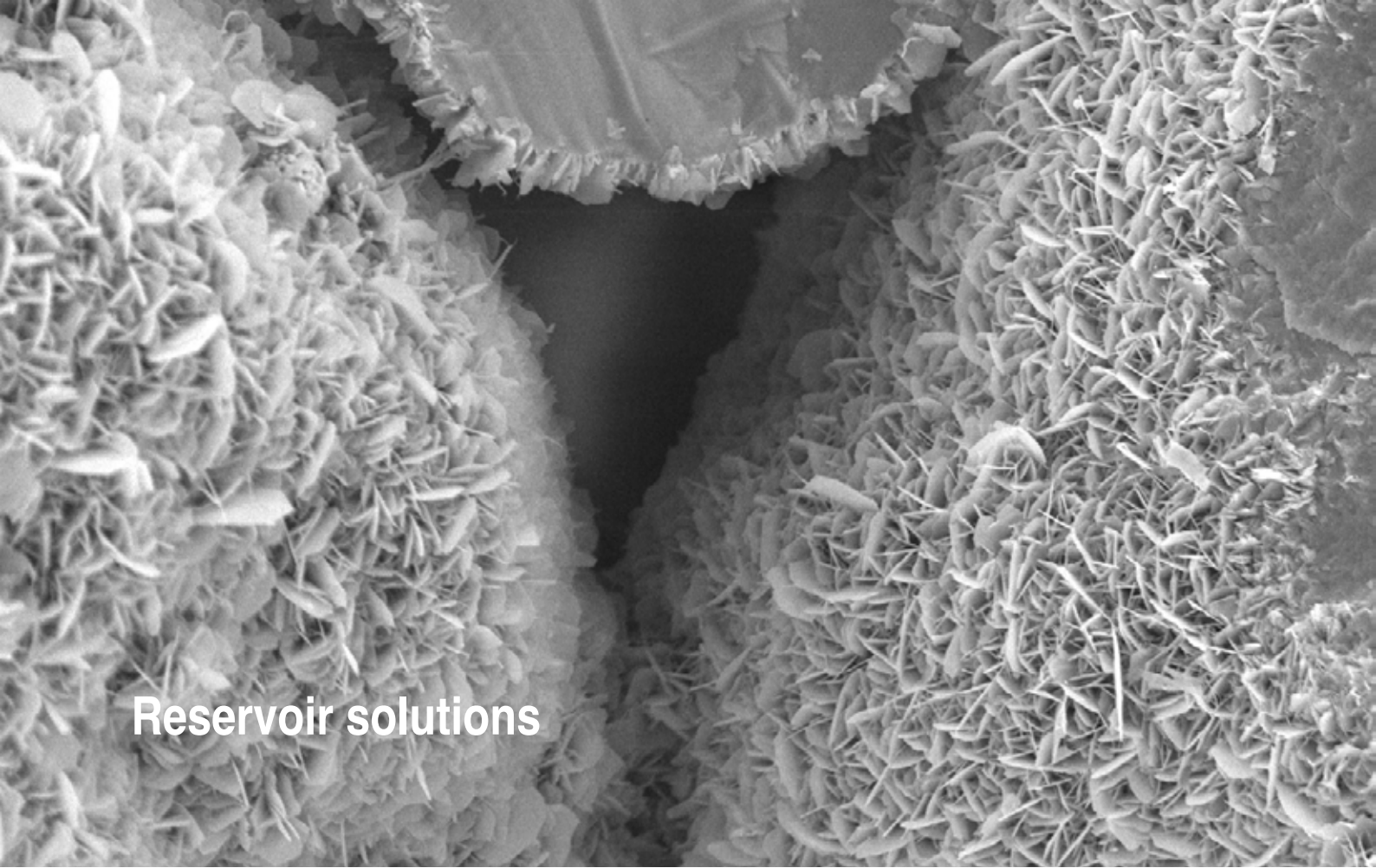
In this section, we present four case studies to further illustrate the social, economic, and environmental impact of CMM activities. Two of these illustrate our engagement with industry and two demonstrate the interface of ‘pure’ science to promising application. All of these case studies reveal a specific feature. Namely, impact from research derives first and foremost from open collaborations among universities, industry, and government.

