Zone Plate Optics in 8-ID I-Hutch

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A new microfocusing diffractometer setup has been installed at the I-Hutch of the 8-ID beamline for use in coherent diffraction.

Speckles are produced by scattering of coherent light from disordered systems. When the typical length scale of the disorder is short, the x-ray diffraction peaks are broad and the corresponding scattering intensities per speckle are weak. For an x-ray intensity fluctuation spectroscopy (XIFS) experiment, one can increase the speckle size by decreasing the scattering volume. Ideally, one would like to simultaneously reduce the coherence volume while preserving the number of x-rays in this volume. This can be partially achieved by focusing optics such as Fresnel zone plates.

Zone plate optics was installed on a table at the end of the coherent small angle x-ray scattering (COSAXS) setup at the I-Hutch of the 8-ID beamline. Figure 1 represents a schematic view of the setup. The spectrometer consists of a horizontal θ–2θ Huber-424 diffractometer. The focusing system consists of a Fresnel zone plate with a 257-µm diameter and nominal focal distance $f \approx 40$ cm at 8 keV. The zone plate is mounted on a motorized translation Y stage (zptrans) so that the focal distance can be scanned (y is the beam direction). An order sorting aperture (OSA) is placed between the zone plate and the diffractometer to absorb the higher orders. Both the zone plate and the OSA are mounted on XZ stages with a submicron resolution to allow scanning of the zone plate and the OSA. The zone plate is set into an evacuated flight path and coupled by bellows to keep the linear motions external to the vacuum. A set of collimating slits is placed upstream of the setup. The diffractometer is fitted with a high-temperature vacuum furnace. A direct illuminated CCD detector array is used for acquiring scattering measurements.

The size of the focal spot was measured by scanning a sharp edge through the beam. The edge was made by depositing a 40-nm film of iron on a silicon subtrate, which was then cleaved to create the edge. This sharp edge was mounted on an XZ translation stage. Knife edge scans consist of measuring the Fe K-fluorescence of the knife edge as a function of its position along the horizontal (x) and vertical (z) directions. Figure 2 shows a typical scan with its fit to an error function. By scanning the zone plate to knife edge distance (Fig. 3), we have measured a focal distance of $f \approx 40$ cm for this zone plate with an x-ray beam of 7.66 keV. We have also measured a focal spot of ≈ 1.2 µm full width at half maximum (FWHM) in both both horizontal and vertical directions, from a 50 µm × 50 µm x-ray beam, and using OSA slits of 45 µm × 45 µm at 20 cm upstream from the knife edge.

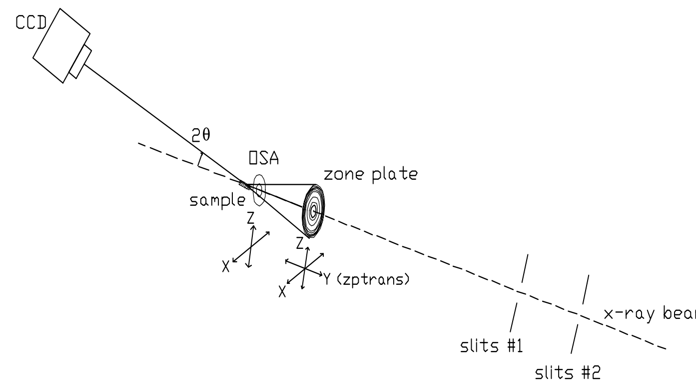

FIG. 1. Schematic of the zone plate setup.

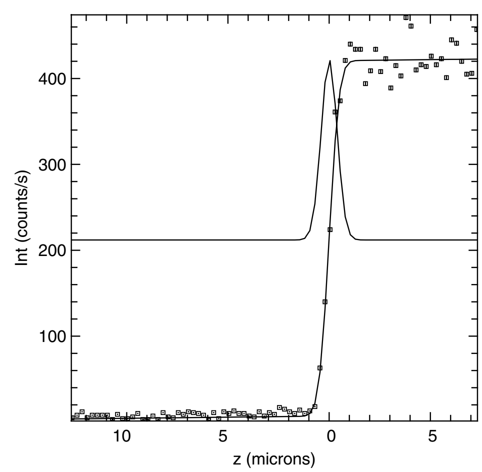

FIG. 2. Knife-edge scan along the vertical dimension of the beam (50 µm × 50 µm before focusing). The solid line through the data is the fit. The other line is the derivative of the fit, FWHM = 1.2 µm.

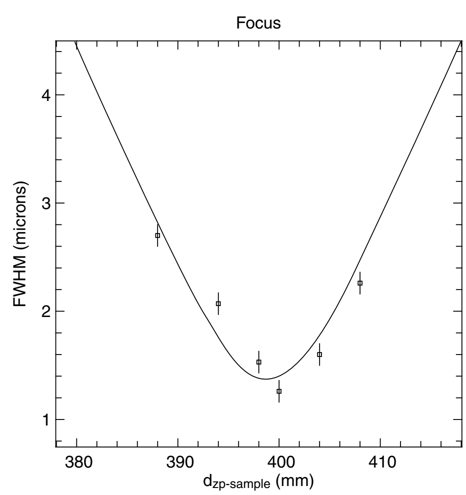

FIG. 3. Focal spot size versus zone plate to knife-edge distance. The minimum corresponds to a focused beam.

Acknowledgments

Use of the Advanced Photon Source was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under contract No. W-31-109-ENG-38. We thank Harold Gibson for his expert assistance.