Evaluation of the optical performance of x-ray zone plates made with overlay nanofabrication technique

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Fresnel zone plates, the diffractive lens with chirped circular grating structures, are one of the most important optics used for extremely ultraviolet (EUV) and x-ray focusing and imaging. High-resolution zone plates are typically fabricated with e-beam lithography and electroplating technologies. The resolution and efficiency of a zone plate are both limited by the achievable aspect ratio of the zone structures in these processes. The overlay nanofabrication technique [1], which employs multi-pass patterning-and-plating of partial zone sets to enlarge the process windows, provided a new approach to fabricate high resolution high efficiency zone plate. However, the inventors of this technique used a customized electron beam lithography system to achieve sub-pixel (1.7 nm) overlay alignment accuracy, which is not universally accessible. This raises a question, how large the overlay alignment error is tolerable?

Numerical simulations are performed to evaluate the impact of overlay alignment error to the optical performance of zone plates using scalar theory. Zone plate with a large number (>100) of zones and different overlay alignment errors (up to one outer most zonewidth) have been investigated. The results of focus resolution, distortion and depth of focus will be discussed in detail.

The simulation results show that zone plate has quite large tolerance to the overlay alignment error. This indicates the overlay nanofabrication technique could have much extensive applications.

References:

[1] W. Chao, B. D. Harteneck, J. A. Liddle , E. H. Anderson, and D. Attwood, *Nature,* **435**, 1210 (2005).

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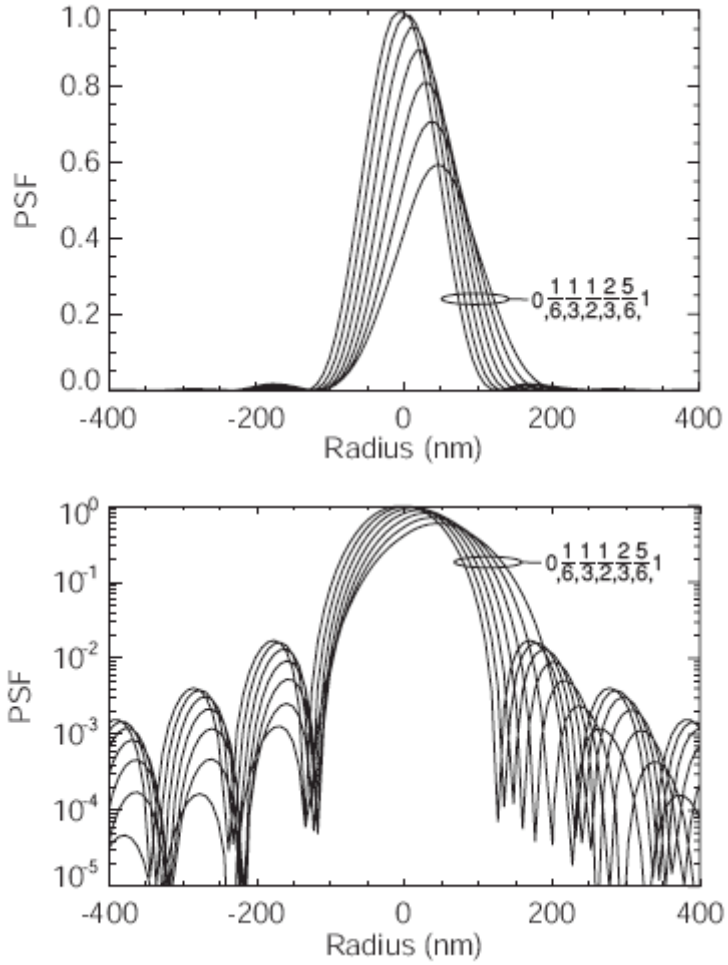

Fig. 1. Point spread function of a zone plate made with two passes of exposure and plating along the misalignment axis. The numbers in the figures indicate the ratio of the misalignment to the outermost zone width. Two figures are from the same data but plotted in different scale for the sake of clarity.