Type of presentation: Poster

IT-15-P-1509 At-wavelength observation of phase defect embedded in extreme ultraviolet lithography mask

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Extreme ultraviolet (EUV) lithography is considered to be the most promising next-generation lithography after the point where 193-nm immersion lithography would cease to deliver smaller features. However, the path to establish the EUV lithography is not without technical difficulties. Issues with insufficient light-source power, defect-free mask fabrication, and resist material development are to be resolved. Regarding the types of mask defects, the nature of the pattern defects in the EUV mask is mostly same as in the case of optical masks except for those defects that are classified as reflective multilayer defects, such as bump or pit phase defects that propagate through the multilayer during its deposition on the substrate surface and it is hard to repair. Therefore, to reduce the effect of the phase defect on wafer printing image, two methods are suggested. One method is to cover the phase defects beneath the absorber pattern by shifting the location of device pattern during mask patterning. The other is to eliminate the influence of the phase error by removing the absorber away from the close proximity of the phase defects after fabricating the device pattern. To make these methods success, it would be necessary to be able to pinpoint the location of the phase defects and the affected areas.
In this presentation, influence of the phase defect structures on EUV microscope images were examined to predict the inclination angle dependency of the phase defect impact on wafers since the phase defect does not always propagate in a vertical direction from the substrate surface through the multilayer. Figures 1(a) and 1(b) show photograph of the EUV microscope and illustration of the imaging optics, developed by Tohoku Univ. that was utilized in this study. The EUV light was sourced from a beam line BL3 of the New SUBARU synchrotron facility at the Univ. of Hyogo. A programmed phase defect EUV mask was prepared. Figure 2(a) shows the cross-sectional transmission electron microscope (TEM) images of the vertical and inclined grown phase defects. The calculated inclination angles of the phase defects were 0 and 4 degrees. Figure 2(b) represents the scanning probe microscope (SPM) images of the phase defects with half-pitch 88 nm lines-and-spaces (L/S). The L/S with the phase defects were observed using the EUV microscope. Figure 2(c) show the EUV microscope images and their intensity profiles. The impacts of the inclination angles on EUV microscope images were significant even though the positions of the phase defect relative to the absorber line, as measured by scanning prove microscope, were same. As a result, the EUV microscope could identify the positional shift of the effective defect position caused by the inclined propagation through the multilayer.

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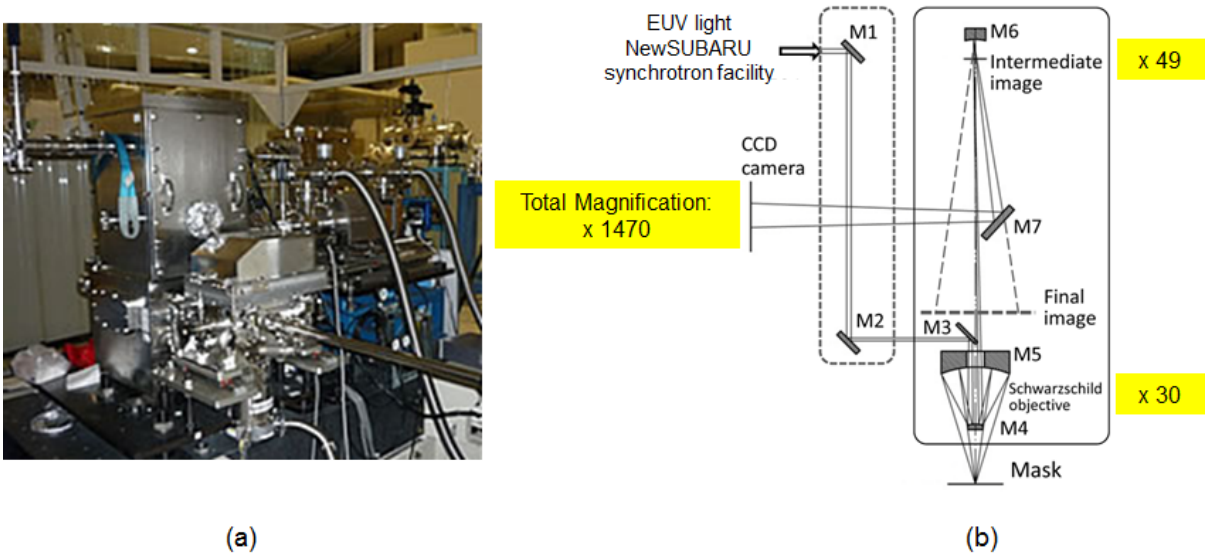

Fig. 1: (a) Photograph of the EUV microscope. (b) Schematic model of the EUV microscope optics.

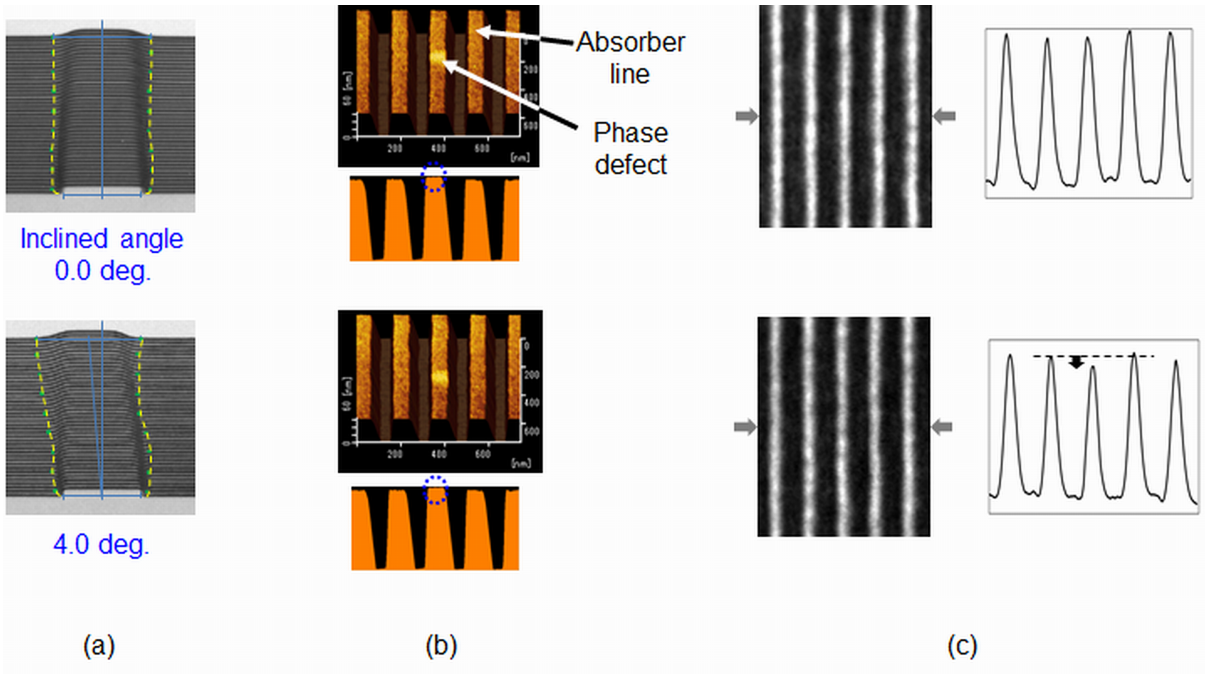

Fig. 2: (a) Cross-sectional TEM images of the vertical- and inclined-grown phase defects. (b) SPM images of the phase defects in half-pitch 88 nm L/S. (c) EUV microscope images and intensity profiles.