Residual-type mask defect printability for EUV lithography

Tsuyoshi Amano, Susumu Iida, Ryoichi Hirano, Tsuneo Terasawa and Hidehiro Watanabe
EUVL Infrastructure Development Center, Inc., 16-1 Onogawa, Tsukuba-shi, Ibaraki-ken, 305-8569, Japan
tsuyoshi.amano@eidec.co.jp

Yuichi Inazuki
Dai Nippon Printing Co., Ltd., 2-2-1 Fukuoka, Fujimino-shi, Saitama-ken, 356-8507, Japan

It is necessary for the development of viable defect-free mask fabrication processes to understand pattern defect impact and detecting printable defect on EUV (Extreme Ultraviolet) mask. As described in some previous papers, the inspection capability of defects on EUV masks and its printability on wafer were investigated using programmed defects with various shapes and sizes.[1)] When the size of the mask pattern becomes small, thin residual absorber layer between adjacent absorber lines often appears as the absorber defects after mask fabrication. Such thin absorber layer is residual-type mask defect but its impact is not clear from the view point of actual pattern printing.

In this paper, we report the defect printability evaluation results by printing test using newly fabricated test mask with programmed absorber defect. The mask has 66-nm-thick Ta-based absorber layer and full-height of bridge type defects in line and space patterns on ruthenium capped EUV reflective multi-layer. The programed residual-type defects were fabricated using mask repair tool and their thicknesses were 2, 4, 8, 16, 33 and 66 nm (Figure 1). Mask pattern printing on wafer was performed using a Small Field Exposure Tool at EIDEC under the conditions: numerical aperture (NA) = 0.3, illumination sigma = 0.3/ 0.7 (inner/ outer), demagnification = 5, and wavelength = 13.5 nm.

As shown in figures 2 and 3, the 2 nm in height of the residual bridge defect causes more than 10 % CD (Critical Dimension) error at outer focus range. These results are in good agreement with the previous simulation estimation. [2)]

Acknowledgement: This work was supported by NEDO.

References: 1) T. Abe, et al., in *Proceedings of the SPIE, 2006*, vol. 6607, 66070L, EUV mask pattern inspection using current DUV reticle inspection tool
2) H. Aoyama, et al., in Proceedings of the SPIE, 2007, vol. 6730, 67305L, Repair specification study for half pitch 32-nm patterns for EUVL

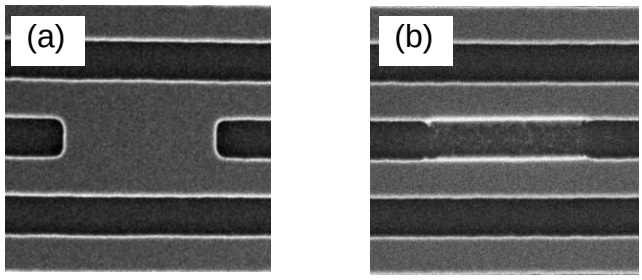

Figure 1 SEM images of the programmed bridge defect with the thickness of (a) 66 nm (equal to the thick of the absorber layer) and (b) 2 nm (residual-type defect) in hp 225 nm L/S pattern.

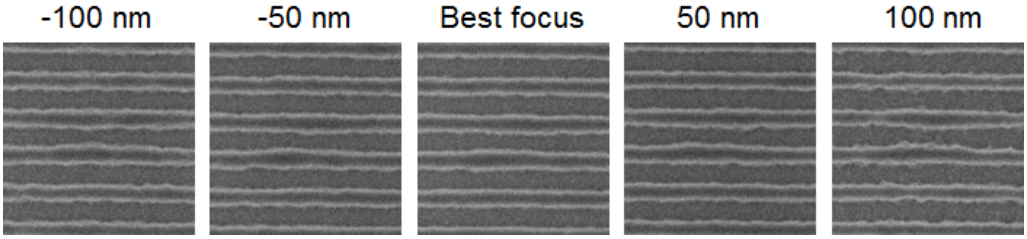

Figure 2 SEM images of the printed resist pattern on wafer with +/- 100 nm focus range. The mask pattern was hp 225 nm L/S with 2 nm thick of the bridge defect.

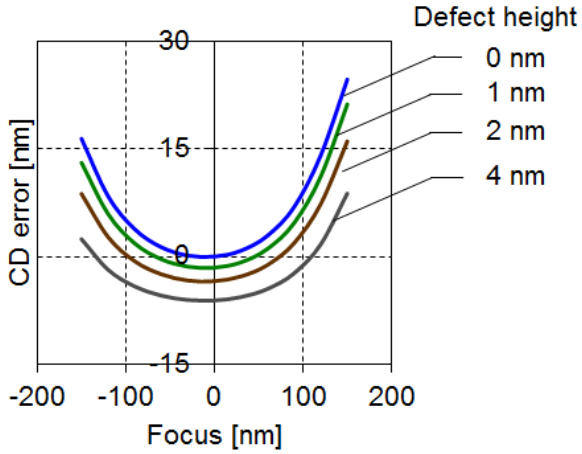

Figure 3 Simulated space CD errors as a function of focus values obtained from aerial image calculation using threshold method. Calculated mask patterns are hp 225 nm L/S (hp 45 nm on wafer) with bridge defects with 0 (reference), 1, 2 and 4 nm in height.