A long-term client of CMM, Dr Julian Baker, provides services to Queensland’s oil and gas exploration industry – an industry that contributes \$1 billion to the state economy. Dr Baker’s services have a direct impact on the national and state priorities: Energy Production and Energy Security, Manufacturing and Environmental Impact. CMM experts have worked with Dr Baker for over 20 years to provide analysis and instrument access, underpinning the economic viability of the exploration industry.

As a society we take for granted that we can exploit new technologies at no risk to ourselves. It is thanks to a myriad of environmental health technologies that we can be so confident in our air and water quality. On page 64 we report on one such technology and the forensic approach taken by CMM to solve a puzzle as to why a micro sensor was failing to detect explosive methane gas.

The classification of our biodiversity, and understanding its untapped potential, is the core mission of many natural history museums. Research from the Queensland Museum has taken advantage of the advanced instrumentation at CMM to study an organism that was otherwise ignored by taxonomists due to its inherent ‘messy’ structure. Sponges from marine environment eg. the Great Barrier Reef have been examined, revealing a much richer diversity than previously thought. In tapping into this species, and understanding its physiology, researchers have discovered cancer inhibiting bacteria within sponges.

The application of cellulose nanofibres from spinifex to strengthen concrete is one such example that has economic, environmental and social impact. UQ researchers have developed and patented a low-cost process to extract very long, very thin (3-4 nm) and very strong nanocellulose fibrils from Spinifex grass. The UQ team is partnering with the Camooweal-based Dugalunji Aboriginal Corporation to share traditional knowledge of the Spinifex and intellectual property of the process and final product.



Reservoir solutions

Reservoir Solutions, based in Brisbane, is the only sedimentary petrology consultancy in Australia.

Dr Julian Baker, founder and operator, provides specialist analyses on drill core samples that yield detailed information on mineralogy, clay distribution, porosity, diagenesis and reservoir quality. These analyses – combined with Dr Baker’s services and expertise – have direct significance on the national and state priorities: Energy Production and Energy Security, Manufacturing and Environmental Impact.

Analyses are used in reservoir prediction, which assists in determining the probability of finding oil or gas in undrilled areas, and can also be used to help establish economic methods to drill at the site, including the use of appropriate drilling fluids to avoid formation damage.

Reservoir Solutions has been operating for nearly 20 years and has relied on the services of CMM throughout this time. CMM provides and facilitates timely and accurate analysis of samples by X-ray Diffraction and Scanning Electron Microscopy with Elemental Analysis.

“The long term relationship with CMM is built upon a number of factors, including their extensive collection of specialist instrumentation”, Dr Baker said.

“The support and knowledge provided by CMM staff (both instrumental and administrative), access to instrumentation

24/7, and the provision of training – allowing me to carry out specialist analysis directly – makes CMM a unique facility in Queensland.”

Dr Baker also credits CMM’s long term knowledge of the workflows and needs of Reservoir Solutions with strengthening this relationship.

The primary clients of *Reservoir Solutions* include oil and gas exploration companies and/or their consultants. Clients range in size from multinational companies to smaller entities and include large Queensland-based companies as well as other companies that have active projects in Queensland.

Clients are typically long term and are attracted by Dr Baker’s expertise and specialist knowledge in the field of sedimentary petrology as applied to reservoir analysis.

“The support, access to instrumentation 24/7, and the provision of training makes CMM a unique facility in Queensland”, Dr Julian Baker

Analysis of methane sensor beads

Brisbane based health, safety and environmental management firm Serinus was faced with a challenging problem. A client had identified a failure of a particular sensor to respond to methane, suspecting silicone poisoning as the possible cause.

Methane is a flammable gas and areas where it can occur need to be monitored to ensure it does not accumulate and pose an explosion risk. A common type of detector used to measure methane can be poisoned by other chemicals present in the atmosphere, and thus hinder the functionality of the detector to measure any methane present.

When one of their clients identified that a sensor was no longer responding to methane at all, Serinus contacted CMM seeking answers

Discussions with CMM relating to the issues with the failed sensors and possible poisoning resulted in the suggestion of two types of analysis, namely X-ray photoelectron spectroscopy (XPS) in the first instance, and then if required scanning electron microscopy/ energy-dispersive X-ray spectroscopy. Sensors from a failed unit and a new sensor were supplied for analysis.

