Optimization of droplet volume for UV-NIL

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A homogeneous residual layer thickness in nanoimprint lithography (NIL) is a serious problem in both thermal NIL and in step and flash (UV-)NIL. Improvement of thickness homogeneity could be expected from optimized size of droplets at resist dispensing in case of UV-NIL. The optimization in droplet size must exclude the stamp geometry involving areas in which the resist has to flow laterally over large distances so stamp geometry should be considered at optimization. Also the optimization should consider process of resist wetting and spreading at imprint analyzing resist viscous flow. The report is devoted to development of an optimizing algorithm, which take into account only filling factor (geometry) of a stamp and does not consider the following resist flow.

Several alternatives could be adopted as jet work model. Two extreme models of jet dispensing are of main interest here: a “continuous” model when the jet is able to provide a drop with infinitesimal accuracy and “discreet” model when final drop consists of several droplets of some minimal volume. Other jet models like “threshold” model or “nonlinear in time” model can be easy incorporated in the approach.

In current realization of the approach a specially developed algorithm transfers stamp geometry defined in standard GDSII (or ACAD) format into rectangular (square) cells and calculates the filling factors taking into consideration stamp depth and desirable residual resist thickness. Then depending of the jet model continuous or discreet volume is calculated and saved for further use by control system of a UV-NIL machine.

Fig.1 shows geometry of a binary stamp as downloaded from GDSII format where black area corresponds to protrusions in imprinted structure. Fig.2 illustrates work of the algorithm where 24x24 cells covering the whole test structure are indicated with different gray ton corresponding to calculated filling factor. Cell filling factor is schematically illustrated one more time in Fig.3 in form of 3D presentation,. In reality dispensed resist has a shape of spherical segment diameter of which is dependent on wetting angle.

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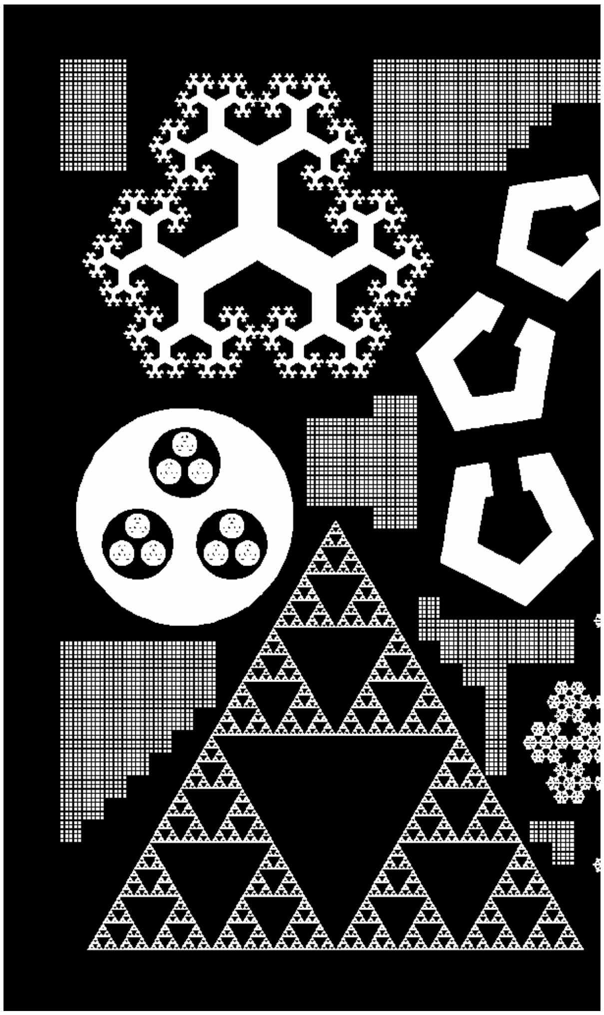

Fig.1 Original binary stamp loaded in GDSII format, black areas correspond to protrusions after imprint

Fig.2 Division into 24x24 square cells (of ~0.5mm) and calculation of filling factor represented in gray scale for each cell.

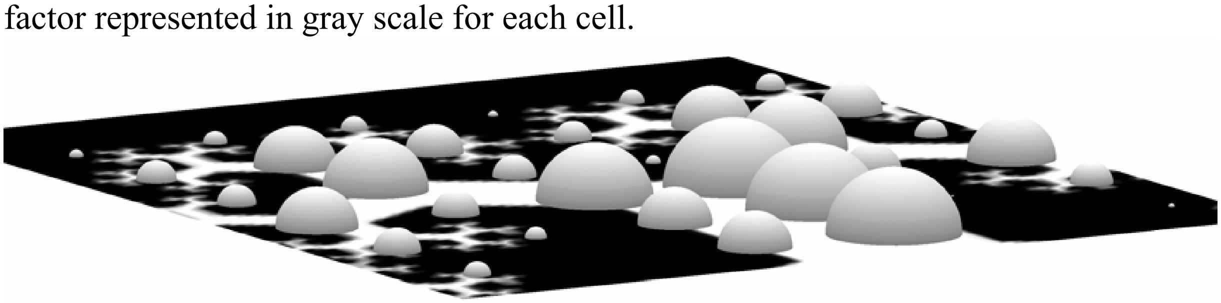

Fig.3 Schematic 3D presentation of optimal resist volume should be dispensed in an each cell (within square area marked in Fig.2). Each droplet comprises a spherical segment corresponding to wetting angle about 90^{0}. Diameter is calculated in "continuous" model.