Liftoff Lithography of Chrome for Extreme Ultraviolet Lithography Mask Absorber Layer Patterning

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Extreme Ultraviolet Lithography (EUVL) is the primary candidate for extending projection lithography to 22nm half-pitch features and beyond. With an illumination wavelength of 13.5nm, the theoretical resolution limit of the technology is less than 10nm. Since EUVL typically uses 4x reduction optics, feature sizes on the mask are falling below 50nm. The manufacture of high resolution EUVL masks at these dimensions is an important challenge and the authors present a lift-off lithography technique to pattern such masks.

EUVL masks are essentially a distributed Bragg reflector, with the pattern defined in an EUV wavelength absorbing layer on top. This absorber layer is typically deposited as a blanket film, and subsequently patterned using an electron beam lithography (EBL) step to define the pattern in resist, followed by a subtractive reactive ion etch (RIE) step to transfer the pattern into the absorber.

The authors propose an alternate method of defining the absorber layer pattern using lift-off lithography – an additive process where EBL is used to define the pattern in resist and the chrome absorber layer is deposited over it. Excess chrome is then removed during the resist strip. This eliminates the need for an RIE step and reduces cost and complexity while maintaining acceptable contrast and line edge roughness (LER). Lift-off lithography is a well known technique and has been used to obtain sub-10nm features for some time[1] on a variety of substrates[2]. The technique is known to cause defects due to metal re-deposition during resist strip – the defects introduced are characterized using a Lasertec inspection system and it is proposed that the defectivity is acceptable for non-production tests.

This study uses quartz wafer substrates to determine the optimal proximity effect correction (PEC) parameters used during EBL, and to develop a PMMA resist based lift-off process for a chrome absorber layer deposited by electron beam evaporation. This process is then applied to ruthenium passivated EUVL mask blanks and the resulting pattern in absorber is characterized using critical dimension scanning electron microscope (CDSEM) metrology.

The results of the study demonstrate that sub-50nm features can be readily defined on EUVL mask blanks using the described process and that the quality of the lithography as defined by its contrast and LER makes lift-off lithography of chrome a viable method for EUVL mask absorber layer patterning for applications where defectivity is not of critical importance.

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[2] Michael D. Austin, Haixiong Ge, Wei Wu, Mingtao Li, Zhaoning Yu, D. Wasserman, S. A. Lyon, and Stephen Y. Chou, Appl. Phys. Lett. 84 (2004) 5299