Possible silicon enrichment was identified for the failed sensor, most likely in the form of silicone (a known poison). Based on these results further analysis was conducted on upstream filters that are designed to capture silicone. No additional silicone was measured in the filter from the failed sensor compared to the new filter.

The manufacturer (UK based) conducted similar testing of the sensors with similar results and indicated that the failure was due to silicone poisoning. However, as with CMM testing, the lack of silicone on the filters did not support the poisoning theory.

Some subsequent failures and further testing showed the failure likely to be an electrical issue rather than poisoning (supported by the analysis by CMM).

“The technical expertise and advice provided by CMM was excellent, including guidance in the appropriate methodology for testing,” Serinus consultant Darren Brady said.

“We greatly valued the quick turnaround time for analysis as determining the cause of the failure had direct safety implications. The samples we provided for analysis were not typical of those normally analysed. Results from testing were explained and reported very well”, Darren said.

“The technical expertise and advice provided by CMM was excellent, including guidance in the appropriate methodology for testing”, Dr Darren Brady.



Left: the sensor bead in the housing, right: sensor bead compared to the housing, with a diameter the size of a 10c piece.



Using SEM to uncover the secrets of sponges

Sponges represent the oldest group of true animals with just over 9,000 species known worldwide. Sponges are true evolutionary winners, yet very little is known about the evolution of the diversity within the phylum. A recent discovery that they contain tumour suppressing compounds has spurred researchers to learn more about these mysterious animals.

Sponges have taught scientists much about human physiology. For example, their ability to recognise “self” and “not self” cells lead to an understanding of human immune systems.

Sponge bacteria may also be a source of new natural products, such as potential new chemotherapeutics, but the inherent difficulties in working with sponges (Phylum Porifera) mean they are often overlooked by taxonomists.

From a practical perspective, making sections for microscopy is very time-consuming and challenging: sponges have a tendency to incorporate a lot of shelly and sandy debris in their bodies, sponges can vary between being dense and rock-like to being wispy and ethereal and fragile, and sponges of the one species can change their overall shape and colour depending on the environment in which they are growing. Viewed under standard light microscopy, sponges do not look especially interesting and semi-thin sections do not provide a lot of information for morphologists.

A CMM user, Dr Kathryn Hall from the Queensland Museum, has successfully been able to advance her studies with SEM images.

Dr Hall’s research focusses on the so-called golf-ball or moon sponges, so named for their pitted round bodies. These sponges, within the Family Tetillidae, are an ancient group of silica spicule-bearing sponges, and are of particular interest because chemists have isolated tumour-suppressing compounds from a number of species.

Work at CMM has involved looking at sections of the skeleton, viewing the outside surface and inside surfaces and sections through the body, examining tiny spicules in precise detail and also building up a picture of the overall structure of the skeleton, to see the patterns made by the spicules and how they fit together into a 3D structure.

The SEM facility at CMM has made it possible to capture high quality and beautiful imagery. As a complement to this work, Dr Hall has also copied the sponge DNA with PCR and amplified target genes to add to existing species trees (phylogenies). From results to date, she has been able to correlate morphological differences with DNA differences, indicating that specimens from Australian waters which were historically thought to be one species actually represent multiple species which are distributed along the eastern seaboard of Australia.

Further, using SEM has produced very exciting results, which show that one species, *Cinachyrella enigmatica*, is actually not even a tetillid sponge at all, but belongs in a totally distinct order (little wonder it was called “enigmatic”!). This result especially highlights the strength and utility of SEM studies for sponge taxonomy: the C-shaped spicules (sigmata) of *C. enigmatica* can be clearly shown to be entirely different to those of other tetillids, have smooth shafts and fine recurved spines only at the sharp ends, in contrast to the stubby and entirely spiky sigmata of true tetillids. Tetillid sigmata are consistent in width along their length, suggesting that they are formed in one direction. The sigmata of *C. enigmatica*, though, taper at each end, and appear to have been created in two directions from a central origin. Although such differences appear minor, for these ancient animals, such differences, observable only using SEM, indicate major differences in spiculogenesis and support the hypothesis of different phylogenetic origins for the two spicule types (and therefore classification in different orders).

Top images from Cinachyrella enigmatica, showing C-sigmata with smooth shafted and micro-spined ends.

