Design, fabrication, and test of extreme ultraviolet microscope with 30-nm spatial resolution

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Full-field microscopy in extreme ultraviolet (EUV) region has been investigated for various research fields, i.e., materials science and inspection of a lithography mask, where wide field of view would be essentially required for rapid observation. Recently, we proposed an innovative objective enhancing a magnification of 1500 [1-2], which is suitable for using a CCD camera as a detector. Besides, this novel design corrected for off-axis aberrations can be configured to have a large field of view with a diffraction-limited resolution, which allows us a rapid observation within a practical observation time.

To demonstrate high spatial resolution of the objective, we are developing a full-field EUV microscope for at-wavelength observation of a lithography mask. As shown in Fig, 1, the optics was made of seven Mo/Si multilayer mirrors, which were optimized at a wavelength of 13.5 nm. The objective was configured as a two-stage imaging system. The Schwarzschild mirror having a numerical aperture of 0.25 projects a bright field image of the mask with a magnification of 30. The intermediate image is magnified again by the concave mirror M3, to have a high magnification of 1480 on the CCD camera. Spatial resolution was evaluated by observing fine line and space patterns with a half pitch between 30 to 80 nm, as shown in Fig. 2. We confirmed that 30-nm half pitch patterns were clearly resolved [3]. This result also indicates that the microscope has high spatial resolution near diffraction limit. In the presentation, we also describe wavefront sensing and control technique for the high magnification objective, which is essential for diffraction-limited spatial resolution.

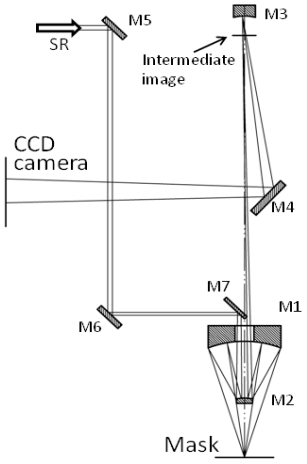

Fig. 1. A schematic of the EUV microscope: Three mirrors (M1-M3) act as a two-stage imaging system.

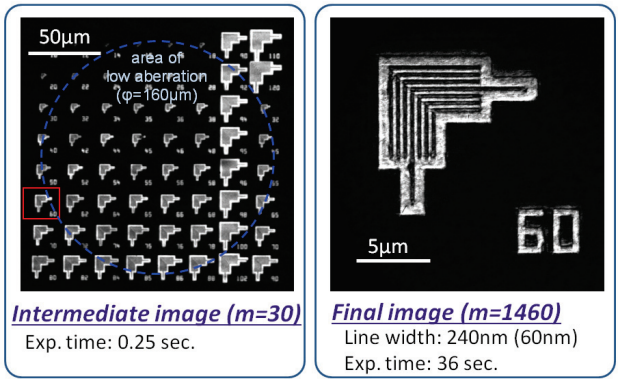

Fig. 2. At-wavelength images of EUV lithography mask.

References

[1] M. Toyoda et. al., Appl. Phys. Express **5**, 112501 (2012).

[2] M. Toyoda, Adv. Opt. Tech. **4**, 339 (2015).

[3] M. Toyoda et. al., Appl. Phys. Express **7**, 102502 (2014).