# Process Simulator for UV-Nanoimprint Lithography

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## 1. Introduction

UV-Nanoimprint Lithography[1)] (NIL) is promising for fine pattern lithography. There consists of several sequential processes and there exist s each process physics. Not only detail investigations of each process but also estimation of final resist profile is indispensable for defect analysis, material design and process optimization. We have been simulated each processes in UV-NIL. In this paper, we propose the total process simulation system for UV-NIL and demonstrate resist profile simulation.

## 2. Simulation system and Numerical Model

Figure 1 shows schematic diagram of the system. First, the resist filling process is analyzed by solving resist flow to investigate bubble traps by solving Nervier-Stokes equation and the continuous equation for in-compressive fluid[1)] and obtain resist profile after temperate pressing to the resist. Next, optical intensity profile in the resist is calculated in UV exposure process by solving Maxwell equation for incident UV light[2)].

Then, the resist shrinkage and modulus modification by resist curing caused by UV exposure is simulated. At present, the chemical reaction such as conversion of the resin is out of consideration. Figure 2 shows typical mechanical characteristics of a UV resist. As the exposure time proceeds, the modulus G of the resist increases by conversion of the photo reactive group and the resist thickness h decreases due to resist shrinkage by UV curing. Modulation of the modulus G is experimentally defined by table data based on experiments. Linear expansion coefficient $\alpha$ is also derived from the experimental data as $\alpha(t) = \partial h / \partial t$, where $h, t$ are resist thickness and exposure time, respectively. The resist profile is simulated in mechanically under variable modules G and the expansion coefficient $\gamma$, using finite element method (FEM). Figure 3 demonstrates resist profiles after UV cure for various resist shrinkage ratio, which is related with UV-exposure dosages.

The simulator will give us inspection of final resist profiles and critical dimensions for various process conditions and material properties.

## References

[1] M. Colburn, et al., Proc. of SPIE **3676** (1999) 378.
[2] D .Morihara, et al., Microelectronic Eng., **86** (2009) 684.
[3] Y. Hirai, et al., J.Vac. Sci. Technol. B, **21** (2003) 2777.

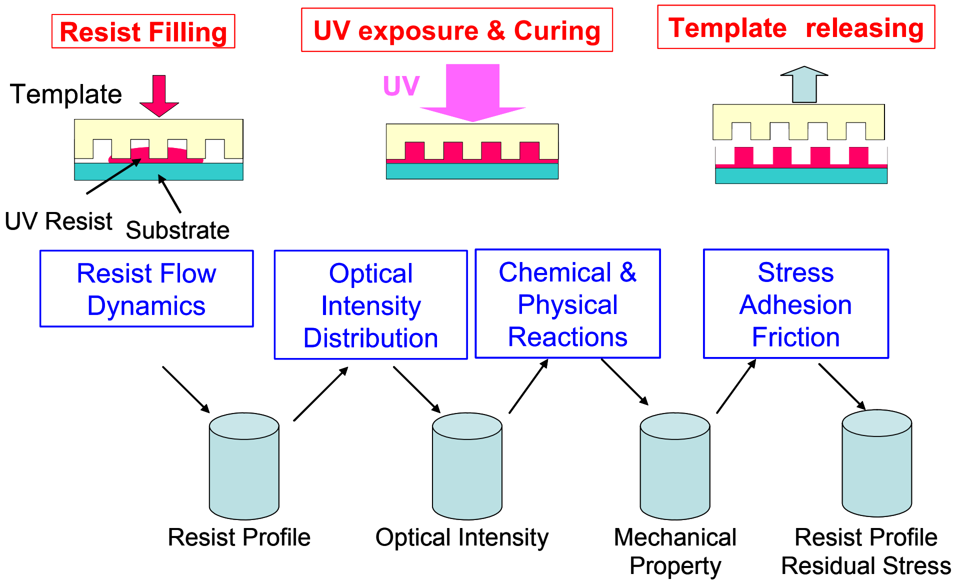


Fig.1 Schematic diagram of the process simulator for UV-NIL.

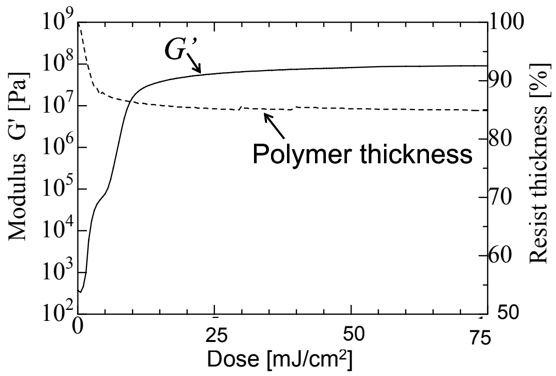


Fig. 2. Mechanical modification of typical UV-resin.
The UV shrinkage is estimated by optical intensity profile and resist mechanical properties

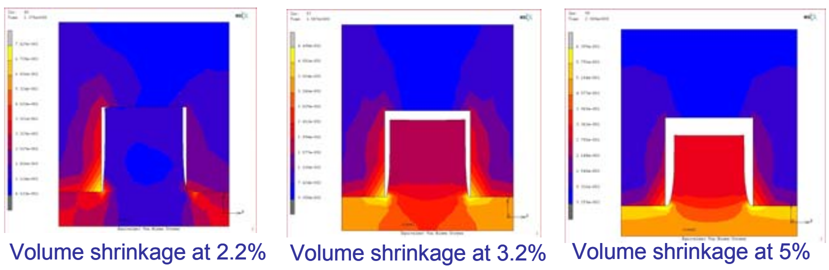


Fig.3. Demonstration of resist profiles in various resist shrinkage (UV-dosage).