Strengthening cement with spinifex

Globally about three tonnes of cement-based building materials are used per capita every year. As the world’s population grows, the demand for building materials is expected to increase by seven per cent in 2021. A team of UQ researchers, led by AIBN Group leader Professor Darren Martin, have identified and discovered a unique high-quality cellulose nanofibre from Australian spinifex grass that can significantly strengthen cement, thus reducing the volumes required for structural stability.

This sustainable technology was discovered in the final year of Dr Nasim Amiralian’s PhD project. Enabled by CMM’s microscopic imaging, the team have created five different types of nanofibers from the ubiquitous spinifex grass.

Applying nanotechnology and material sciences, they focused on improving durability by increasing the strength and resistance of cement using spinifex nanofibers.

In the initial investigation, three types of nanofibers showed impressive improvements of at least 20% in the strength of cement and mortar. This means that the amount of cement needed can be reduced and/or structures made thinner.

Seven years of research have now resulted in Australia’s first and largest nanocellulose production facility and the commissioning of Australia’s first nanocellulose pilot plant at UQ, which is one of the few nanocellulose production facilities in the world that focuses on extracting nanocellulose from non-wood resources.

The facility has now produced hundreds of kg of quality-assured product leading to many successful commercial customer trials in concrete, rubber and recycled paper applications.

This technology is at an early stage of commercialisation and validation for several commercial opportunities including ultra-thin latex membranes for condoms and gloves, compounded rubber products, and as a reinforcement for recycled cardboard and concrete.

Some other potential commercial applications are under development. The team are testing at a larger scale in NATA accredited laboratory in partnership with Department of Transports and Main Roads and Cement Australia.

“We are still working on perfecting how to improve these products with spinifex nanofibers at affordable cost and expect to see them in the real world applications around you such as footpaths and bikeways within three to five years”, Research Fellow Dr Pratheep Annamalai said.

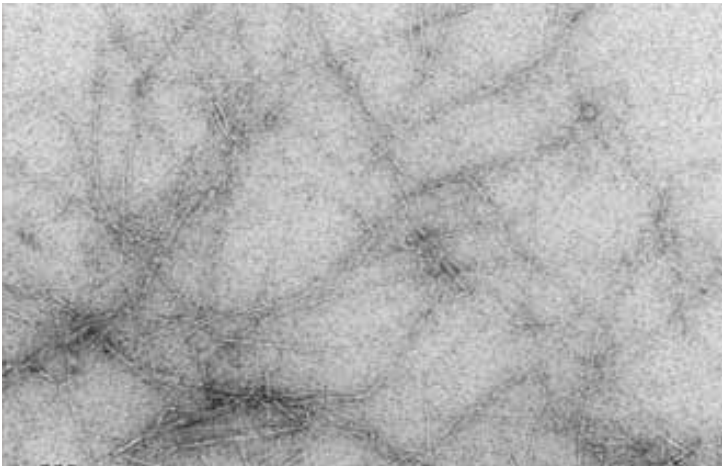
“Our research has benefited greatly from the training program and access for microscopic imaging and characterisation of CMM. As enabled by microscopic imaging, we were able to optimise the processing methods and produce at least six different types of nanofibres”, he said

The spinifex nanofibre platform technology has the potential to benefit both the QLD state’s and national ‘advance manufacturing’ industry sector, providing drop-in solutions through polymer and building construction industries in the immediate future.

The discovery will also have a positive impact on the environment, by reducing emissions originating from the typically CO₂ intense cement manufacturing industry - less cement equals less CO₂ emissions.

The social impact on indigenous Australian communities through the generation of new jobs for growing and harvesting this specific grass in the remote areas is also notable.

“Advanced microscopy has been an essential and integral part of both the research and commercialisation advancement”, Professor Darren Martin.



In the media: Spinifex promises stronger condoms

Spinifex grass could be used to create thinner, stronger latex for gloves and condoms, as well as more durable seals and tyres, an Australian scientist says.

Advance Queensland research fellow Dr. Nasim Amiralian is exploring how to incorporate spinifex-derived nanofibres into natural rubber. It might be difficult to imagine the spiky grass being comfortable to wear in that way. But when tiny nanofibres of spinifex are added to rubber, the result is a stronger and more flexible product.

Nasim, who is based at the University of Queensland, says she first discovered spinifex’s potential during her Ph.D. research.

She started out looking at extracting spinifex resin to see if it could be used as a glue or adhesive.

