EUV-Mask Pattern imaging by the Coherent Scatterometry Microscope

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In the extreme-ultraviolet (EUV) lithography, a defect-free mask production is one of the critical issues for high-volume manufacturing. For mask inspection and metrology, we have developed the coherent EUV scatterometry microscope (CSM). This microscope is simple lens-less system that has no objective. The CSM characterize an EUV mask actinic at EUV wavelength of 13.5 nm [1].

Figure 1 shows a schematic view of the CSM system, which was developed at a synchrotron facility of the NewSUBARU. The synchrotron radiation is monochromatized by Mo/Si multilayers and is spatially filtered by a ϕ5-μm pinhole. The focusing mirror image the pinhole aperture on the EUV mask. A CCD camera records diffraction image of the mask by the coherent EUV light directly. The numerical aperture of this CSM system is 0.14, and the field of view size is ϕ5 μm.

The CCD camera records diffraction intensity only. To reconstruct pattern image in the real space, phase information is necessary to retrieve from the intensity by the iterative calculation, which is not recorded at the CCD camera. This kind of phase retrieval algorithm has been developed at the hard X-ray region as the coherent diffraction imaging. In this paper, we choose ptychography for a phase retrieval algorithm [2]. At ptychography, a part of a pattern is illuminated by a confined illumination function. The sample position is moved more than 16 times to illuminate with overlapping the beam. The CCD camera records the diffraction intensities. The phase information is retrieved with iterative calculation of Fourier transform and inverse Fourier transform.

Figure 2 shows an EUV mask pattern reconstructed by ptychography. The aperiodic structure of the edge and the periodic 128-nm L/S pattern were clearly reconstructed. We also observed the cross-line pattern, the CD error in the periodic L/S pattern and the phase difference own to the height difference of the substrate. We demonstrate that the CSM is useful for inspection of the finished EUV mask.

References
[1] T. Harada *et. al.*, J. Vac. Sci. Technol. B **27** (2009) 3203.
[2] J. M. Rodenburg et. al., Appl. Phys. Lett. **85** (2004) 4795.

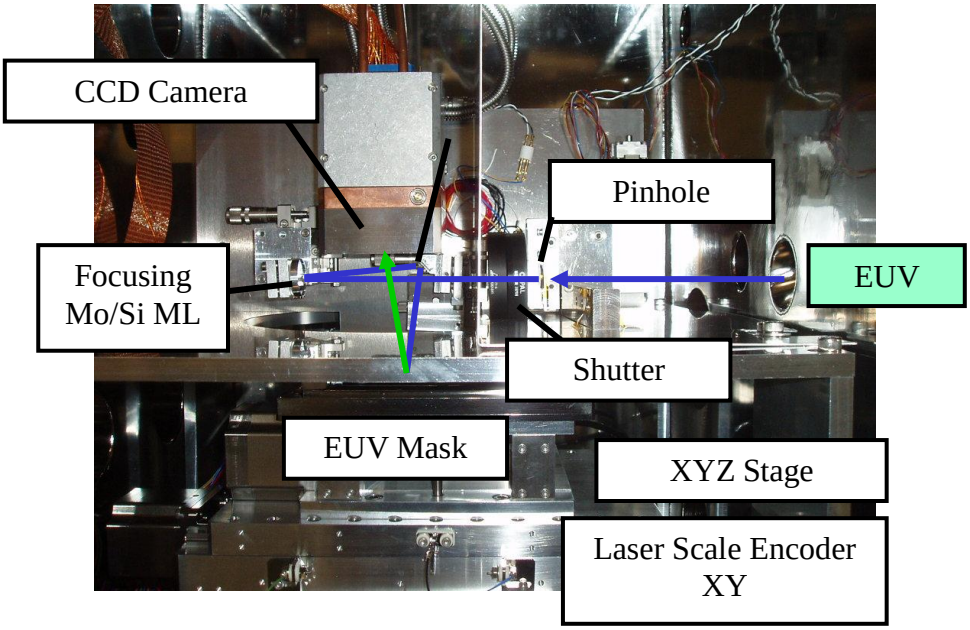

Figure 1: Schematic view of the Coherent EUV Scatterometry Microscope.

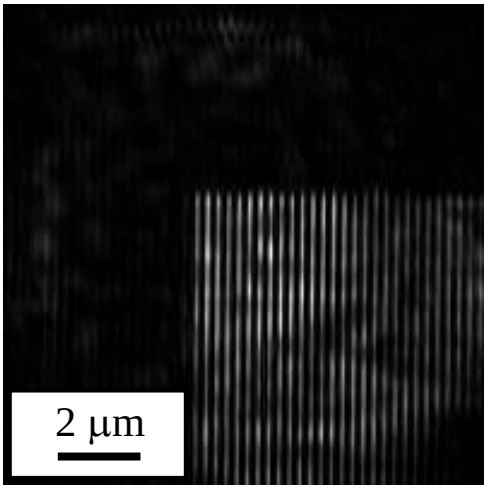

Figure 2: Reconstruction image of an edge part of 128-nm L/S pattern.