Cross-sectional Film Characterization of Exposure-induced Carbon Contamination on Patterned EUV masks

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Carbon contamination in EUV exposure tools is one of the critical issues challenging the introduction of EUV lithography into high volume manufacturing. It occurs when multilayer surfaces are exposed to EUV radiation in the presence of low, partial pressure residual hydrocarbons. In this work, we investigated the effect of carbon contamination on patterned Si-capped EUV masks, as well as an Ru-capped EUV mask patterned on a 4” silicon wafer to simplify cross-section analysis. Selected fields on the mask were contaminated with a series of exposures and printed using the SEMATECH Berkeley MET. In addition, the SEMATECH Berkeley AIT and an AFM were used to analyze the mask to determine the effect of the contamination layer on the absorbing features and on printing performance.

The masks were then cleaved and prepared for TEM cross-sectional analysis to directly measure the thickness of the contamination layer. Density of contamination film was also determined based on directly measured film thickness, composition analysis, the absorption coefficient from CXRO, and reflectivity measurements at EUV wavelength. With the knowledge of topography, lithographic simulations were used to predict the required dose to print the contaminated features. The contamination topography based on the absorption and secondary electron emission from the TaN absorber was also modeled. Preliminary results show that the modeled topography is similar to the real topography using TEM cross-section analysis.

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