Canadian Centre for Electron Microscopy

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McMaster University

The Canadian Centre for Electron Microscopy provides world-class electron microscopy capabilities and expertise. We are the go-to provider of electron microscopy services to Canadian industry and researchers working in a broad range of fields. Located at McMaster University and operated by the Brockhouse Institute for Materials Research, the CCEM features state-of-the-art instrumentation and experienced, dedicated staff who are happy to work with you to find solutions to your materials research and development questions.

Instruments

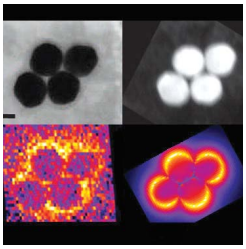
One of the unique features of the CCEM is its varied suite of instruments. We have, at one site, transmission electron microscopes, scanning electron microscopes, a focused ion beam instrument, an atomic force microscope, instruments for atom probe tomography and Auger electron spectroscopy. We also have sample preparation facilities for a wide variety of materials.

Transmission Electron Microscopy

FEI Titan 80-300 HB
The Titan HB is a double aberration-corrected TEM/STEM that can operate at multiple accelerating voltages to allow imaging of a variety of materials, including beam-sensitive samples. The instrument achieves sub-Ångstrom resolution both for phase contrast imaging and STEM. A monochromator allows 0.1eV energy resolution for high-resolution electron energy loss spectroscopy. The Titan HB is used for atomic-resolution imaging and detailed chemical analysis of a wide variety of materials.

FEI Titan 80-300 LB
The Titan LB is a high-resolution, image-corrected HRTEM/STEM that operates at 80 and 300 keV. A high-brightness source and a monochromator suit this TEM for high-energy-resolution analytical work including energy-filtered imaging. A cryogenic capability and the option to acquire and analyse electron tomography data are also available.

JEOL 2010F and **Philips CM12**
The JEOL 2010F TEM/STEM is a versatile instrument for imaging and fast analytical microscopy. It is also regularly used for in-situ liquid electrochemistry experiments. The Philips CM12 is a general purpose imaging TEM, well set up for electron diffraction from a selected area and diffraction contrast imaging. This instrument is an excellent training microscope.

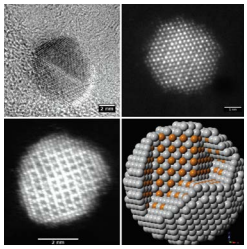


Bright-field TEM and dark-field STEM images of gold nanosphere tetramers, top. Experimental and simulated EELS maps for the same tetramer arrangement, bottom.

Reference: Electron Energy Loss Spectroscopy Investigation into Symmetry in Gold Trimer and Tetramer Plasmonic Nanoparticle Structures, S.J. Barrow, S.M. Collins, D. Rossouw, A.M. Funston, G.A. Botton, P.A. Midgley, P. Mulvaney, ACS Nano 10 (2016) 8552–8563

Atomic-resolution BF and HAADF images of an as-prepared Pt_3Fe_2 intermetallic core–shell nanocatalyst and model with Pt (gray) and Fe (yellow) atoms.

Reference: Strained Lattice with Persistent Atomic Order in Pt_3Fe_2 Intermetallic Core–Shell Nanocatalysts, S. Prabhudev, M. Bugnet, C. Bock, G.A. Botton, ACS Nano 7 (2013) 6103–6110



Industry partners The CCEM provides imaging and analysis services to a wide range of Canadian industries. We have long-standing, productive relationships with companies in the areas of nuclear materials, semi-conductor technology, automotive materials and many others. Our experienced staff can advise on the best techniques to obtain the data required to solve problems of materials performance, optimize materials production methods or design new materials.

> “World-class instruments, wide range of techniques available and high-level maintenance by the staff.”
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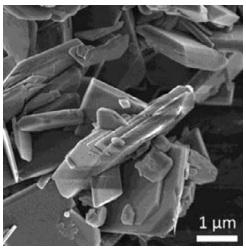
> **User comment,** 2016 CCEM user survey.

Scanning Electron Microscopy

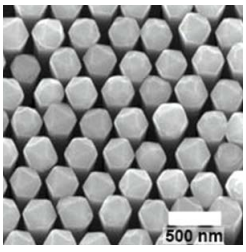
FEI Magellan 400
The FEI Magellan 400 is an SEM with nanometer resolution. An in-situ plasma cleaner and a liquid nitrogen cold finger allow the analysis of sensitive materials. SEM analysis at low beam energies enables characterisation of nanometer-scale surface structures, even of non-conductive materials. The Magellan’s dual EDXS detectors allow high-sensitivity compositional analysis, particularly from rough surfaces. The concentric back-scattered electron detector provides flexibility in imaging compositional contrast, so the image can be ‘tuned’ to clearly show selected features of interest.

