3D Resist Patterning with a Hybrid NIL and DUV/Ebeam Lithography

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NanoImprint Lithography (NIL) [1] is a promising technique for the fast duplication of nanostructures. It has already proved its potential during the past ten years, and many applications have been developed using this technology. It has been demonstrated that the imprint process can be achieved even on large surfaces such as 200 mm silicon wafers with a good uniformity to provide sub-100 nm structures [2].

In this paper we investigate now the capability to create multi level resist features by combining the Hot Embossing NIL and Optical DUV and/or Electron Beam Lithography. The aim of this technique is to manufacture resist patterns with different heights onto the wafer in one lithography exposure and one resist spin coating. Although multi level resist features may be manufactured with only one NanoImprint Lithography, it should be noticed that this process generates a residual layer thickness over the whole printed area. Our approach ensures multi level lithography without residual resist layer.

Figure 1 is a schematic description of the processes sequence used in our approach. A Scanning Electron Microscopy picture illustrates this combined lithography technique. A 284 nm thick NEB22 resist film onto a 200 mm silicon wafer have been printed with 250 nm dense line array silicon stamp 180 nm deep. The NEB22 (from Sumitomo) resist is PHS based polymer dedicated to ebeam lithography. We have already shown that this resist may be also used for NIL [2]. The residual layer thickness was about 200 nm and the optical exposure was performed onto an ASML 300 stepper with a 248 nm wavelength. The development was carried out with MF702 developer. Dark areas correspond to resist features with two levels and bright area to the silicon substrate respectively.

Figure 2 shows SEM images of a printed 250 nm dense line array exposed with DUV. Depending of the optical exposure dose the resulting pattern the imprint residual layer thickness (h_r) may be removed (right picture dose = 5 mJ/cm²) or not (left picture dose = 12 mJ/cm²), opening new possibilities to NIL processes since the plasma etching of h_r will be no more needed. Similarly to classical optical or ebeam lithography, it is thus possible to determine the contrast curve in such approach. In this paper we will fully characterize (AFM, scatterometry) the resist behaviour. We will demonstrate how this hybrid lithography (NIL/DUV) may be used to achieve ultra-high resolution complex patterns, resist features without h_r and multilevel resist mask thickness for transfer into the underneath substrate.

[1] S.Y. Chou, P.R. Krauss, P.J. Renstrom, Appl. Phys. Lett. 1995, 67 (21) 3114-3116.
[2] S. Landis, N. Chaix, C. Gourgon, C. Perret, T. Leveder, Nanotechnology 2006, 17 (10) 2701-2709.

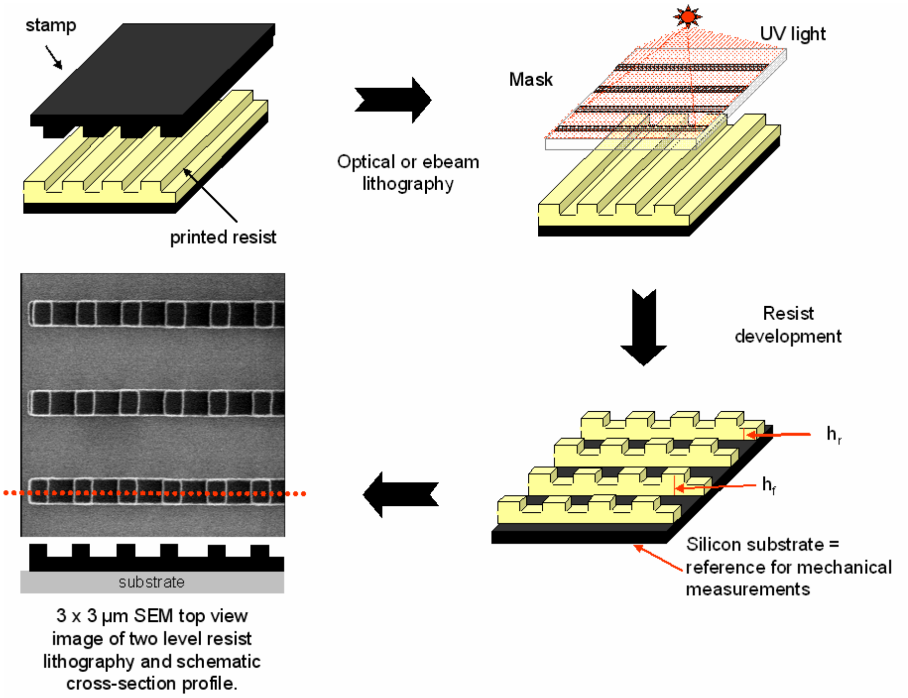

Figure 1: Schematic description of the multilevel resist lithography and SEM top view image of resist features.

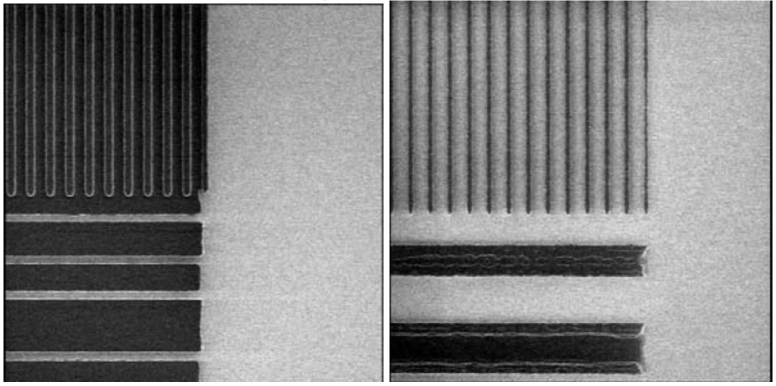

Figure 2: 10 x 10 µm SEM top view images of multilevel resist features. In the left picture, the printed resist have been exposed with a 12 mJ/cm² at 248 nm and the right one with a 5 mJ/cm² respectively.