



INAUGURATION OF THE HITACHI HF5000

6 -7 September 2018

The University of Queensland



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May Hancock Auditorium,

Women's College

College Road, St Lucia



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA



HITACHI
Inspire the Next



cmm.centre.uq.edu.au

Welcome to the Inauguration of the Hitachi HF5000

Discussion and investigation of applications for advanced electron microscope technologies

On behalf of The University of Queensland (UQ), I welcome you to the reopening of the Hawken Microscopy Facility and the launch of the Hitachi HF5000 Cs-STEM/TEM Microscope.

This is a great moment for the Centre for Microscopy and Microanalysis (CMM) and Hitachi. We hope you will enjoy the next two days at UQ and gain new insights into the world of microscopy and microanalysis. Leading experts in the field will share their knowledge with us and you will have the opportunity to see outstanding scientific instruments in their new purpose built home.

For more than 20 years, CMM has been a world-class research facility with leading capabilities in electron microscopy and micro and nanoscale analysis. The facility is generously supported with funding from State Government and the federal National Collaborative Research Infrastructure Strategy (NCRIS). The Centre brings together researchers from disciplines ranging from quantum physics to molecular biology with state-of-the-art research microscopes and imaging science to build on the long-term development of world-class facilities in health, synthetic biology, advanced materials, unique electronic devices and cutting-edge research in Queensland.

Researchers at CMM work on innovations in spectroscopic and imaging technology, novel sensing and coating technologies, novel solutions for the energy challenges we face, and probing the innermost working of cells. This work is aimed at providing new commercial opportunities and improving health outcomes for Queenslanders.

The HF5000 is a new 200kV Transmission Electron Microscope, combining both Hitachi High-Tech'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 facility will be the first of its type in Queensland and the first 'pixelated' detector (CERN/Quantum Detectors) on a STEM in Australia. The microscope will be used in fields ranging from academic research of advanced nanomaterials and electronics, future battery technology to sustainable soft-matter investigation for technology and life-science applications. Also new to Queensland are its unique in situ capabilities at the nm range enabling us, for the first time, to not only characterise, but also test materials and devices in-situ. None of this would have been possible without the generous support from various stakeholders or the outstanding Development & Research Team at Hitachi, which was willing to collaborate to shape the future of our capabilities and push the technology boundaries.

UQ and the Faculty of Science have made a significant investment in CMM, and hence the NCRIS AMMRF node, including \$5.5M for building refurbishment, \$5 million for the cutting-edge Hitachi Microscope and \$4.5 M for a Nanolithography Suite as part of the ARC Centre of Excellence for Engineered Quantum Systems (EQuS). Last but not least, Hitachi took on the challenge to realise and deliver a unique research platform: the HF5000. These joint efforts signify a major commitment to the future prosperity of Queensland.

We hope that you will enjoy this exciting moment for CMM and UQ. Together with the CMM team and an outstanding list of international speakers let me invite you to join us on a journey: starting from the meter scale we all experience in our daily life, we 'zoom-in' by a magnification of up to 10'000'000 times to 'see/visualise' atoms in their 'natural' and 'altered' context and analyse them to help scientists enable the 6th technology wave - the so called sustainable 'green wave' – and shape our future.

With best regards

Professor Roger Wepf

Workshop program

Hitachi HF5000 Inauguration

Thursday 6 September 2018

Advanced STEM/TEM Workshop PART 1

- 12:00 *Welcome lunch*
- 12:50 Professor Roger Wepf: Welcome and acknowledgement of the traditional owners of the land.
- 12:55 Representatives of Hitachi High-Technologies and NewSpec: Welcome
- 13:05 Professor Roger Wepf: Introduction of new Hawken Laboratory
- 13:20 CMM user: Introduction and application of HF5000
- 14:00 Dr Cory Czarnik, Gatan Inc.
- 14:20 Associate Professor Thomas Zega, The University of Arizona
- 15:00 Professor Rafal Dunin-Borkowski, ER-C
- 15:40 Professor Joachim Mayer, ER-C/Aachen University
- 16:20 Group memorial photos
- 16:30 *Coffee Tea/ Tour of new laboratory and HF5000*

Workshop program

Hitachi HF5000 Inauguration

Friday 7 September 2018

Formal inauguration of the HF5000 and Hawken Laboratory

- 08:30 *Welcome coffee and tea*
- 09:00 Welcome address
- 09:05 Celebratory speeches
- 09:40 Symbolic 'unveiling' of the HF5000
- 09:45 *Morning tea*

Advanced STEM/TEM Workshop PART 2

- 10:15 Professor Dmitri Golberg, Queensland University of Technology
- 10:45 Professor Thierry Epicier University of Lyon
- 11:15 Dr Felix von Cube, Hitachi High-Technologies, Europe
- 11:45 Dr Arthur Blackburn, University of Victoria (Canada)
- 12:15 Dr Sacha De Carlo, Dectris Ltd
- 12:35 *Lunch*
- 13:30 Dr Toshiaki Tanigaki, Hitachi Ltd
- 14:00 Professor David Bell, Harvard University
- 14:30 Dr Qian He, Cardiff University
- 15:00 Professor Jin Zou, The University of Queensland
- 15:30 Professor Raynald Gauvin, McGill University
- 16:00 Closing address.

