Comparison of fast 3D simulation and actinic inspection for EUV masks with buried defects and absorber features

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Aerial images for isolated buried defects and the interactions of defects with features are compared between the Actinic Inspection Tool (AIT) at Lawrence Berkeley National Laboratory (LBNL) and the fast EUV simulation program RADICAL[1].

The AIT is a direct CCD actinic (EUV-wavelength) EUV mask inspection tool[2]. It employs a bending magnet at the Advanced Light Source synchrotron at Lawrence Berkeley National Laboratory as its source and uses a Fresnel zone plate lens to project a high-magnification image with numerical aperture values that emulate current EUVL printing tools.

The simulator used in this study, RADICAL, is a full 3D EUV mask simulator designed to predict the aerial image from an EUV mask with a buried defect and absorber features. It simulates the mask pattern and defective multilayer stack separately so that simulation methods optimized for each can be used. The mask used in this study is a programmed defect EUV mask in which 48nm high posts in a substrate are over-coated with a multilayer. The over-coating produced defects with about a 60 nm FWHM diameter and heights ranging up to 10nm[3].

This study addresses three issues. The first is to characterize the aberrations and lithographic parameters in the AIT tool at the time of measurement. The second is to verify the accuracy of RADICAL in simulating buried defects near absorber lines. The third is to give additional insight into defect printing, especially its dependence on position relative to the absorber and also through focus. Thin-mask simulations of EUV defects will be presented first to illustrate similarities with the printing of phase defects in DUV. These include through-focus trends, such as the dark-to-light shift in the intensity at the center of the defect, and the rotation of the isolated defect ellipse through focus with astigmatism. AIT images of contacts and simulation with RADICAL will then be used to calibrate astigmatism and coma and estimate effective defect sizes and phases. A systematic comparison of AIT and RADICAL images will then be made for key parameter cuts such as focus, position relative to the absorber lines, and defect size. Finally, an overall perspective will be given of the nature of EUV defect-feature interactions vis-à-vis those for DUV.

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[1] C. H. Clifford, et al. “Fast three-dimensional simulation of buried EUV mask defect interaction with absorber features,” Proc. of SPIE 6730, (2007).

[2] K. A. Goldberg, et al. “Performance of actinic EUVL mask imaging using a zoneplate microscope,” Proc. SPIE Photomask (BACUS) 6730, (2007)

[3] T. Liang, et al, “Growth and printability of multilayer phase defects on extreme ultraviolet mask blanks,” J. Vac. Sci. Technol., B25(6), 2098 (2007)

