Refined coarse-grain modeling of stamp deformation in nanoimprint lithography

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The inhomogeneous distribution of the residual layer thickness is a vital issue in nanoimprint lithography (NIL). Using the simulation of NIL, this problem can be alleviated by optimizing the stamp geometry and by choosing process parameters.
In [1] coarse-grain software for modeling of NIL process has been presented. The software takes into account the stamp bending during squeeze flow and is able to predict the distribution of the residual resist thickness with an accuracy better than 10%. The software is based on the model in which for the calculation of the deformation, the stamp is represented as semi-infinite region (an elastic medium bounded by a plane).
In [2] a dramatic effect of the stamp thickness on the distribution of the residual resist thickness has been described. The experiments were performed for 4" silicon stamps with thickness of 400 and 1000 μm. On the stamps nine different arrays (gratings with 12 μm period) are placed. They are comprised of different areas (1×1 mm^2, 2×2 mm^2 and 4×4 mm^2) and different fill factors (0.25, 0.5 and 0.75). The stamps were imprinted on 300 nm thick of mr-I7030.
Here refined coarse-grain software is tested. This version of the software takes into account the composition and elastic properties of the imprint setup (the stamp + a "pressure buffer layer").
Below it is shown that for the 1000 μm stamp the experimental and simulated results agree very closely. Slightly worse agreement is observed for the 400 μm stamp. The reason is the lack of information about the exact elastic properties of the "pressure buffer layer".

[1] V. Sirotkin, A. Svintsov, S. Zaitsev, H. Schift, J.Vac.Sci.Technol. B **25**, 2379 (2007).
[2] S. Merino, A. Retolaza, A. Juarros, H. Schift, Microelectron. Eng. (submitted).

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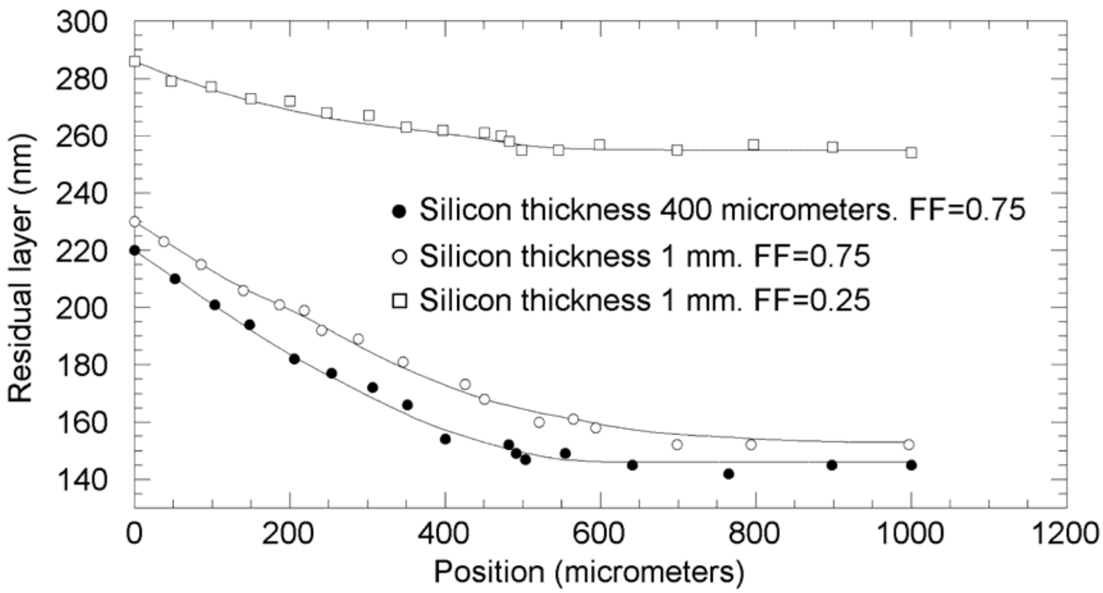

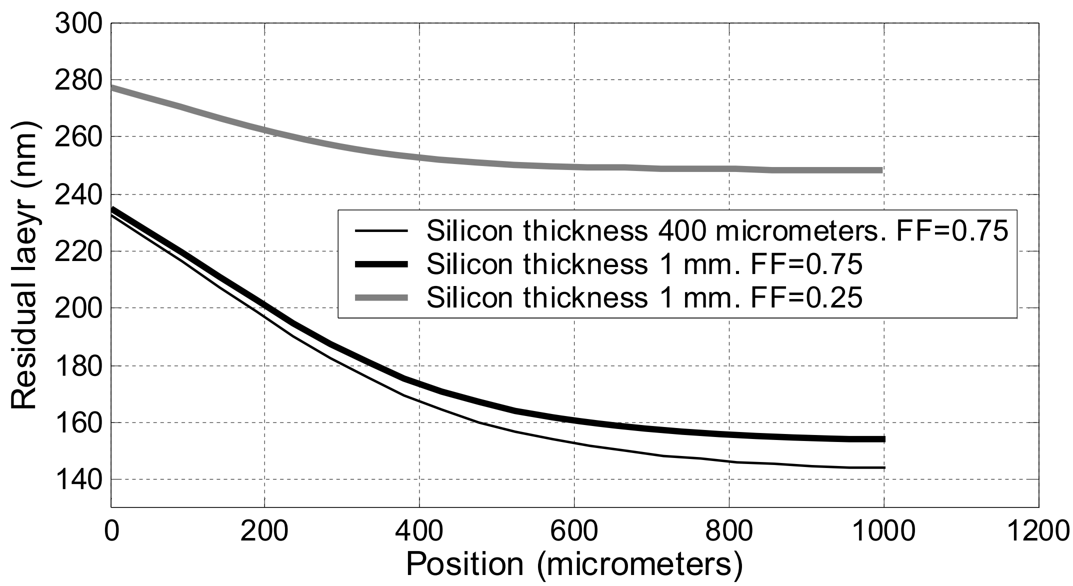

Figs: Measured (top figure) and simulated (bottom figure) values of residual layer thickness for a 2×2 mm^2 array size imprinted from different silicon stamp thickness for FF=0.25 and 0.75. The position 0 shows the edge of the grating.

Experiment and simulation parameters: the stamp cavities depth – 170 nm, the initial resist thickness – 300 nm, the imprint temperature – 140°C (the resist dynamic viscosity – 5×10^3 Pa·s), the duration of the imprinting process – 1200 s.