The Centre for Microscopy & Microanalysis



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 university researchers. 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.

The CMM is a foundation member and the Queensland Node of the Australian Microscopy and Microanalysis Research Facility (AMMRF) which was established in July 2007 under the Commonwealth Government's National Collaborative Infrastructure Strategy (NCRIS).

CMM actively supports and initiates microscopy & 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, service and research and to further push research projects beyond the current frontiers.

Microscopy Australia (previously AMMRF)



**MICROSCOPY
AUSTRALIA**

Microscopy Australia is a joint venture between Australian university-based microscopy and microanalysis centres. It is a national grid of instruments and expertise in microscopy and microanalysis. Providing nanostructural characterisation capabilities and services to the Australian research community it enables scientific discovery and innovation. Microscopy Australia operates as a collaborative facility with nodes in major capital cities and links to smaller units in specialist centres. Accessible to all Australian researchers, Microscopy Australia offers its suite of instruments to publicly funded researchers on the basis of merit for a nominal fee and to industry-based researchers for proprietary research at commercial rates.

Hitachi

HITACHI Inspire the Next

Hitachi High-Technologies Corporation (TSE:8036) was originally founded as Nissei Sangyo Co., Ltd. back in 1947 as a trading company. The company name changed to Hitachi High-Technologies in October 2001 following the integration of Hitachi's instrument and manufacturing group companies. Hitachi High-Technologies comprises four business segments, Science & Medical Systems, Electronic Device Systems, Industrial Systems and Advanced Industrial Products business groups with revenue of 687.6 billion Japanese Yen (approximately US\$6.2 billion) and 10,898 employees in 26 countries and regions. The electron microscope business unit belongs to the Science & Medical Systems Business Group, and our global network of locally managed subsidiaries and business partners provide sales, technical and service supports to our local customers in more than 30 international regions.

In January 2012, we reached an IEEE Milestone for developing the world's first practical field emission scanning electron microscope from the IEEE.

Our instruments and solutions services address the full range of scientific and academic research needs. We work closely with customers to help them solve complex analytical challenges and to provide the most innovative solutions.

Science for a better tomorrow

We desire to contribute to the betterment of society through Hitachi's innovative scientific instruments and expertise.

NewSpec



NewSpec

NewSpec Pty Ltd was established in December 2004 as an Australian owned company and the exclusive Australasian distributor for the Newport Corporation. We specialise in the marketing, sales, importation, installation and service of scientific research equipment, primarily in the fields of lasers, optics, electron microscopes and surface metrology.

Based in Adelaide, with offices in Melbourne, Brisbane and Sydney, NewSpec continues to grow, offering an expanding range of Laser Systems, Electron Microscopes, Benchtop SEM, AFM's, Surface Profilers, and related optical equipment to the scientific research, aerospace & defence, microelectronics and life science markets throughout Australia and New Zealand.

NewSpec is the exclusive Australasian Distributor for leading suppliers of scientific research equipment including Hitachi High-Technologies, Newport Corporation, Spectra-Physics Lasers, Princeton Instruments, Sirah, Zygo, Avantes, NKT Photonics, Edgewave, Kentek and Univet.

Scientific Program: Abstracts and Biographies (in order of appearance)

Dr Cory Czarnik

Gatan Inc., USA

Title

First Electron Data and Low Dose Imaging for Beam Sensitive Materials

Abstract

Next-generation high speed sensors and data processing architectures for TEM are creating new opportunities to evaluate material systems (e.g., metal-organic frameworks (MOFs), zeolites, etc.) while minimizing beam effects with low-dose, electron counting techniques. Although the structural biology community has provided numerous examples of how electron counting extends the utility of TEM to provide higher resolution reconstructions, the materials community is only now employing the same techniques for beam sensitive materials, holography, high speed STEM, and generally quantifying how electron-specimen interaction degrades samples even at low doses.

