Study of Heat Load & Temperature-Induced Distortion in High Power Wiggler X-Ray Exposure at CAMD & BESSY-II

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One of the major steps in ultra deep X-ray lithography is exposure of thick photoresist using high power synchrotron radiation such as wiggler radiation available at CAMD and BESSY-II. These intense X-ray sources make it possible to pattern very tall high aspect ratio microstructures in reasonable time. However, this powerful X-ray beam can cause significant heat load in the assembled mask-substrate-stack eventually impacting patterning accuracy. Heat load and its impact on the patterning accuracy in deep X-ray lithography has been studied for many years and reported in a number of publications [1-5]. These studies show that thermal load can cause temperature increases that rang from a few degrees to above glass transition temperature of PMMA.

Experiments were conducted at the CAMD (DEX3, Jenoptik, Germany) and BESSY (DEX1, Jenoptik, Germany) wiggler beamlines, respectively, using different scanners and clamping mechanisms. The substrate is placed onto the water-cooled scan stage back plate (21°C). NIST ring mounted X-ray masks, typically made from graphite, 150µm thick, with about 30 µm thick Au absorber is placed face down on top of the substrate separated from the mask with predefined proximity gap, typically 500µm. Based on experiments conducted at CAMD/LSU and BESSY-II lateral shifts of up to 10µm across the exposed area (~85mm) was measured. The shift depends upon the location on the mask and the way the mask is mounted.

In order to understand these shifts and associate them to thermal effects low mass K-type Omega thermocouples with Ø 0.076mm were placed at specific locations on the X-ray mask, substrate, and PMMA resist in order to measure the temperature increases within the assembled stack under typical exposure conditions. The presentation will describe on the efforts to measure temperature increase during exposures and present some first results.

References

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