

The X-ray Lithography of 200 nm Nano Resosolution via Taiwan Light Source

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We found the minimal thickness of gold absorber for photo-resist of PMMA around 1000 nm via SHADOW-VUI™. The gold absorbers determinate the line-width and the aspect ratio of patterns in processing the X-ray lithography experiments at the 19A1 beamline of Taiwan Light Source, NSRRC. The absorption ratio of region exposed by X-ray to region shielded by gold absorber must be 10 at least to create a sufficient contrast for definition the pattern of resist PMMA. Hence, a gold absorber thicker than 500 nm is necessary to carry out a X-ray mask for patterning NEMS devices. The designed gold absorbers were realized through many tests at NSRRC in the year of 2008. The patterns of nano-scale absorbers were defined with a E-beam writer within the critical dimension = 200 nm and then construct during electroplating process in a gold bath. The gold absorbers were electroplated with a cyclic voltammetry (CV) method and a multi-current method respectively. In experiments of the CV method, the working voltages were between -0.4 and -0.8 at scan rate = 0.75 V/s. The gold absorbers thickness of running 96 segments were 120 to 180 nm revealed in the SEM pictures. These absorbers were too thin to shield the photo-resist of PMMA under a X-ray exposure. Added running segments to 128, the thickness of absorber still cannot increase obviously. Compared with the above CV method, the multi-current method using the recipe of 0.4 ASD successfully generates many nano-structures of 500 nm in height. Now the gold absorber with minimal thickness is ready to make up a X-ray mask to fabricate NEMS device in BL-19A, which were showed in the Fig. 1.

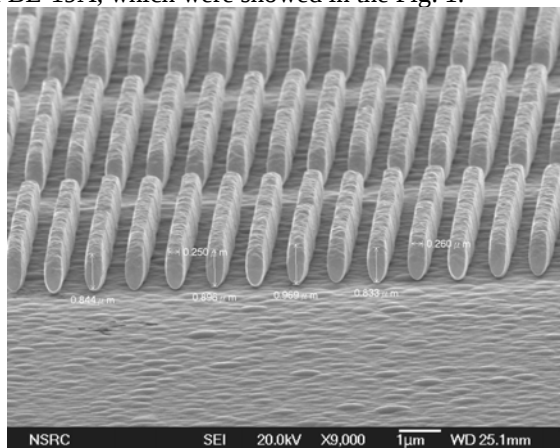


Fig. 1: The pattern of X-ray mask with 200-250 nm in resolution and 950 nm in height was defined via 20 KeV E-beam writing then accomplished electro-chemistry with multi current method using recipe of 0.4 ASD.

The minimal absorber is numerically calculated as 700-900 nm to earn a clarify lithography for the photo-resist, PMMA and also to avoid the proximity effect following the e-beam writing. The force of both the buoyancy and the surface tension of H₂ bubbles were balanced to plate nano gold-absorbers with electrochemistry

method of multi-current recipe. Moreover, we use the mask to reproduce a high aspect ratio structure via soft X-ray exposure. The new generation of sub-micro to nano machining technique is ready to be applied widely and effectively for manufacturing optical device, capillary driven microfluidics chip, fresnel zone plate and lotus surface in Taiwan Light Source.

In results, the minimal absorber is calculated as 700-900 nm to earn a clarify lithography for the photo-resist, PMMA and to avoid the proximity effect following the e-beam writing. The force of both the buoyancy and the surface tension of H₂ bubbles were balanced to plate nano gold-absorbers with electrochemistry method of multi-current recipe. The X-ray machining technology was successes generated many nano-structures around 3000 nm in height, which were revealed in the Fig. 2.

Now the new generation of sub-micro to nano machining technique can be applied widely and effectively for manufacturing optical device, capillary driven microfluidics chip, fresnel zone plate and lotus surface in Taiwan Light Source. A novel absorber is also preparing to cross the limitation of low voltage E-beam hardware. We predict that a mask just needs the half volume to earn the same function.

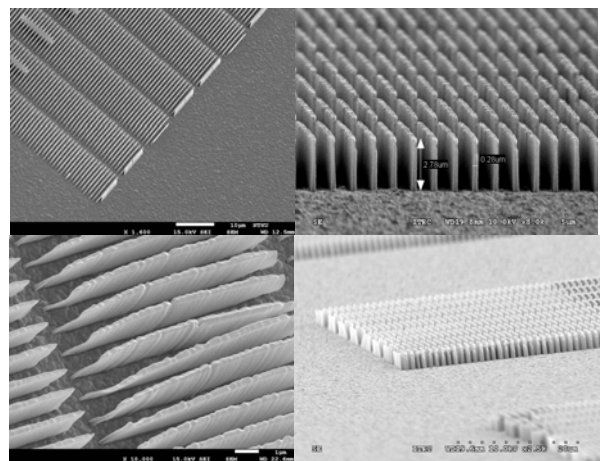


Fig. 2: the replica structure under our X-ray mask, which aspect ratio was achieve 10 by synchrotron radiation.

References

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