Easy mask-mold fabrication for combined nanoimprint and photolithography

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Combined nanoimprint and photolithography (CNP) has been developed [1] as a self-aligned mix and match process to generate mixed patterns of nano- and microstructures within one single resist layer. CNP also produces three-step profiles and resist structures without residual layer [2,3]. This is done by using a hybrid semitransparent mask-mold consisting of a transparent stamp with both a surface relief and absorbing mask pattern. In a first step nanoimprint lithography (NIL) is used to generate a thickness profile in resist by squeeze flow and capillary filling. Before detachment of the stamp, the (negative) resist is locally exposed through the stamp areas not covered by the mask absorber, demolded and the non-crosslinked resist selectively removed by wet development.

Depending on the location of the absorption pattern (typically Al or Cr on the stamp protrusions or in the stamp recessions), different types or structures can be generated (see Fig. 1). However, the silane based antisticking layer (ASL) does not covalently bind to metal layers and therefore damage is possible due to resist adhesion, particularly if the coated area is high. It would therefore be desirable to define the absorption pattern independently from the shape and the properties of the surface relief. One solution is to coat a thin transparent layer with the stamp relief on top of a patterned metal layer (see Fig. 1).

In this article we present a simple process based on the organic-inorganic hybrid polymer Ormostamp® by replication on pre-patterned Borofloat® substrates [4]. The microstructured absorption layer was generated by standard UV-photolithography and dry etching of 20 nm thick Cr using Cl_2/CO_2 plasma. The relief was replicated into a thick (few µm) transparent hybrid polymer layer (see Fig. 2). Using these working stamps, grating arrays with 70nm period were replicated in thermoplastic UV-curable resist mr-NIL 6000.3. After this the resist is cured like during the standard flood exposure process and developed, resulting in three-step profiles with mixed patterns. The method is easy to employ for backfilling with microstructures in thermal NIL applications.

[1] K. Pfeiffer et. al., Microelectron. Eng. **57-58** (2001) 381-387
[2] X. Cheng, L. J. Guo, Microelectron. Eng. **3-4** (2004) 288-293
[3] M.B. Christiansen et al., Optics Express **15**(7) (2007) 3931-3939.
[4] A. Klukowska et al., Proc. SPIE **6792** (2008) 67920J.
[2] H.H. Solak, J. Phys D – Appl. Phys. **39** (2006) R171-R188.

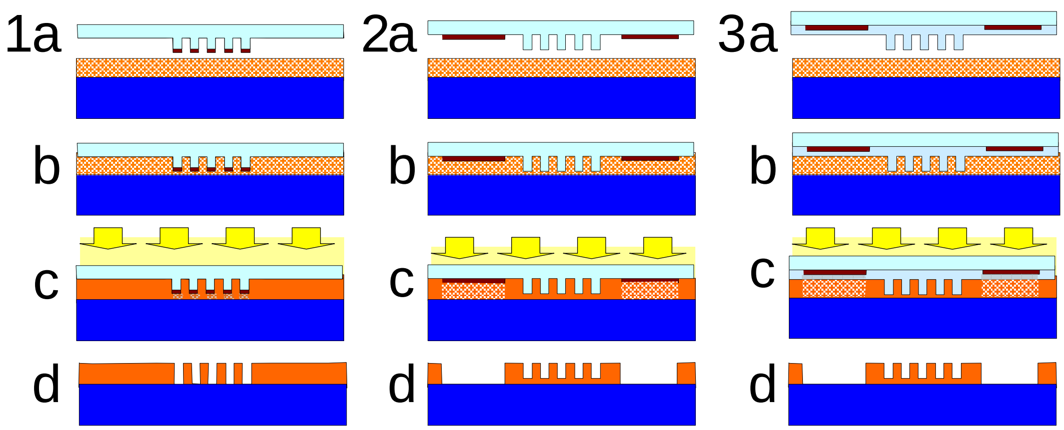

Fig. 1: Schematic of CNP processes (a-d) using different mask-mold designs, depending on the location of the absorber pattern: (1) on stamp protrusions, (2) in recessed stamp areas, (3) below surface relief. Steps (a+b) show imprint, (c) exposure through the semitransparent mask-mold, (d) after development.

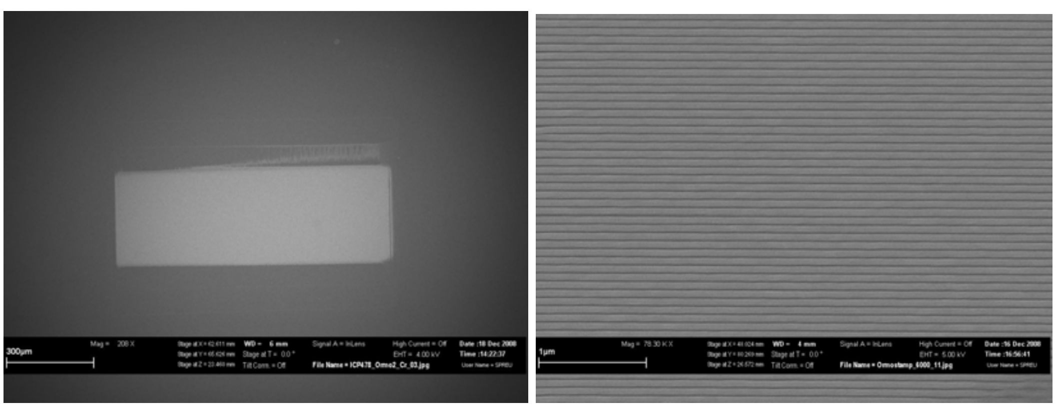

Fig. 2: Micrographs of a typical example of a nanograting used for a mask-mold process by backfilling. Left side: Grating array (1.0×0.2 mm^2) generated by EUV-interference lithography in hybrid polymer [5]. Right side: Replicated grating (70nm period) in mr-NIL 6000.3 resist using thermal NIL @ $T_{imprint}$=110°C / p=50 bar and photolithography with $I \cdot t_{exposure}$ = 2.8 $mW/cm^2 \cdot 5$ s = 14 mJ/cm^2 @ λ=365nm with Δλ=10nm.