

High Spatial Resolution Scanning Transmission X-ray Microscopes at the Advanced Light Source

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The main advantage of scanning transmission x-ray microscopes (STXM) over other types of microscopes is the ability to record high quality images from samples of widely varying sizes and to complement these images with high resolution spectroscopy, time resolved, polarization, and magnetization measurements.

The Advanced Light Source is the home of two high performance STXMs. One is located at a bending magnet on beamline 5.3.2 and is dedicated to work mainly in the 250 eV to 600 eV energy range covering all important C, Ca, K, N, and O absorption edges. The other STXM is located at the ALS Molecular Environmental Science beamline 11.0.2. This beamline has as a source a 1.5 m elliptically polarizing undulator (EPU) and a high quality entrance slit-less variable included angle plane grating monochromator providing x-rays from 80 eV to 2100 eV with high energy resolution, excellent beam stability and a high degree of coherence. Both microscopes have high spatial resolution that is currently limited by zone plate performance. Current zoneplates made by LBNL-CXRO have 25 nm outer zones which focuses the x-ray beam to a spot size of about 30 nm. With such a zoneplate, features of 15 nm -20 nm in size can be resolved.

While the 5.3.2 STXM is mainly dedicated to routine measurements, the 11.0.2 STXM is constantly modified to meet the requirements of many novel and challenging experiments. The current performance characteristics and capabilities of the ALS-MES beamline 11.0.2 STXM follow:

- Energy range: 80 eV – 2100 eV with energy resolution > 7500 .
- Spot size: 30 nm (theoretical). Can resolve smaller structures -15 nm (practical).
- Photon flux: Up to 10^9 ph/s with full spatial resolution and $E/\Delta E > 3000$. 4 basic zone plates: 25, 35, 40 and 45 nm.
- Minimum dwell time per pixel: 0.05 ms, maximum scanning rate: 12 Hz.
- Scanning range: 4000 x 2000 pixels – up to 20 x 4 mm.
- Minimum step size: 2.5 nm.
- Positional stability of staying at the same spot for spectra acquisition: < 50 nm (laser interferometry).
- EPU – polarization dependence, circular dichroism + electromagnetic studies.
- Possibility to scan sample at 60 deg relative to the photon beam for out of plane linear polarization and in plane magnetization.
- Single photon timing (50 ps resolution).

Those STXM capabilities and performance will be demonstrated with results of measurements of environmental, polymer, magnetic and biological samples.