Apertureless Beam Pen Lithography Based on Fully Metal-coated Polyurethane-acrylate (PUA) Micro-pyramids Array

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Abstract

This study demonstrate an arrayed transmitting type apertureless near-field photolithography, named apertureless beam pen lithography. A 60-nm-thick chromium fully coated polyurethane acrylate (PUA) pyramidal microstructures array was illuminated by traditional UV lamp source to create massive UV beam pens array and achieve apertureless beam pen lithography. Experimental results show that UV energy can pass through the apex of fully metal-coated PUA pyramid even the metallic coating was much thicker than the penetration depth. Both depth and full-width-half-magnitude (FWHM) of patterned photoresist profile were increased with respected to the increasing exposure dosage. Combining with metal lift-off process, arrayed metal dots with 300-nm-diameter was achieved. Finite-element simulation of intensity distribution near the apex of pyramid and within photoresist layer was also mentioned to evidence that the pyramidal structure can induce enhanced energy concentration within the pyramids by about an order, and therefore significantly enhancing the UV energy passing through the fully metal-coated apex. Combining with the contrast curve model of photoresist, the patterned photoresist profile with respect to energy distribution was also calculated. Both experimental results and theoretical analysis are given along with possible improvement and application in the future.

References

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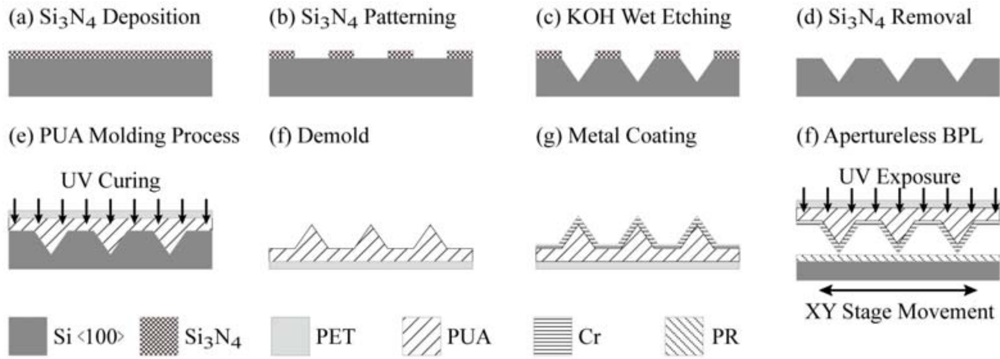

Figure 1: The complete flow diagram on the fabrication processes of a fully metallic coated PUA mold and apertureless beam pen lithography.

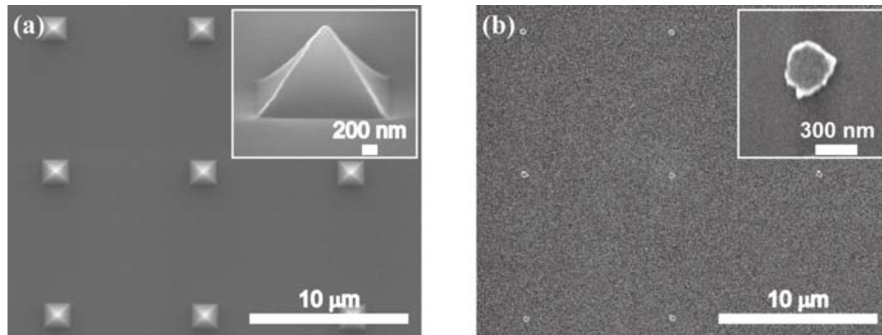

Figure 2. The SEM images of (a) fully chromium coated PUA micro-pyramids. The PUA micro-pyramids are rectangular arranged with a period of 10 μm. The bottom width and height of pyramid are 2 μm and 1.4 μm, respectively. The radius of curvature on the pyramidal tip is estimated to be smaller than 100 nm. (b) Patterned metal dots, the diameter of metal dot is 300 nm.

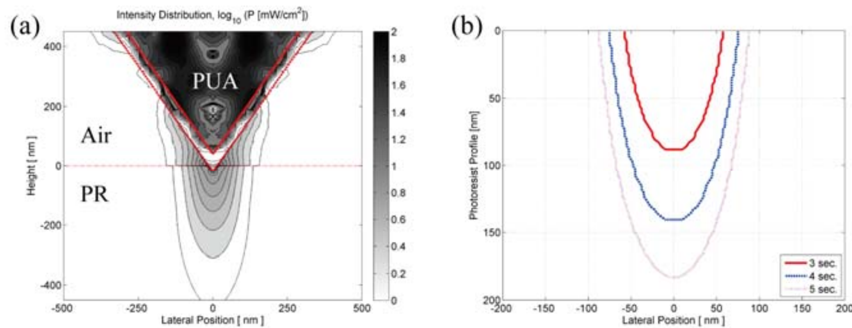

Figure 3. Numerical simulation of apertureless near-field lithography. A plane harmonic wave of UV light with a wavelength of 365 nm and an average power density of 18 mW/cm^2 is incident from the top surface of the model. (a) The UV power density distribution near the fully chromium coated PUA pyramidal structure tip. (b) Variations of patterned photoresist profile with different exposure time based on contrast curve model of photoresist and calculated intensity distribution within photoresist layer.