This presentation will focus on results from MOF material systems. MOFs usually have very large surface areas due to large porosity, and the morphology can be engineered to optimize performance for a wide range of applications including catalysis, gas separation, ion conduction, etc. It is well established that MOFs and zeolites suffer from e-beam damage effects in many TEM investigations, and the final image resolution is typically limited by the structural damage incurred by electron beam irradiation. Compared to X-ray or electron diffraction techniques, TEM provides data on periodic crystal structural data including interface, surface, and defect information, potentially at the atomic scale.

This presentation will offer examples of how to improve resolution when imaging such structures and quantify damage in these materials as a function of dose including “first electron” data.

Biography

Dr Cory Czarnik received degrees in Materials Science & Engineering from Rice University and the University of Michigan. This included time at Los Alamos National Laboratory as a graduate student researching thin film interactions and the deformation of high temperature structural materials; early work employed nanoindentation and subsequent dislocation analysis via TEM.

He then spent 10 years at Applied Materials including Program Manager of integrated advanced gate stack processes for 65 and 45 nm CMOS technologies, resulting in more than 10 issued patents. After an additional seven years at KLA-Tencor as Director of Applications for e-beam inspection, Cory is currently Imaging Product Manager at Gatan and oversees the development of advanced imaging techniques including high speed, direct detection sensors for materials science applications. He is author of over 20 publications with recent work on 4D STEM and *in-situ* studies of single particle growth in liquid cells.

Associate Professor Thomas Zega

The University of Arizona, USA

Title

Chemical insights into the origins of our solar system and ancient stars through atomic-scale studies of planetary materials

Abstract

The chemical history of our solar system is encoded within the solid relics left over from its birth over 4.5 billion years ago. Deciphering that history requires detailed analysis of planetary materials. Over the past decade, advances in electron optics have led to the development of a new generation of instruments capable of providing chemical and structural information on materials at increasingly smaller spatial scales. We can now routinely probe planetary materials down to the atomic level. Such advances allow us to investigate chemical processes that occurred over length scales that range from atomic to astronomical units and in astrophysical settings as diverse as circumstellar environments, planetary surfaces, and the solar protoplanetary disk. My talk will provide a broad overview of the way my research group applies the modern analytical STEM to address fundamental questions on our origins.

Biography

Thomas Zega is Associate Professor in the Lunar and Planetary Laboratory and the Department of Materials Science and Engineering at the University of Arizona. He is the Scientific Director of the Kuiper Materials Imaging and Characterization Facility at the University of Arizona and the PI of the planetary-materials research group that examines those pieces of condensed matter that were leftover from the time that our solar system formed over 4.5 billion years ago. His current research efforts are focused on: the origin of the presolar grains, nm to μm -sized dust particles that formed inside of ancient stars but preserved inside of primitive meteorites; the structure and crystal chemistry of 4.6-billion-year-old refractory inclusions in meteorites that are the first solar-system solids; the functional chemistry and preservation state of primitive pre-biotic organic compounds that formed in the early solar system and interstellar space; and the development of analytical techniques for investigations of such materials. Prior to joining the University of Arizona, he was a National Research Council Postdoctoral Fellow and later staff scientist at the Naval Research Laboratory, Washington DC, where his work focused on using electron microscopy to investigate spintronic materials, catalysts, photovoltaic materials, and the origins of planetary materials.

Professor Rafal Dunin – Borkowski

Director, Ernest Ruska Centrum Forschungszentrum Jülich, Germany

Title

Towards three-dimensional characterization of magnetic moments inside individual nanocrystals in the TEM

Abstract

Transmission electron microscopy (TEM) has been revolutionised in recent years, both by the introduction of new hardware such as field-emission electron guns, aberration correctors and *in situ* stages and by the development of new techniques, algorithms and software that take advantage of increased computational speed and the ability to control and automate modern electron microscopes. In this talk, I will describe how the specialised TEM technique of off-axis electron holography, in combination with a model-based approach for the reconstruction of magnetization distributions from electron optical phase images, can be used to image the magnetic properties of materials with close-to-atomic spatial resolution, both in projection and in three dimensions. I will present results obtained from individual magnetic nanocrystals, as well as from magnetic skyrmions in extended films and geometrically-confined structures fabricated using focused ion beam milling. I will also provide an overview of other TEM-based research in the Ernst Ruska-Centre in Jülich and conclude with a personal perspective on directions for the future development of transmission electron microscopy.

