The Hard x-ray Nanoprobe Beamline at the Advanced Photon Source

Jörg Maser, Brian Stephenson, Robert Winarski, Christa Benson, Deming Shu, Barry Lai, Stefan Vogt, Martin Holt, Brian Tieman

The hard x-ray nanoprobe beamline at sector 26 of the Advanced Photon Source is designed to characterize nanoscale systems and devices at a spatial resolution of 30 nm, using x-ray fluorescence spectroscopy, x-ray diffraction, and transmission imaging.[1] X-ray fluorescence will provide element-specific imaging with sensitivity to individual nanoparticles embedded in thick specimens. X-ray diffraction and scattering will probe strain state and ordering of nanoscale systems and their environment. Transmission imaging will allow visualization of thick specimens and devices in 3D. To allow x-ray fluorescence spectroscopy of most elements in the periodic system, the beamline will deliver x-rays with photon energies between 3 keV and 30 keV. Two collinear insertion devices with a period of 3.3 cm and a combined length of 4.8 m are used as source of x-rays. This maximizes the coherent x-ray flux available in the nanoprobe instrument. The beamline optics are designed to allow two modes of operation: a scanning probe mode, where the spatially coherent fraction of the undulator beam is focused by a high-resolution x-ray optic on a small specimen area, and a full-field transmission mode, where the full, partially coherent undulator beam is used to allow transmission imaging at high resolution.

The nanoprobe instrument will use Fresnel zone plates as high-resolution x-ray optics. The system is being designed to ultimately accept zone plates providing a spatial resolution of 10 nm. To understand how to achieve the required mechanical stability of 5 nm, we are performing experiments with an early version of the nanoprobe instrument.[2] The zone plate is driven by a custom flexure stage, and will be scanned for data acquisition at high spatial resolution. The specimen stage is used for positioning and coarse scans only; it will provide x/y/z positioning as well as a single degree of rotation for tomography and microdiffraction. High precision positioning is achieved by measuring the position of both zone plate and specimen stages in x and y with individual laser Doppler interferometers with respect to a reference frame. Deviations of the position from the desired values are corrected using the flexure stage. A feedback loop operating at a frequency of 100 Hz provides active vibration control. First measurements of the system performance at have yielded a source-size limited resolution of 70 nm at a photon energy of 7.4 keV, and a noise level of below 30 nm.

We will present the overall beamline concept, as well as first data from the nanoprobe instrument.

References

[1] J. Maser, G.B. Stephenson, D. Shu, B. Lai, S. Vogt, A. Khounsary, Y. Li, C. Benson, G. Schneider, *AIP Conf. Proc.* **705**, AIP (2004) 470 – 473.

[2] D. Shu, J. Maser, B. Lai, and S. Vogt, *AIP Conf. Proc.* **705**, 1287-1290 (2004).

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