NANOSURVEYOR 2: A COMPACT INSTRUMENT FOR NANO-PTYCHOGRAPHY AT THE ADVANCED LIGHT SOURCE

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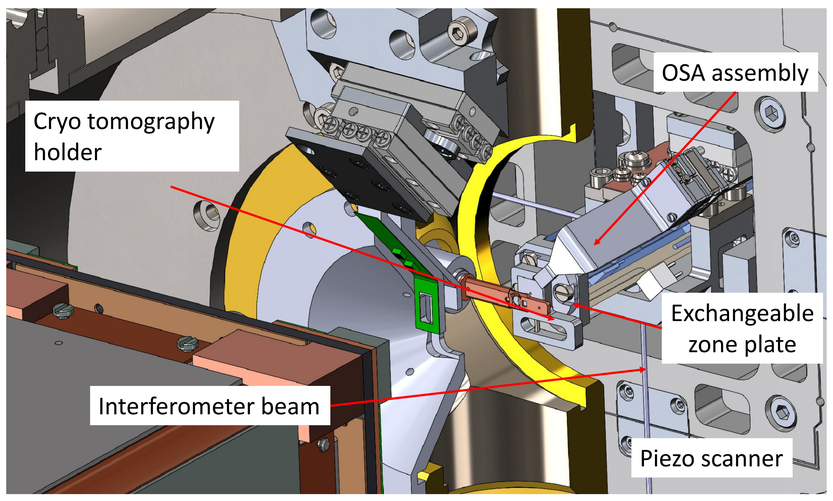
The Advanced Light Source has developed a compact tomographic microscope based on soft x-ray ptychography for the study of meso and nanoscale materials. The microscope utilizes the sample manipulator mechanism from a commercial TEM coupled with laser interferometric feedback for zone plate positioning and a fast frame rate charge-coupled device detector for soft x-ray diffraction measurements. The microscope has achieved scan rates of greater than 50 Hz, including motor move, data readout and x-ray exposure, with a positioning accuracy of better than 2 nm RMS and will achieve spatial resolution of better than 5 nm. The instrument will enable the use of commercially available sample holders compatible with FEI transmission electron microscopes. This will allow in-situ measurement of samples using both soft x-rays and electrons.
Once fully operational at the new Coherent Scattering and Microscopy beamline (COSMIC), it will enable spectromicroscopy and tomography of materials with wavelength limited spatial resolution.
Current spatial resolution has been demonstrated to be better than 10nm during commissioning experiments.

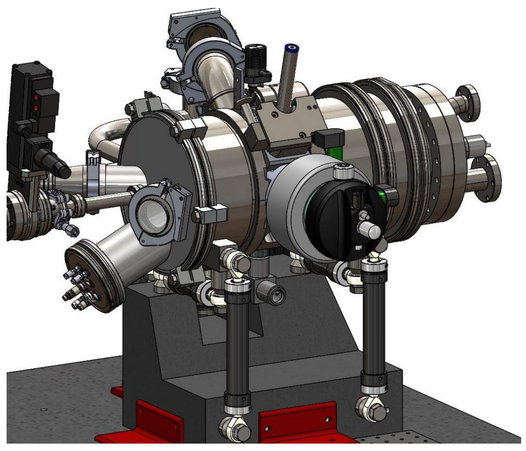
Nanosurveyor 2 sample area



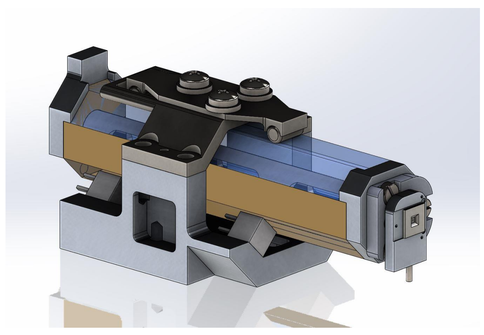
Scanning optics and motion hardware are incorporated into a volume that minimizes mechanical path lengths between motion stages, scanning optics and the interferometry system used to measure zone plate position. The OSA stages are mounted to the Piezo scanner in a manner such that the order sorting aperture moves with the zone plate in XY when the beam is being scanned across the sample. System is designed to be able to operate at rates of over 100 Hz.