Biography

Professor Rafal Dunin-Borkowski is Director of the Institute for Microstructure Research and the Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons at the Forschungszentrum Jülich. Between 2007 and 2010, he led the establishment of the Center for Electron Nanoscopy at the Technical University of Denmark. From 2000 to 2006 he held a Royal Society University Research Fellowship at the University of Cambridge. He specializes in advanced transmission electron microscopy. In 2009 he was awarded the Ernst Ruska Prize of the German Society for Electron Microscopy. In 2012 he was awarded an Advanced Grant by the European Research Council

Professor Joachim Mayer

RWTH Aachen University, Germany

Title

Aberration Corrected TEM: State of the Art and Future Challenges in Data Acquisition and Analysis

Abstract

The invention of aberration correctors has revolutionized the development of TEM and STEM instrumentation. Only shortly after the development and installation of the first TEM with a corrector for the spherical aberration, commercial instruments with aberration correctors are now offered by all major manufacturers. In order to provide a platform for these novel developments and based on the experience with the first aberration corrected TEM, Research Centre Jülich and RWTH Aachen University have jointly founded the Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons (ER-C). At the Ernst Ruska-Centre we have recently installed the FEI Titan 60-300 PICO. PICO is a fourth-generation transmission electron microscope capable of obtaining high-resolution transmission electron microscopy images approaching 50 pm resolution in the C_c - and C_s -corrected mode at 300 keV. It is currently one of only two microscopes in the world capable of chromatic aberration correction. In the present contribution we will report on the initial results obtained with the PICO instrument. In the PICO instrument, HRTEM images can be obtained with simultaneous correction of the spherical and the chromatic aberration. Furthermore, a spherical aberration corrector also exists in the illumination system for Cs-corrected STEM imaging. The benefits of chromatic aberration corrected imaging are particularly large for HRTEM imaging at low accelerating voltages and for energy filtered (EFTEM) imaging with large energy window width. In the present contribution we will focus on new applications and resulting challenges for data acquisition and analysis.

Biography

Professor Joachim Mayer has been Professor and Head of the Central Facility for Electron Microscopy at RWTH Aachen University since 1999. In 2004, he received a co-appointment as one of the two directors of the newly founded Ernst Ruska-Centre, a German national user facility jointly founded by the Research Centre Jülich and RWTH Aachen University. He studied Physics at the University of Stuttgart, and received his PhD in Physics at the Max-Planck-Institut für Metallforschung, Stuttgart, in 1988. After completing his PhD, he joined the Materials Department at the University of California, Santa Barbara as a postdoctoral researcher for two years before returning to the Max-Planck-Institut für Metallforschung, Stuttgart. His research focuses on the application of new methods in electron microscopy in the areas of materials science, nanoelectronics and energy systems.

Professor Dmitri Golberg

Queensland University of Technology, Australia

Title

Nanomaterial Property Analysis in TEM

Abstract

Understanding mechanical, electrical, thermal, thermoelectric, optical, optoelectronic and photovoltaic properties of a material, in particular on the individual nanostructure level, is of key importance as far as its effective integration into any modern technologies is concerned. However, in the vast majority of cases, these property measurements are performed by means of instruments with no direct access to the materials' atomic structure, its crystallography, spatially-resolved chemistry and existing point and/or linear structural defects. I demonstrate the full usefulness of *in situ* high resolution transmission electron microscopy (HRTEM) probing techniques for diverse property analyses of many advanced materials, e.g. individual inorganic nanotubes, graphene-like nanosheets, nanowires and nanoparticles. Elasticity, plasticity, fracture strength and toughness, electrical conductance, thermal gradients, photocurrents, photovoltages and spatially-resolved cathodoluminescence now may accurately be measured inside HRTEM, while employing piezo-driven nanomanipulators and/or optical fibers inserted into the microscope column.

Biography

Professor Dmitri Golberg obtained his BS, MS and PhD degrees in Moscow, Russian Federation and in 1995 he joined the National Institute for Materials Science (NIMS), Tsukuba, Japan. He joined the Queensland University of Technology (QUT), Australia in 2017, as a Professor, after winning an ARC Laureate Fellowship. His other awards include the 'Tsukuba Prize', the 'Thomson Reuters Research Front Award', the 'Seto Award' from Microscopy Society of Japan, and the NIMS President Prize. Dmitri was nominated as a highly-cited Researcher by *Thomson Reuters* between 2014-2017. With more than 650 peer-reviewed papers, more than 40,000 citations, and a H-factor of 100, he is currently placed among the world's top-300 most cited materials scientists.