“I found that it has a very complicated chemistry,” Nasim says.

“So I started working with the grass biomass and extracting nanofibres. I found that the nanofibres extracted from these spinifex grasses are very thin and long, they are very flexible.”

Nasim says that, while you can extract nanofibres from any plant, spinifex nanofibres are very easy to extract and very tough.

“It comes back to the specific environmental conditions that spinifex grows in,” she says.

“To be able to survive the hot and dry conditions, its composition is a bit different to the other plants.”

And there’s no shortage of supply.

Nasim says there are 69 species of spinifex grass, and it’s found all over.

“Spinifex is everywhere, it covers 27% of Australia,” she says.

“We have more of this in Western Australia than in North West Queensland.”

So what’s the recipe for spinifex rubber products?

Nasim is working with industry partner Derby Rubber on reinforcing natural rubber for the railway, construction and mining industries. Just a small amount of spinifex—less than 5%—is enough to reinforce rubber, polyurethane or another polymer, Nasim says. Spinifex could also be used to reinforce cement, concrete and cardboard boxes.

Nasim is working hard to optimise the synthesis of the spinifex nanofibres. And she’s collaborating with people who have used spinifex and its sticky resin for thousands of years—Indigenous Australians.

The University of Queensland team and partner Dugalunji Aboriginal Corporation have won funding to commission a nanocellulose pilot plant at the university. Under an umbrella agreement between the university and the Dugalunji Aboriginal Corporation, all decisions and profits surrounding the venture are shared with Indigenous people in the area. Nasim says the partnership is providing jobs for Aboriginal trainees, harvesting spinifex grass and working on preliminary processing procedures.

Source: December 20, 2018 by Michelle Wheeler, Particle Read more at: <https://phys.org/news/2018-12-spinifex-stronger-condoms.html#jCp>

Publications

296
Journal articles

2
Book chapters

5
Conference papers

2
Corrections

1
Editorial

10
Reviews

BOOK CHAPTER

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Peng, Hong; Vaughan, JamesIn-Situ XRD Investigation of Bauxite Dehydroxylation. Characterization of minerals, metals and materials. 2018. DOI: 010.1007/978-3-319-72484-3_3

CORRECTION

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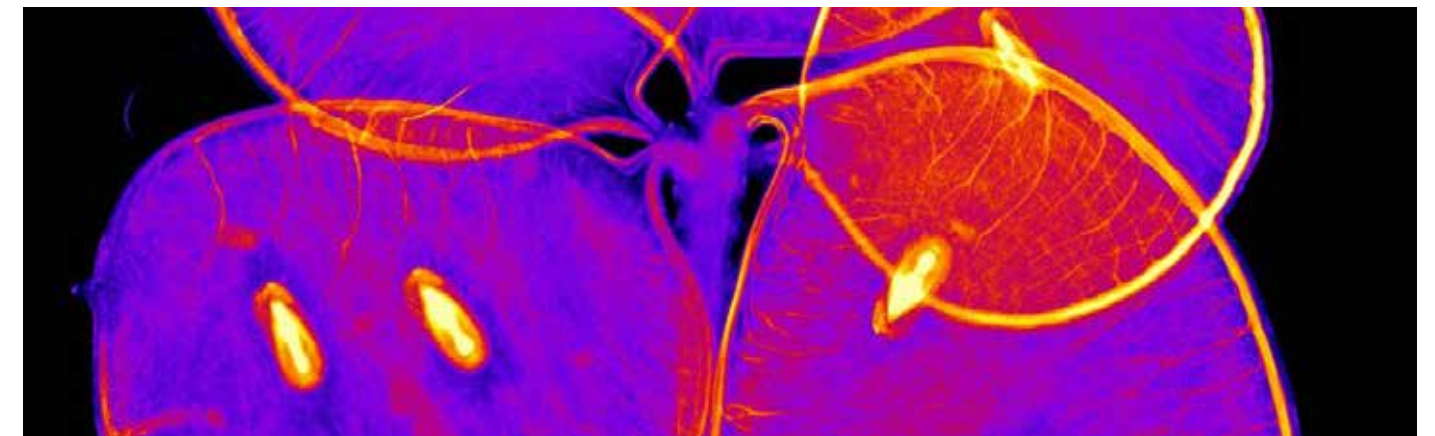
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