EMSL

Instrument Series: **Microscopy**

Environmental Transmission Electron Microscope

EMSL's environmental transmission electron microscope (ETEM) provides *in situ* capabilities that enable atomic-resolution imaging and spectroscopic studies of materials under dynamic operating conditions. In contrast to traditional operation of TEM under high vacuum, EMSL's ETEM uniquely allows imaging within high-temperature and gas environments—with a gas pressure up to 20 Torr. With a spherical aberration corrector for the objective lens, the ETEM captures atomic-level processes as they occur, enabling vital research across a range of scientific fields.

Research Applications

Chemical science and engineering – providing *in situ* observation of catalytic processes with atomic-level resolution

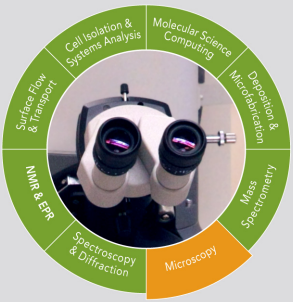
Materials science and engineering – allowing material evaluation such as *in situ* observation of microstructural evolution during device operation (e.g., a battery); dopant grain boundary segregation; defect structure; the dynamic response of a defect to an external stimulus; as well as mass, ion, and charge transport mechanisms

Nanoscience and technology – showcasing nanoscale structure and properties correlation, local electronic structure, and chemical state with single atomic column resolution

Environmental science – identifying aerosol structure and chemical composition, detecting trace elemental contaminants, and mapping contaminant spatial distribution

Interfacial phenomena – showcasing solid-liquid, solid-gas, and solid-solid interface structures

Biogeoscience – detailing soft-hard materials interfaces, biogeo-materials interface structure, and biomineralization



Quick Specs

- Beam Energy: 80 keV–300 keV
- HRTEM Point-to-Point Resolution: < 0.1 nm
- STEM-HAADF Image Resolution: < 0.136 nm
- EELS Energy Resolution: < 0.7 eV
- Adjustable Pressure (around sample): Up to 20 Torr
- Temperature Range (around sample): Cryogenic and 25°C–1100°C
- Sample Tilt Range: -70° to +70°
- CCD Camera: 2 k by 2 k (2048 x 2048 pixels)
- EDS: Boron and above
- EELS: Lithium and above
- Exit Wave Function Reconstruction from Focal Series Images
- Manufacturer: FEI Company

EMSL's ETEM Offers:

HRTEM imaging – structural analysis with sub-angstrom resolution

S/TEM-HAADF Z-contrast imaging – enables single-atom sensitivity and direct visualization and quantification of the spatial distribution of heavy atoms supported on a light element matrix

***In situ* TEM capability** – combination of differential pumping aperture and micro-fabrication technology allows imaging and spectroscopic analysis at temperatures ranging from room to 1100°C and gas pressures from high vacuum up to 20 Torr

Chemical composition – using energy dispersive X-ray spectroscopy (EDS) and electron energy loss spectroscopy (EELS) allows chemical composition analysis and mapping of the spatial distribution of elements

3-D tomographic imaging – available using EDS as well as TEM, S/TEM-HAADF, and energy-filtered imaging

Live image capture – a high-speed charge coupled device (CCD) camera captures dynamic processes during sample system operation (e.g., mass, ion, and charge transport in a battery), microstructural evolution, catalytic reactions, nucleation, and growth of a secondary phase.

To learn more about EMSL's capabilities and how they are being applied to EMSL users' research, see: http://www.emsl.pnl.gov/capabilities.

EMSL, a national scientific user facility, provides free instrument access for open-source research. Learn how to become a user and about upcoming proposal calls at http://www.emsl.pnl.gov/access/calls/.

CHONGMIN WANG
Senior Research Scientist
chongmin.wang@pnl.gov—(509) 371-6268

LIBOR KOVARIK
Senior Research Scientist
libor.kovarik@pnl.gov—(509) 375-4377

PNNL-SA-74055

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