Professor Thierry Epicier

University of Lyon, France

Title

Environmental electron microscopy of nanomaterials under gaseous atmospheres

Abstract

In the last decade, Environmental Transmission Electron Microscopy (ETEM) has become a new sharp blade of the 'TEM' Swiss Army knife for studying materials at the nanoscale and down to the atomic resolution in almost operando conditions. Spectacular technological improvements have been made for both dedicated ETEMs and Environmental cells, enabling today to follow the evolution of nanomaterials reacting under a gaseous or liquid environment. The present contribution will focus on chemical reactions involving nanoparticles (NPs) in a catalysis context, where most of the experiments require to heat the sample in a gaseous reactive atmosphere. Several studies related to this topic and conducted on the 80-300 kV FEI-TITAN ETEM installed at CLYM (www.clym.fr) in Lyon will thus be presented, mainly collaborative works with IRCELYON or CREATIS labs (Univ. Lyon, F) and IFPen (Solaize, F). They include atomic mobility studies at the surfaces of ceria nanocubes, calcination and reduction of Pd NPs supported on delta-alumina, soot oxidation in the presence of zirconia-based catalysts. Special attention will be paid to the possibility of performing 3D observations in environmental conditions, with the development of fast tomography applied for the first time in an ETEM under operando conditions ^[1].

[1] The support of ANR through the project 3DCLEAN n°15-CE09-0009-01 and of CLYM for access to the microscope are gratefully acknowledged.

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Biography

Professor Epicier is a Research Director within the CNRS (French 'National Centre for Scientific Research') in the "Chemistry of Materials, Nanomaterials and Processes" field. He works at the MATEIS laboratory (mateis.insa-lyon.fr/) at INSA de Lyon (National Institute for Applied Sciences).

His activities deal with 'all-purposes' Electron Microscopy (SEM, TEM, FIB), with the aim of establishing a correlation between structure, nano- and microstructures, and macroscopic and functional properties of (multi-)materials and nanomaterials, using imaging, high resolution, tomography spectroscopic analysis (EDX and EELS) and environmental EM. From 2007 to 2015, he was responsible for the CLYM (Consortium Lyon - St-Etienne de Microscopie, www.clym.fr), a microscopy facility involving several laboratories from the University of Lyon in Lyon and St-Etienne. In 2012, Professor Epicier became the Director of the national 'TEM and Atom Probe' network METSA (www.metsa.fr, FR CNRS 3507) for which he is now Deputy Director since 2016. He was the General Physics Secretary of the French Society of Microscopies - SF μ ([www.sfm \$\mu\$.fr](http://www.sfmμ.fr)) in 2010 and 2011. He was the Chairman of EMC2016 (www.emc2016.fr) held in Lyon, France, under the auspices of the SF μ , the European Society (EMS) and the world body IFSM. As such, he has been a member of the EMS board since 2012. His most recent research activities deal with real time operando Electron Tomography to study in 3D the morphological evolution of nanomaterials, mainly nanocatalysts, during environmental TEM studies under gas and at high temperatures.

Dr Felix von Cube

Hitachi High-Technologies Europe

Title

Hitachi HF5000: Applications and Examples

Abstract

The combination of imaging and chemical analysis at the atomic scale is driving research & development in advanced nanomaterials and electronic devices. The ability of a TEM to perform these atomic-scale studies quickly and routinely while acquiring a wide range of analytical data is key to future technological developments.

Hitachi's HF5000 FE-TEM, with spherical aberration corrector, has been developed to achieve sub-angstrom(\AA) imaging combined with high-sensitivity elemental analysis. The HF5000 builds on features from Hitachi's dedicated STEM HD-2700 including Hitachi's own fully automated aberration corrector, dual symmetrical SDD EDX and Cs-corrected SE imaging.

I will present examples ranging from simultaneous STEM and SEM observations to EDX analysis and in-situ gas and heating experiments.

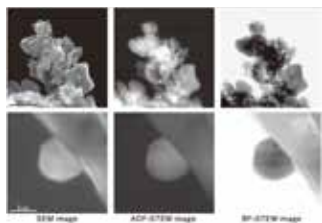


Figure 1: Simultaneous SEM & STEM imaging, thanks to true SE detection capability. This offers correlation of surface and internal information and insights to the 3D structure of a specimen, without the need to perform 3D tomography. Au/CeO₂ catalyst SEM/ ADF-/ BF-STEM images (upper row), and respective high resolution Au particle images (lower row).

Biography

Dr von Cube is working with Hitachi as an application specialist for TEM and FIB. He joined the Krefeld office in 2016 and covers the application support throughout Europe. Before joining Hitachi, he was a post-doctoral research Fellow at Harvard University in the group of Professor David C. Bell, with the research focus on quantum materials and high resolution S/TEM. He received his PhD from the University of Bonn, where he used electron energy loss spectroscopy (EELS) for the detection of surface plasmons on metamaterials.

