Development of large field-of-view high-resolution hard x-ray microscope using polymer optics at Advanced Photon Source

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As the development of next-generation X-ray light source, the full-field dark-field imaging techniques have emerged as a promising real-space probe with high resolution [1-2]. Here we present the development of the high-resolution hard x-ray dark field microscope at Advanced Photon Source (APS) which is built using a matched pair of polymer-based condenser–objective. A unique condenser comprising arrays of high-aspect-ratio prisms with equilateral cross section is used for uniformly illuminating samples over a large field of view (FOV) from all angles, which match the acceptance of an objective made of interdigitated orthogonal rows of one-dimensional lenses. State-of-the-art Talbot grating interferometry is used to characterize these lenses revealed excellent focusing properties and minimal wavefront distortions. To reach diffraction-limited spatial resolution achievable with this lens pair we needed to explore schemes, such as cross-correlation and machine-learning algorithms, to mitigate blurring due to vibrational instabilities. Specifically, we used short-exposure times and image registration to obtain distortion-free images with a uniform resolution of 240 nm (smallest resolvable line pair) over a large FOV, 80 × 80 μm2 in extent. The results were contrasted with those collected using commercial two-dimensional parabolic lenses with a smaller FOV. This approach implemented on a diffractometer would enable diffraction-contrast or dark-field microscopy for fast observations of "mesoscopic" phenomena in real space complementing reciprocal-space studies using diffraction on the same instrument.

References

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