Development of Standalone Coherent EUV Scatterometry Microscope for EUV Mask Observation

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In extreme-ultraviolet (EUV) lithography, defect-free mask production is a one of critical issues for high-volume manufacturing. EUV mask is reflection type coated with a Mo/Si multilayer. Thus, actinic (at-wavelength) EUV inspection tool is required to investigate phase defect that is buried with the multilayer. We developed a coherent EUV scatterometry microscope (CSM), which is a simple lensless system. CSM records EUV diffraction light from mask patterns with a CCD camera directly, which is illuminated with coherent EUV light. Mask pattern and critical dimensions are evaluated with the diffraction images.[1,2]

Since a practical standalone mask-inspection system is strongly required by the industry, we have developed a standalone CSM system employing high-order harmonic generation (HHG) EUV source. Figure 1 shows the schematic view of the CSM system employing HHG source. We focus the femto second, sub-TW and Ti:Sapphire laser pulses upon a semi-infinite gas cell filled with Helium gas, which causes non-linear wavelength conversion from near-infrared light of 800 nm to EUV light of 13.5 nm. The mirrors in the EUV branching chamber relayed the EUV light to an entrance pinhole in the CSM chamber.

Figure 2 shows a diffraction image from a program defect in an 88-nm lines-and-spaces (L/S) pattern. The defect was a line defect that one line in the L/S pattern had 30-nm wider than the others. At the center position, the Fraunhofer-diffraction ring from the entrance pinhole is clearly recorded with good signal-to-noise ratio. Beside the center signal, there were ±1st diffractions from the L/S pattern. And the diffraction from the line defect was clearly recorded as line diffraction through the 0th to ±1st diffraction orders. Thus, we successfully developed the HHG-CSM system that was a practical standalone tool for actinic metrology and inspection of the EUV mask.

[1] T. Harada *et al*., J. Vac. Sci. Technol. B **29** (2011) 06F503,.
[2] T. Harada *et al*., Jpn. J. Appl. Phys. **50** (2011) 06GB03.

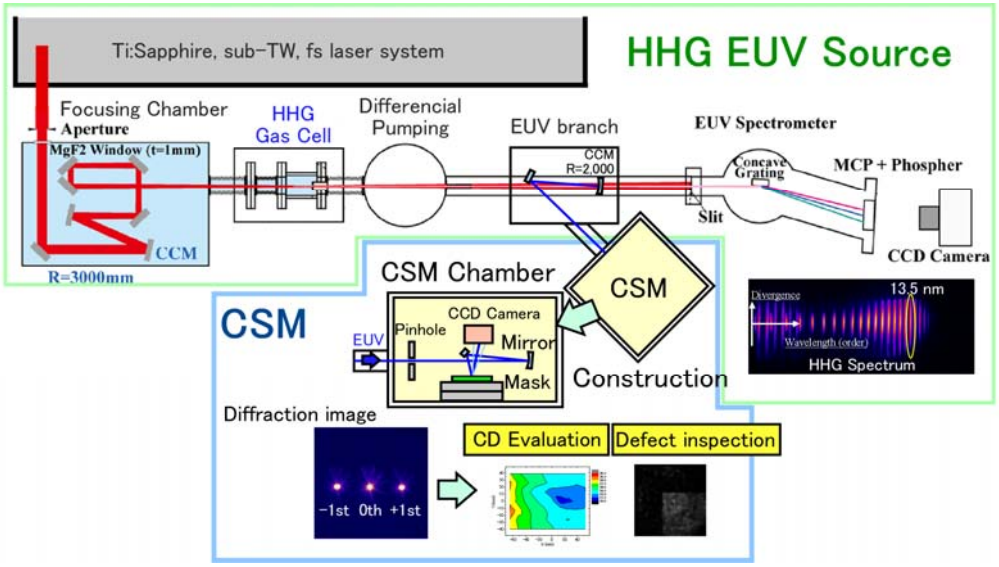

Figure 1: Schematic of the standalone CSM system, which employs the HHG EUV source. The source provides coherent and bright EUV light. The CSM system is lensless, which records diffraction image from the mask. CD values and the pattern images are evaluated with the diffraction images.

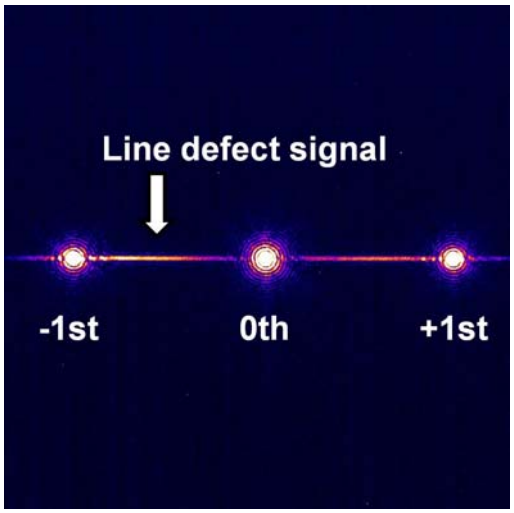

Figure 2: Diffraction image of an 88-nm L/S pattern with a line-type defect observed by the standalone CSM system. The EUV direct reflection signal of 0th order diffraction was recorded at the center, and there were two signals of ±1st diffractions beside the 0th signal. The line defect was clearly recorded as the line diffraction signal.