JEOL 6610LV and **JEOL JSM-7000F**
The JEOL 6610LV SEM has a large chamber, which enables observation of specimens up to 200mm in diameter. Also, it can analyse non-conductive specimens without coating. The JEOL JSM-7000F offers high resolution and large probe currents at small probe diameters permitting characterization of nano-scale structures including with EBSD. Both instruments are equipped with energy dispersive X-ray micro-analysis systems, permitting qualitative and quantitative elemental analysis and mapping.



SEM image of calcium phosphate crystals.

Reference: Synthesis of calcium phosphate crystals with thin nacreous structure, S. Chen, K. Grandfield, Y. Shun, H. Engqvist, W. Xia, Cryst. Eng. Comm. 18 (2016) 1064-1069



SEM image at 15° tilt of AlInP passivated p-i-n core-shell GaAs nanowire array with a nearest neighbor pitch of 360 nm.

Reference: Characterization of a Ga-assisted GaAs nanowire array solar cell on Si substrate, J.P. Boulanger, A.C.E. Chia, B. Wood, S. Yazdi, T. Kasama, M. Aagesen, R.R. LaPierre, IEEE J. Photovoltaics 6 (2016) 661

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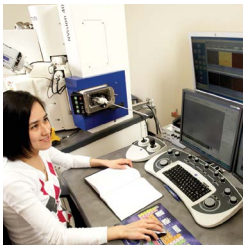
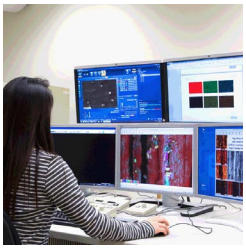


Focused Ion Beam – Zeiss NVision40

The Zeiss NVision40 is a dual-beam instrument combining a Schottky field emission SEM with a focused beam of gallium ions. The combination of FIB and SEM allows an area of interest to be identified and extracted for TEM analysis or Atom Probe Tomography, or for any application involving the precise and controlled removal of material at the micro or nano scale. The instrument can also be used for 3D FIB tomography and energy dispersive X-ray spectrometry (EDXS).

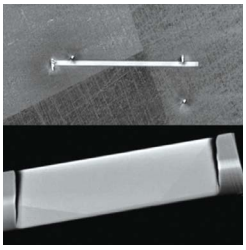


Auger Electron Spectroscopy –JEOL JAMP-9500F FEG – AES

The field emission Auger microprobe is a high-sensitivity instrument for surface analysis. Elements can be detected with concentrations as low as 0.2 atomic%, although higher concentrations are required for accurate quantification. An incorporated SEM provides images of the sample and an EDXS detector provides a quick preview allowing precise selection of the location for analysis. The surface can be milled away with the in-situ ion gun, allowing depth profiling to a depth of a few hundred nanometres.

Atom Probe Tomography – CAMECA LEAP4000X HR

The Local Electrode Atom Probe (LEAP) allows for 3D analysis of materials at the sub-nanometer scale. Materials are examined by successive field-evaporation of ions. The collected data is then reconstructed to yield a 3D computer model of the material, offering an unparalleled combination of spatial and compositional accuracy. In addition to the traditional method of high-voltage pulsing to induce field evaporation, the LEAP 4000X HR also uses an ultraviolet laser. The capability for laser pulsing expands the range of potential materials for analysis from metals, alloys, semiconductors to ceramics, minerals and bio-materials.

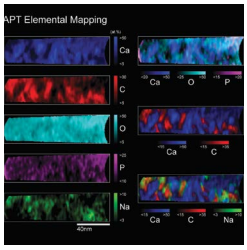


Preparation of a TEM sample using a focused ion beam. Top, selected grain boundaries marked with a line of Pt; bottom, cut specimen with grain boundaries at the two ends.

Reference: Sigma and Random Grain Boundaries and Their Effect on the Corrosion of the Ni-Cr-Mo Alloy 22, N. Ebrahimi, P. Jakupi, A. Korinek, I. Barker, D. E. Moser, D. W. Shoesmith, J. Electrochem. Soc. 163 (2016) C232-C239

Using atom probe tomography, the primary elements in the major components of bone are revealed (Ca in the mineral phase, and C in the organic phase). Minor elements such as Na can also be detected.

Reference: Atomic scale chemical tomography of human bone, B. Langelier, X. Wang, K. Grandfield, Nature Scientific Reports, 7 (2017) 39958



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