Supporting Images

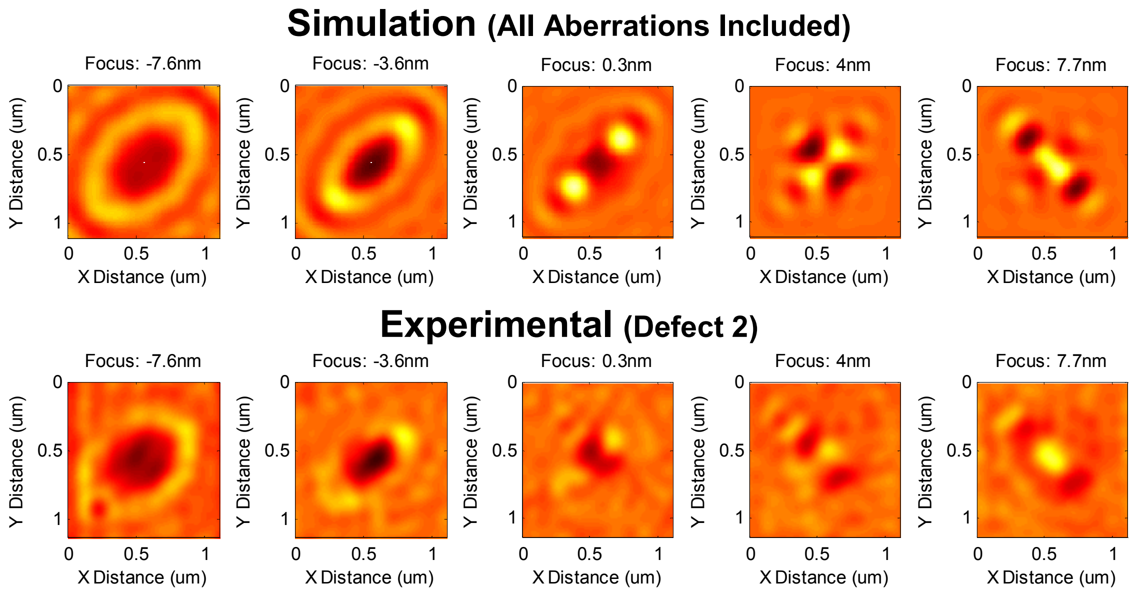

Figure 1. Comparison of aerial images from an isolated EUV buried mask defect predicted by RADICAL simulations (top) and produced by AIT inspection (bottom) through focus. The defect was 6.2nm tall and 58nm FWHM on the surface of the multilayer

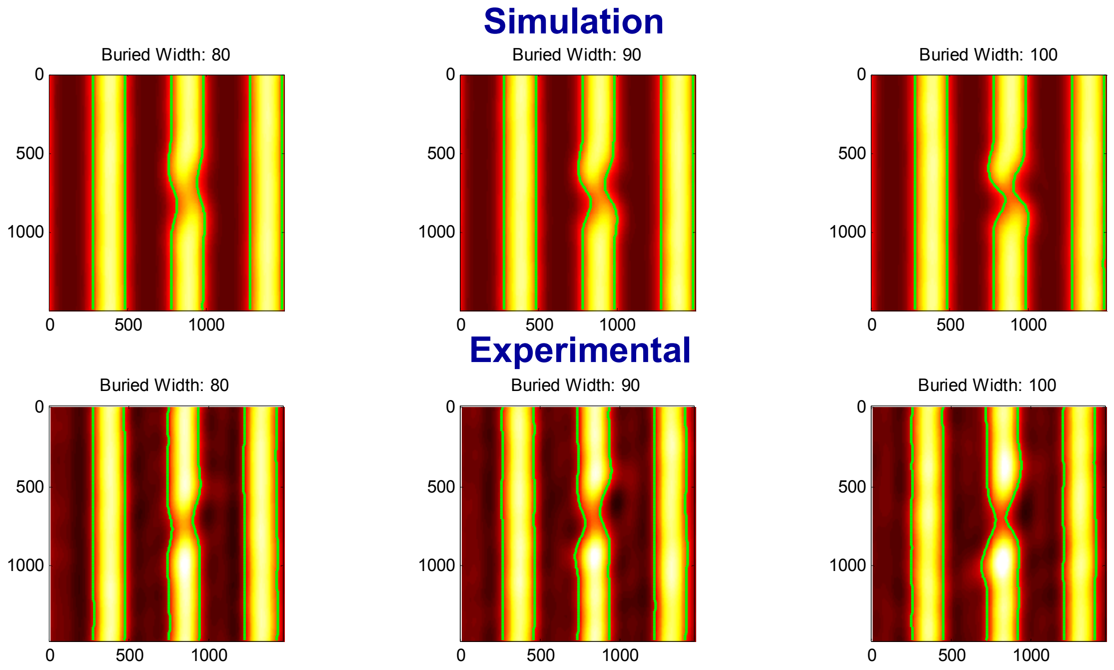

Figure 2. Comparison of aerial images from EUV buried mask defects near features predicted by RADICAL simulations (top) and produced by AIT inspection (bottom). The surface defect heights varied from 4.4nm to 8nm and the surface width varied from 55nm to 60nm FWHM. The defect position relative to the absorber feature was constant. All predicted AIT aberrations were included for these simulations.