For his work he was awarded by the European Microscopy Society (EMS) and the German Academic Exchange Service (DAAD). His expertise lies in EELS and aberration corrected (S)TEM.

Dr Arthur Blackburn

University of Victoria, Canada

Title

Advancing Diffractive and Reconstructive Scanning Electron Microscopy for Enhanced Material Insight

Abstract

High resolution electron microscopy (EM) has been greatly advanced in recent years through the development and refinement of aberration correctors and imaging detectors. Atomic resolution images and insights into a vast range of materials are now achievable with EM and it is thus taken as essential for progress in nanotechnology and nanoscience. In the most widely used scanning EM (SEM) mode, recently introduced high-speed and robust pixelated detectors now allow the collection of scattering angle information at each scanned beam position, which hitherto was inaccessible. Analysing and processing this diffraction-like data allows the mapping of otherwise not obvious material structures and the reconstruction of exceptionally high-resolution and quantitative phase images of materials.

In this talk I will give examples of high resolution reconstructed images and diffraction maps of nanoparticle containing sample materials, where these methods are improving our understanding of their formation. To collect and process these large datasets requires co-ordination and synchronisation of the microscope functions with the high-speed image acquisition and beam-scan systems. Addressing this need, a Python based microscope and acquisition control system has been developed in collaboration with Hitachi High Technologies. This allows flexible and extensible design of advanced EM image acquisition which, as will be described, is essential for this work and its advancement, particularly as big-data and machine learning methods are now being applied in EM.

Biography

Dr Blackburn is a Research Scientist at the University of Victoria (UVic), Canada, within the Centre for Advanced Materials and Related Technologies. His current research work looks primarily at methods of advancing electron microscopy through processing and collecting vast diffraction-like datasets produced from scanning electron microscopes.

Prior to joining UVic in 2015, he was a Research Scientist for Hitachi, embedded with the Physics Department of the University of Cambridge, from which he gained a PhD in 2005. The research he undertook in Cambridge on phase plates, electron vortex beams, shaped electron probes and microfabricated elements to enhance electron microscope performance and capabilities, continues at UVic. His work there is enabled by the double aberration corrected Hitachi HF-3300V scanning transmission electron microscope. He manages this instrument and collaborates with fellow researchers and users who require the ultimate high-resolution imaging, electron holographic capabilities, high-speed diffractive imaging, or other advanced electron microscopy techniques offered by this microscope.

Dr Sacha De Carlo

Dectris Ltd, Switzerland

Title

DECTRIS Hybrid Photon Counting (HPC) Technology

Abstract

I will briefly present DECTRIS Hybrid Photon Counting (HPC) technology and how it helps getting better data by capturing X-ray photons and electrons. Better and faster detectors are playing a key role in developing new applications on one hand, but also to help streamline existing ones. I will briefly present our effort to develop fast, accurate direct electron detectors with a great dynamic range, making them suitable for materials science TEM/STEM applications.

Company Information

DECTRIS Ltd. is the leading company in Hybrid Photon Counting detectors. DECTRIS' pioneering technology has transformed basic research at synchrotron light sources, as well as X-ray applications in laboratory diffractometers. The broad portfolio of DECTRIS' detectors is carefully scaled to meet the needs of various applications. With an aim to continuously grow, the company has started to look into new markets, and electrons are a good alternative to pave a bright future for DECTRIS detectors in electron microscopy and electron crystallography.

Dr Toshiaki Tanigaki*Hitachi Ltd, Japan***Title**

Quantitative Magnetic Imaging of Skyrmions and Magnetic Thin Layers by Advanced TEM

Abstract

Electron microscopy is advantageous for observing magnetic structures inside materials at high resolutions. There are several techniques in electron microscopy such as the Lorentz transmission electron microscopy (TEM), electron holography, differential phase contrast, diffractive imaging, and ptychography. I will present quantitative magnetic imaging of magnetic skyrmions and thin layers by Lorentz TEM and electron holography. To visualize the full 3D magnetic vector configurations, holographic tomography was needed. We successfully created a 3D reconstruction of the magnetic vortex structures in ferromagnetic discs. To improve the resolution of the electron holography, we developed an aberration corrected 1.2-MV holography electron microscope. A multilayer of CoFeB/Ta was observed, and a spatial resolution of 0.67 nm was attained in the magnetic phase image.