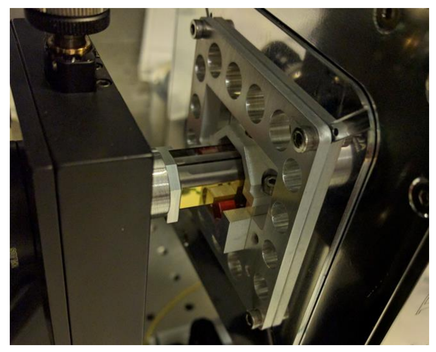
The nanosurveyor 2 instrument is based on the sample area hardware of an FEI CM200 series TEM. The microscope octagon system has been modified to form a vacuum chamber that contains the zone plate scanning system, order sorting aperture, interferometry system and the downstream frame-store CCD unit along with other diagnostic hardware.

The instrument is installed on the COSMIC Imaging beamline (7.0.1.2) at the Advanced Light Source.

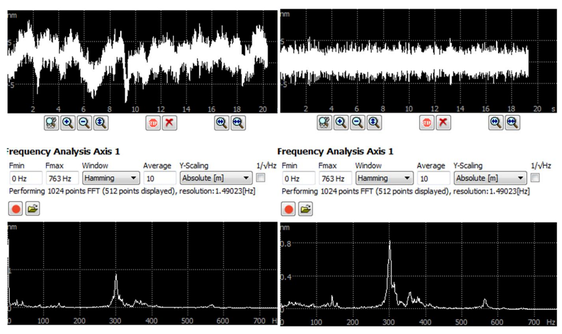


Nanosurveyor 2 zone plate focus stage

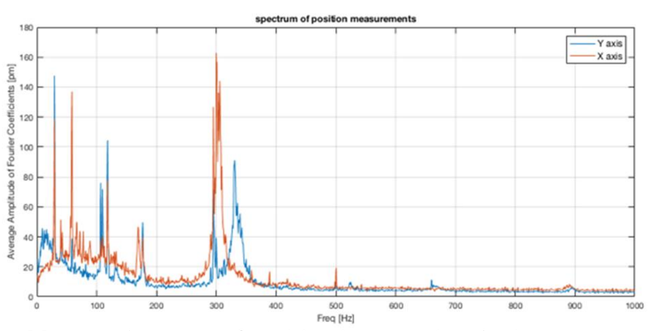




Zone plate focusing stage was developed in house using picashear actuators from PI and a custom designed sapphire octagon which incorporates interferometer reflecting surfaces and bearing surfaces to minimize scanning mass and alignment issues.



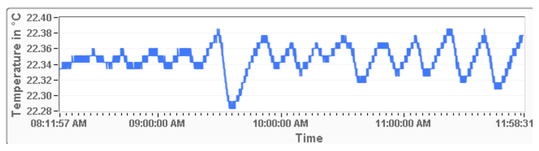
Feedback with cap sensors vs. interferometer on prototype system in laboratory.



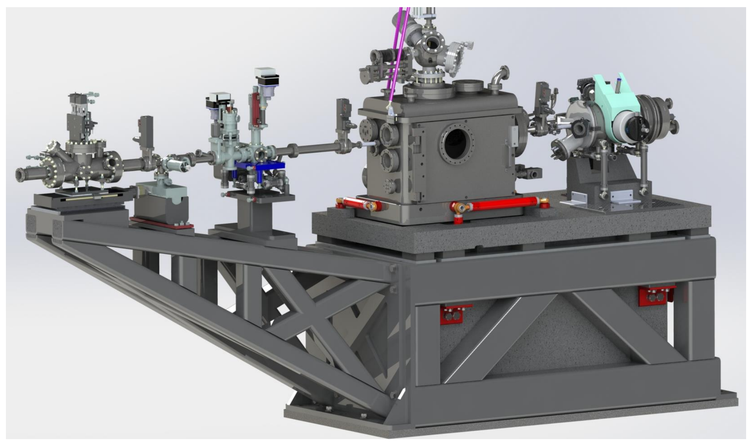
Measured spectra of position in operational microscope. Smaract picoscale interferometer.

