# Coarse-grain simulation of resist flow in SFIL

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Pattern transfer in “step and flash” (SF) imprint lithography (IL) is largely dependent on the distribution of droplets. In relatively simple cases, to achieve uniform filled areas and a homogeneous residual layer thickness it is suggested to dispense droplets of different sizes depending on local filling factor of imprinted stamps. However, the strictly optimal dispensing should be designed using viscous flow simulation for the detailed analysis of resist spreading. For real complex stamps, the viscous flow simulation based on the solution of Navier-Stokes equations requires unreasonable large computational costs. Here a coarse-grain approach is presented, which makes it possible to simulate SFIL process adequately even using Personal Computers.

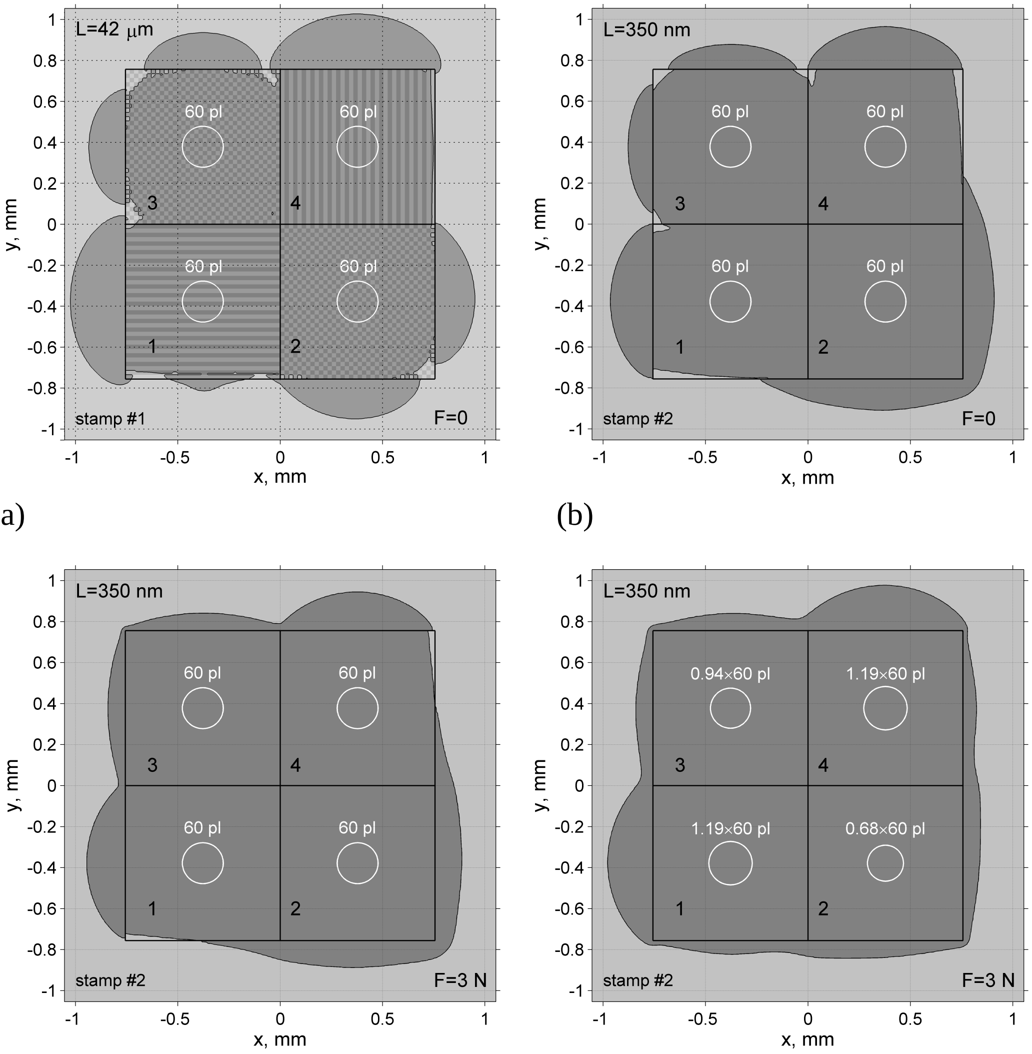
In [1], a mathematical model for the calculation of the viscous resist flow in thermal IL has been detailed described. The model is derived from 3D Navier-Stokes equations with the understanding that the resist motion is largely directed along the substrate surface and characterized by ultra-low values of the Reynolds number. By the numerical approximation of the model, a special finite difference method is applied (the coarse-grain method). The method provides a high precision of simulation results by using a reasonably coarse grid. Results published in [1, 2] indicate that the coarse-grain modeling allows predicting the residual layer thickness in thermal IL with accuracy better than 10%.

For the simulation of the resist flow in SFIL, the model from [1] has been supplemented with the ability to compute resist-air interface motion caused by the surface tension. A coarse-grain modeling tool for SFIL has been developed.

Here the application of the modeling tool is demonstrated with simple test stamps. The stamps contain pattern of 2×2 cells with chequerwise and streaky alternations of protrusions and cavities (see Fig. 1 (a)). The filling factor for all the cells is equal to ½. But the design features of the cells have a dramatic effect on drops spreading. By using four equal drops placed at the centre of the cells, it is almost impossible to provide complete filling of all cells (see Figs. 1 (a-c)). The modeling tool enables one to obtain the optimal dispensing by further drop volumes fitting (see Fig. 1 (d)).

[1] V. Sirotkin, A. Svintsov, S. Zaitsev, H. Schift, J.Vac.Sci.Technol. B25, 2379 (2007).

[2] N. Kehagias, V. Reboud, C. M. Sotomayor Torres, V. Sirotkin, A. Svintsov, S. Zaitsev, Microelectron. Eng. 85, 846 (2008).



(a) (b)

(c) (d)

*Fig 1:* Simulated resist distributions for two test stamps with chequerwise and streaky alternations of protrusions and cavities. The alternation spacing is denoted by L. For the “microscale” stamp the protrusions and cavities are specified by light and dark grey areas, respectively (Fig. 1 (a)). For the “nanoscale” stamp the patterns are not shown (Figs. 1 (b-d)). The cavities depth is 125 nm. The residual layer thickness is 35 nm. The drop volumes are indicated on the figures. The total volume of the drops is equal to 240 pl. The resist dynamic viscosity is $1.5\times10^{-2}$ Pa·s. The surface tension is $2\times10^{-2}$ N/m. In Figs. 1 (a-b) the results are presented for a zero net force on the stamps (F=0), in the case where viscous forces and surface tension forces balance exactly. In two bottom figures the resist distributions are given for the loading force F=3 N.