Biography

Dr Toshiaki Tanigaki is Senior Research Scientist at the Center for Exploratory Research, Research and Development Group, Hitachi, Ltd., Japan. His current research interests are applications of 1.2-MV holography electron microscope with an aberration corrector. His activities include the developments of electron holography for three-dimensional observation, high-precision and high-resolution observations of electromagnetic fields, and its applications to fundamental physics, material science, and industrial development. He completed his PhD in physics supervised by Professor Chihiro Kaito at Ritsumeikan University, Japan in 2004. Since then he has been pursuing the development of electron microscopy in Hitachi High-Technologies Co., Japan. In 2010, Dr Tanigaki became a visiting researcher at RIKEN, Japan in a group of Dr Akira Tonomura. He developed several technologies of electron holography through the FIRST Tonomura program from 2010 to 2014. In 2014, he became a researcher of Hitachi.

Professor David Bell

Harvard University, USA

Title

Application of Multimodal Electron Microscopy to Identify New Topological Materials for Quantum Computing Applications

Abstract

Depending on the composition, Quantum Materials may act as conductors, insulators, semiconductors or even as superconductors. Combinations of different quantum materials are of high interest to explore new phenomena and act as the foundation for future electronic devices at the nanometer scale. Our quantum materials research reaches to the characterization of hybrid quantum materials using multimodal electron microscopy. Together, these often improve the contrast to damage ratio obtained on a large class of samples. The exploration and synthesis constitute only one aspect of the challenges in the development of new topological materials, another challenge is their characterization. Since the phenomena appear at very restricted and dedicated conditions, the characterization method must have very high sensitivity, resolution, localization and precision.

Electron microscopy is a powerful technique to investigate structural, compositional or electromagnetic properties of topological materials. Especially with implementation of aberration correction optics in electron microscopy which has made chemical and structural characterization with very high spatial resolution (in the range of picometers) and sensitivity possible. This in turn allows detailed analysis of superconductor and topological materials, where small compositional variations have large effects on the material properties. We use low voltage and low energy electron microscopy to study single crystal as well as other more complex topological insulators with particular interest in the correlated behavior in topologically non-trivial materials.

Biography

Professor David C. Bell is the Gordon McKay Professor of Applied Physics at the John A. Paulson School of Engineering and Applied Sciences at Harvard University. He is also Associate Director of the Center for Nanoscale Systems at Harvard running the center's Imaging and Analysis group. The Center for Nanoscale Systems houses high resolution aberration corrected TEM and STEM and the only atom probe in the New England region. Professor Bell received his doctorate in physics from the University of Melbourne in Australia and did a postdoctoral study at the Massachusetts Institute of Technology.

His research focuses on the 'Emergent Phenomena' of new materials systems. Using theory and application of aberration-corrected and high resolution analytical electron microscopy with particular application of low voltage and low energy electron microscopy to study the structure and properties of advanced material systems. Current research areas are quantum materials, nanowires, bimetallic catalysis systems and characterization of nanomaterials for nano-toxicological research. Professor Bell lectures on electron microscopy, cryo-EM, nanotechnology and microfluidics. He has authored numerous publications and books (most recently a chapter for "the Science of Microscopy" edited by Hawkes and Spence), he serves on editorial boards, project review boards and funding agency boards; he is also currently an associate editor of Ultramicroscopy. Professor Bell is a fellow of the Microscopy Society of America as well as the Royal Microscopical Society UK.

Dr Qian He

Cardiff University, Wales

Title

Better Catalysts via STEM

Abstract

Catalysis is the key technology for the modern society. It enables 90% of all industrial chemical processes, including the production of fertilisers, synthetic fibres, plastics and fuels. Catalysis also promises us a better future: improved or new catalysis technologies can allow greener routes for energy and raw material production, both are key factors in a sustainable world.

Scanning Transmission Electron Microscopy (STEM) plays a crucial role in catalyst research, thanks to its unique capability of probing chemical information of materials with atomic resolution and sensitivities. The structure-synthesis-property relationship in practical catalysts can be revealed, providing not only new mechanistic insights into the catalytic process but also guidelines for new catalyst design.

In this presentation, a few recent examples from the Cardiff and Lehigh team will be briefly introduced to demonstrate “Better Catalysts via STEM”. STEM has helped us identify various active species in monometallic Au catalysts for low-temperature CO oxidation. Improved catalyst preparation then allow us to isolate atomically dispersed Au species, which are the best catalyst for hydrochlorination of acetylene. We will then discuss catalysts with multiple components, using the examples of the development of Pd based bimetallic catalysts for selective hydrogenation. Finally, some prospects of emerging STEM techniques for catalyst characterisation will also be briefly discussed.

The presented work was supported by Dow Chemical, DOE, EPSRC and Royal Society.

