Optical Performance of Binary Mask with a Tantalum Telluride Absorber Layer for Extreme Ultraviolet Lithography

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Extreme ultraviolet lithography (EUVL) at 13.5-nm wavelength is expected to be employed as a next-generation lithography (NSL) for decreasing the feature size of half-pitch of 16 nm and below in semiconductor devices. Especially, it is reported that the lithography performance of a EUVL mask depends on the choice of absorber materials because it is directly related to the imaging contrast, shadowing effect, focus shift effect, and thermal effect [1]. Therefore, recent development of novel mask materials with high absorption in EUVL is important for an actinic inspection of EUV mask and a low lithographic performance by a high numerical aperture (NA) optical system[2].

In this study, we proposed tantalum telluride ($TaTe_2$) as a new absorber material for EUVL mask. The optical constants of $TaTe_2$ films at 13.5-nm are calculated by an indirect method by using X-ray reflectivity (XRR) and Rutherford backscattering spectroscopy (RBS). The result shows that the optical constants of $TaTe_2$ film with 25.95 nm thickness are n = 0.9527 and k = 0.0557 at 13.5 nm wavelength. It turns out that the extinction coefficient of $TaTe_2$ is 1.82 times larger than that of TaN, a typical absorber in EUV. We simulated the reflectance of EUV binary mask by applying the optical constants of $TaTe_2$ absorbing layer in the Essential Macleod software and found that the thickness of 43.8 nm has the lowest reflectance of 0.20%. Furthermore, we fabricated the binary masks with $TaTe_2$ absorber layers with various thicknesses by using RF-magnetron sputtering system on Mo/Si multilayer mirror to study their optical performance in the EUV range. The reflectance of 0.248% is observed for $TaTe_2$ thickness of 54.47 nm. It is lower than that of typical TaN absorber thickness, 70nm, which is currently used in EUVL mask. Hence, it is expected that the $TaTe_2$ absorber material can reduce significantly the geometric shadow effect.

[1] K. Kemp and S. Wurm, C. R. Physique **7**, 875 (2006).
[2] International Technology Roadmap for Semiconductors (2010). (http://www.itrs.net)