Vibration Control and Thermal Stability Systems

Vibration control and stability of the entire endstation assembly is critical to reaching the ultimate planned system resolution of 1nm. To this end, the exit slit assembly is incorporated into the structure of the endstation support in order to remove effects of experimental hall floor motion. The slit assembly is installed on a cantilever section of tubular steel that is mounted to the endstation support structure. Both the endstation and exit slit frames are filled with epoxy concrete (Zanite) for vibration damping and increased thermal stability. The cantilever was designed to maximize horizontal stability of the exit slits with respect to the focusing optics in the endstations. The two endstations that comprise the COSMIC Imaging station are mounted on a single 1500kg casting of Zanite. This casting is isolated from the support frame by an array of engineered viscoelastic urethane polymer isolation pads (Sorbothane) which provide passive vibration isolation. This has excellent passive vibration isolation of 19 Hz in the vertical (Y) and 5 Hz in the lateral direction (X). Damping of motion is aided by the center of gravity of the experimental system being located 50 mm below the top surface of the Zanite filled steel assembly.
The endstation assembly is contained within an acoustically dampening enclosure which is thermally stabilized. The temperature of the enclosure is maintained by a recirculating, closed-loop HVAC system which has been demonstrated to maintain temperature within 0.1 degrees Centigrade over long periods of time.

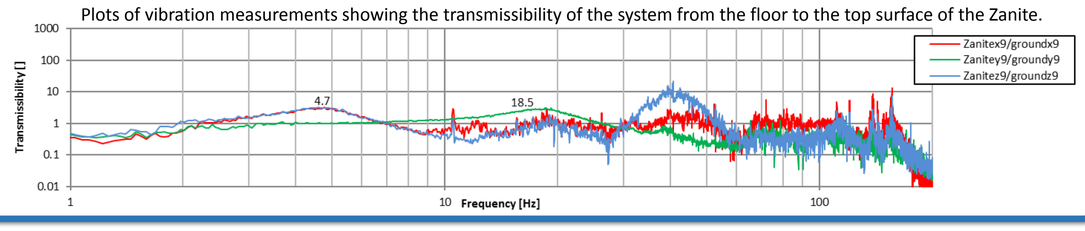


Plot showing typical stability of temperature in the environmental enclosure over a period of 4 hours.



COSMIC imaging “raft” assembly which supports exit slit assembly, diagnostics, high speed shutter and the isolation system supporting the in-line experiments Nanosurveyor 1 and Nanosurveyor 2.
Combined mass of the entire system is approximately 5 tons.

Plots of vibration measurements showing the transmissibility of the system from the floor to the top surface of the Zanite.



First ptychography results from Nanosurveyor 2 at the COSMIC beamline during commissioning. The sample, provided by aBeam Technologies, is a WSi2/Si multilayer, with fundamental linewidth of 2.8nm (all other lines are integer multiples), and thickness of 100nm. Data was collected at beam energy of 1000eV using a 45nm zone plate supplied by the Center for X-Ray Optics (CXRO). The zone plate was scanned with a step size of 30nm and the sample was exposed for 20msec at each point. The CCD was placed further downstream than the standard operating position to increase dynamic range for commissioning, thus decreasing the Numerical Aperture and limiting the resolution to 10nm.
Further testing has resulted in higher resolution results which are in the process of being published.

The Nanosurveyor 2 instrument on the COSMIC Imaging Beamline is currently open for user operations and further refinements to the operation and capabilities of the station are in development.