Phase Defect Characterization on an EUV Blank Mask using Micro Coherent EUV Scatterometry Microscope

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The critical issue of EUV lithography is production of defect-free mask. An EUV mask is reflective type that consists of glass substrate, reflective Mo/Si multilayer, and absorber pattern. Phase structure is printable as a defect, which is bump or pit structure on the substrate or a particle in the multilayer. Shallow structure of 1-nm height would be printable because of EUV short wavelength of 13.5 nm. Defect hiding and defect compensation methods have been proposed, which work by modifying the absorber pattern to compensate the aerial image. Thus, defect characterization is necessary to repair the defect. Since the EUV scanner and the EUV microscope collect scattering (diffraction) from a mask, scattering signal is important to represent the defect property.

We have developed a new defect-characterizing tool of micro coherent EUV scatterometry microscope (micro-CSM) shown in Fig 1. Micro-CSM records scattering from a defect directly that is exposed with focused coherent EUV to sub-μm in diameter. The focusing optics is Fresnel zoneplate of off-axis type. Phase distribution of the defect is estimated with the scattering image using by model-fitting method and coherent diffraction imaging. A sample mask was a EUV mask that contained programmed bump structures on a glass substrate. Micro-CSM recorded strong scattering signal from a small defect shown in Fig 2, which had ϕ70-nm diameter and 2-nm height. The sample mask also had asymmetric shape defects with about 160×80 nm^2 ellipse, which had varied orientation. Scattering signals of the ellipsoidal defects had asymmetric distribution, which were corresponded to surface shapes evaluated by AFM. Micro-CSM records actinic scattering signal and can evaluates the phase information, which will become essential tool for EUV mask fabrication.

We will also show reconstruction result of the defect shape from the scattering image, and observation result of actual phase defects.

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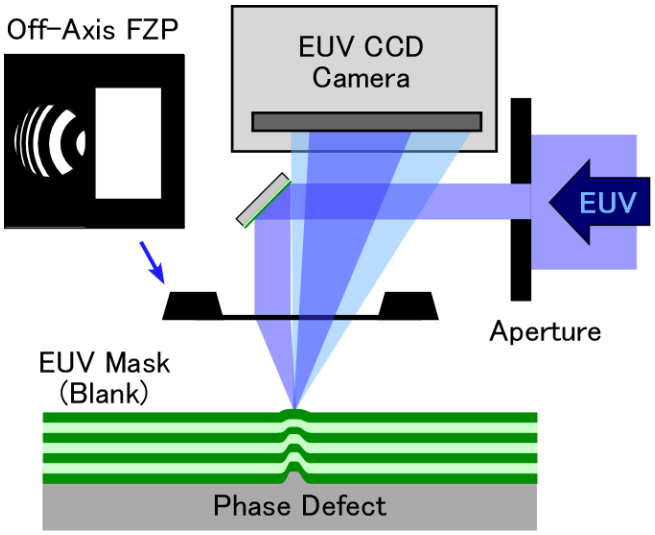

Figure 1: Schematic view of the micro-CSM system: The micro-CSM is a characterization tool of phase defects that consists of the focusing optics of the off-axis FZP and the two-dimensional detector of the CCD camera. The focused beam is exposed to a phase defect, where the scattering signal is recorded with the camera. The signal includes the defect information. Focused size was estimated to 200 nm in diameter. The camera records ±16 degree angle from the chief ray.

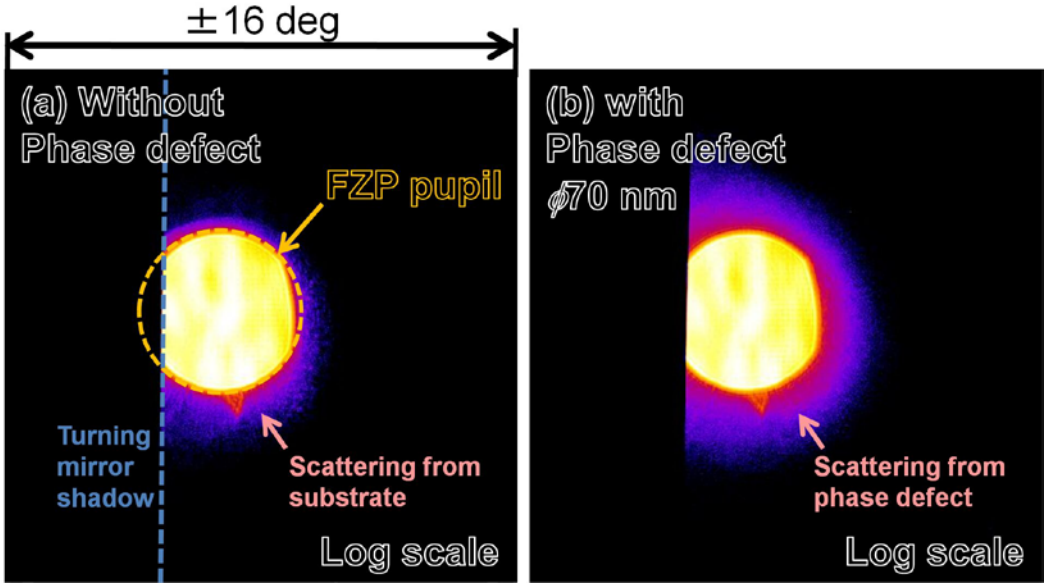

Figure 2: Scattering signal images of EUV mask with programmed phase defects: (a) without defect, (b) with defect of 70 nm in diameter and 2 nm in height. Exposure time was 10 s.