The improvement of imaging properties by optimizing the capping structure in Extreme Ultraviolet Lithography

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Extreme ultra violet lithography (EUVL) using 13.5nm wavelength is expected to be the mainstream of production process for 22nm half pitch and below. Mask shadowing is a unique phenomenon caused by using of multilayer mirror-based mask with oblique incident angle of light. This results in a horizontal-vertical (HV) biasing effect and ellipticity in contact hole pattern. To meet the reflectivity requirement (< 0.5%) of the SEMI standard, the required absorber thickness is at least 70nm. Thick absorber stack is not desirable, because it induces many practical problems such as shadowing effect and difficulties in manufacturing.

In this paper, we suggest an optimal structure of capping layer for EUVL to minimize mask shadowing effect without a loss of image contrast. Phase shift concept would be a possible solution to improve image contrast with thinner absorber stack. The changes of phase shift and reflectivity depending on the structure of capping layer were studied using aerial image simulation. We analyzed the effect of material, which have been widely studied as capping materials in EUVL mask structure, such as ruthenium (Ru) and silicon (Si), and the thickness variation. The influence of phase shift on the imaging property including image contrast, mask error enhancement factor (MEEF), and process window was also calculated using EM-SUITE simulation tool. In addition, the impact of mask shadowing and strategies for shadowing effect mitigation will be discussed.

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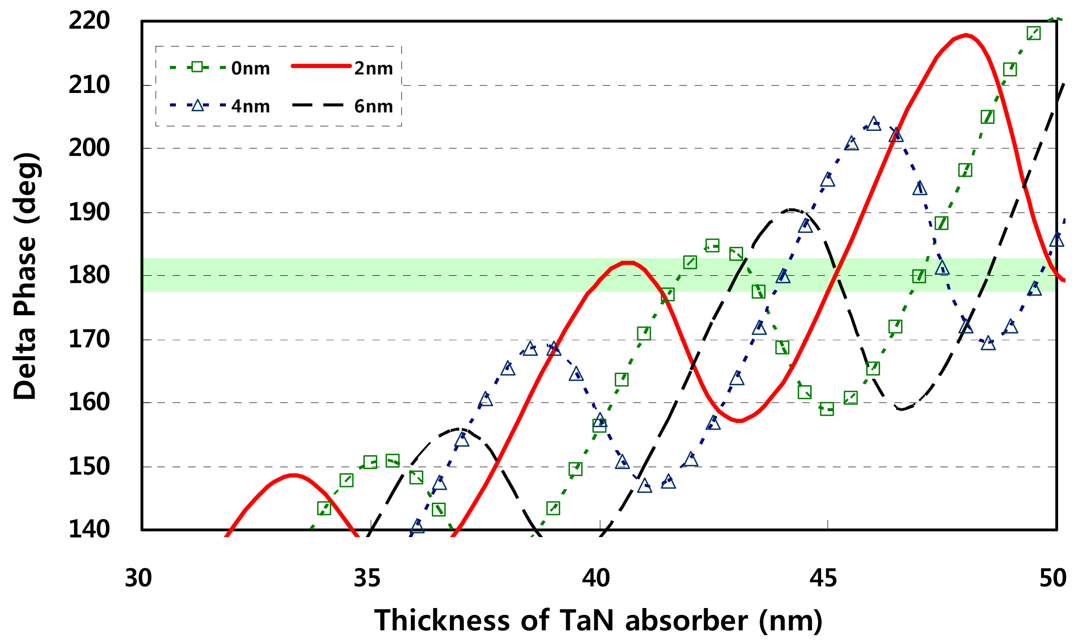

Fig. 1. The calculated phase shift change as a function of TaN absorber and Ru capping layer thickness on Mo-Si multilayer at 13.5nm wavelength