Biography

Dr Qian He is a Research Fellow in the School of Chemistry, Cardiff University. He obtained his BS (2006) and MS (2008) in Materials Science and Engineering from Tsinghua University, and a PhD (2013) in Material Science and Engineering from Lehigh University. He completed his postdoctoral research in the STEM group of the Oak Ridge National Laboratory from 2013 until being appointed as a Research Fellow in Cardiff in June 2016. His research focuses on nanomaterial characterisation using atomic-scale imaging and spectroscopy via aberration-corrected scanning transmission electron microscopy (STEM). His main interest is to develop novel energy and environment-related nanomaterials using a combination of quantitative STEM and in-situ microscopy.

Professor Jin Zou

The University of Queensland, Australia

Title

Power of Cs-corrected STEM in Understanding the Metal Chalcogenide Nanostructures

Abstract

2D materials, including graphene and transition metal chalcogenides, are attracting a lot of interest among researchers because of their exotic mechanical, optical, thermal, and electronic properties. The properties are associated with their Van der Waals-connected layered structures and their polymorphic phases. In this talk, I shall present some of our recent investigations into metal chalcogenide nanostructures using Cs-corrected STEM, from which we clarify the structural features. This clear understanding is essential in the design and fabrication of such materials with desired properties.

Biography

Professor Jin Zou is currently the Chair of Nanoscience at the University of Queensland. He gained his PhD in 1993 from the University of Sydney under the supervision of Professor David Cockayne. After receiving his PhD degree, Professor Zou remained at the University of Sydney for 10 years with various prestigious fellowships, including an Australian Research Council Queen Elizabeth II Fellowship. Since this time, Professor Zou's research has focussed on understanding advanced nanostructures using state of the art electron microscopy. Professor Zou moved to the University of Queensland in 2003 and was awarded an Australian Research Council Future Fellowship in 2009. Professor Zou has published in more than 630 SCI publications, with most publications in leading international journals. He has been cited over 17,500 times and has a H-index of 64.

Professor Raynald Gauvin

McGill University, Canada

Title

Analytical STEM at 30 keV

Abstract

This seminar will present start of the art results acquired with the new SU-9000EA dedicated 30 keV (and less) STEM that has EELS capabilities. It has a resolution of 0,22 nm in bright field STEM without aberration correctors. It is equipped with an Extreme SDD EDS detector that allows Lithium detection. With EELS and EDS, results for Li detection will be presented and the challenges, in regards of quantification and beam damage, will be covered. Examples of EELS analysis at 30 keV for nanomaterials will be presented, including surface plasmon. The SU-9000EA allows to perform electron diffraction and CBED patterns acquired at the nanoscale will be presented. Finally, the concepts of Bohmian mechanics to compute electron trajectories will be covered.

Biography

Professor Gauvin received his PhD in 1990 at École Polytechnique de Montréal in Metallurgical Engineering. He was then appointed as an assistant professor in Mechanical Engineering at Université de Sherbrooke where he became associate Professor in 1995 and full Professor in 1998. In 2001, he joined the department of Mining and Materials Engineering of McGill University, Montréal, Canada, as a full Professor. Professor Gauvin's research interests are related to developing new methods to characterize the microstructure of materials using high resolution scanning electron microscopy with x-ray microanalysis and Monte Carlo simulations. He is the creator of the CASINO program that is used by more than 10 000 users in the world. He has more than 300 papers in scientific journals and conference proceedings. He was Invited Speaker at more than 100 international scientific conferences. He won several scientific prizes, most notably the 31st Canadian Materials Physics Medal in 2007 by the Metallurgical Society of the Canadian Institute of Mining, the Heinrich Award in 1997 from the Microbeam Analysis Society of America and the Prix d'excellence du président de l'École for the best Doctorate Thesis defended in 1990 at École Polytechnique de Montréal. Professor Gauvin was the President of the Inter American Societies of Electron Microscopy (CIASEM) from 2009 to 2011, the President of the Microbeam Analysis Society of America (MAS) from 2005 to 2006, the President of the Microscopical Society of Canada (SMC) from 2001 to 2003 and the President of the International Union of the Microbeam Analysis Societies (IUMAS) from 2000 to 2005. He is currently the holder of the Birks Chair in Metallurgy. He was appointed in 2017 Honorary Member of the European Microbeam Analysis Society (EMAS).

Map



1. CMM Head Office and AIBN Laboratory
 2. Hawken Laboratory (including the Hitachi HF5000)
 3. X-ray Facility
 4. QBP Cryo TEM and QBP UQROC X
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- A. Venue - May Hancock Auditorium, Women's College
 - B. UQ Chancellor Place bus stop and taxi rank
 - C. UQ Lakes bus stop
 - D. Citycat ferry terminal

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