Lithographic Performance of EUV Mask using Coherent Scattering Microscopy

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Extreme ultraviolet lithography (EUVL) is a next-generation high-volume manufacturing (HVM) technology for sub-22nm semiconductor devices. However, there are still a number of problems to be resolved before it can be inserted into mass production, and a shortage of mask metrology and inspection is one of them.

In this paper, we report the application of the coherent scattering microscopy (CSM) equipped with femto second laser-based EUV source to analyze aerial images for the EUVL mask. The CSM employs a EUV beam with 13.5 nm wavelength and an incident angle of 6 degrees for the wafer scanner emulation.

The CSM as shown in Figure 1 mainly consists of condenser optics that deliver the EUV beam to the mask and detector that measure a field spectrum which is diffracted by mask pattern. IR light from femto second laser is filtered by Zr filter. Using a pair of EUV spherical and plane mirror the image is relayed to EUVL mask and the diffracted light by the mask pattern is measured by 1 inch size CCD (Charge-Coupled Device) detector. The integration time of EUV beam in the detector is controlled by high speed shutter. It experimentally records the coherent diffraction pattern from the EUV mask and reconstructs its aerial image using a phase retrieval algorithm. These features made it possible to investigate the projected image properties, such as depth-of-focus (DOF), exposure latitude, mask error enhancement factor (MEEF), H-V CD (horizontal-vertical critical dimension) bias, normalized image log slope (NILS), and so on. It also provides mask CD from RCWA (Rigorous Coupled-Wave Analysis) algorithm modeling based on Maxwell equation through measured diffraction pattern. Figure 2 shows NILS according to half-pitch design node as measured by CSM and simulated by Solid-EUV simulator. Illumination conditions of NA and sigma (σ) values are 0.25 and 0.8, respectively, which are the same as those of EUV exposure tool. The NILS as measured by CSM and that by Solid-EUV simulation show good consistency. Conclusively we could provide and expect the useful information for the issues in high-NA EUV imaging.

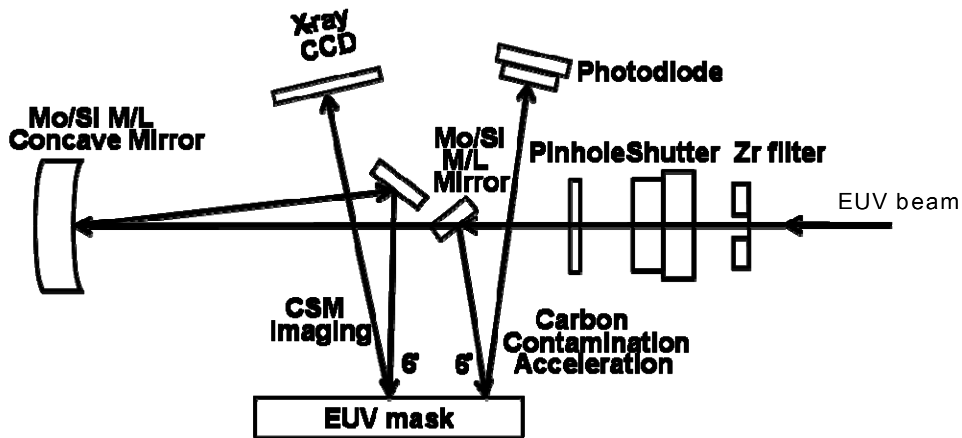

Figure 1: The schematic diagram of CSM: CSM consisted of condenser optics that deliver the EUV beam to the mask and detector that measure a field spectrum which dispersed in mask pattern.

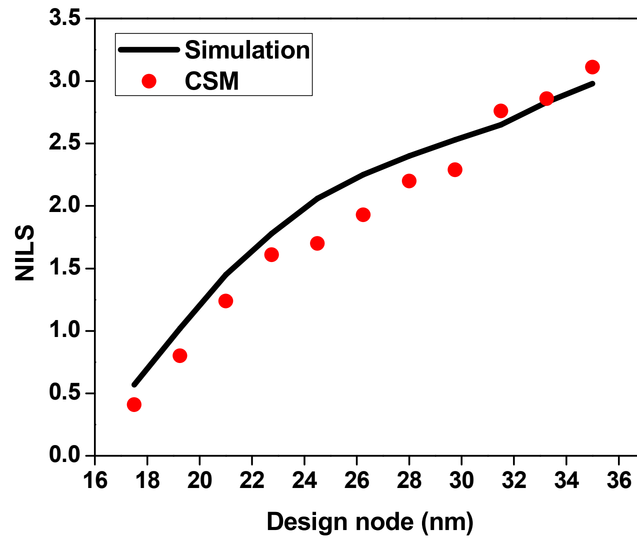

Figure 2: NILS according to half-pitch design node: Design node was split by 17-nm to 35-nm and the NILS as measured by CSM and that by Solid-EUV simulation show good consistency.