Shrinkage Pattern Correction (SPC) in Nanoimprint Lithography

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Introduction

For fine pattern transfer in conventional lithography, pattern correction such as OPC (Optical Proximity Effect Corrections) is commonly used to compensate optical diffractions.

On the other hand, thermal and UV curing shrinkage are unavoidable problem in nanoimprint lithography (NIL) , which induces critical dimension errors. Some experimental reports on pattern width modifications have been reported[1-4] due to shrinkages in UV NIL. To eliminate the critical dimension errors, pattern size correction in mold is one of the most promising method to compensate the resist shrinkages.

In this paper, we estimate the critical dimension errors based on simulation study and proposes estimation functions for the shrunken pattern width after NIL. Using the estimation functions, mold pattern size is corrected illustrated in Fig.1.

Estimation function of critical dimension error

The pattern width after shrinkage is simulated using numerical simulation system[5] by FiniteElement Method (FEM) as plotted by the triangles in Fig.2. In NIL process, the resist is coated on substrate and the shrinkage is restricted due to adhesion between resist and substrate. As a result, the critical dimension error is relaxed in wider patterns. To express the pattern width shrinkage, we adopt filtering function in space frequency $p(w)$ as follows;

$$p(w) = \frac{k}{1+\left(w/w_0\right)^n} \cdot \alpha \qquad 1),$$

where α , w I, w_0 , n, and k are linear expansion coefficient, line width, cutoff length, fitting order, and fitting coefficient, respectively. The shrunken line width w' is expressed using $p(w)$ as:

$$w' = w(1 - p(w)) \qquad 2).$$

The parameters are fitted to the estimated shrunken pattern width obtained by the simulation and the estimated line width after shrinkage is shown in solid line in Fig.2, which successfully estimates the shrunken line width w' .

Verification of the shrinkage pattern correction

Based on the estimation function, mold pattern correction is performed as:

$$w_c = w/(1 - p(w)) \qquad 3),$$

where w_c is corrected pattern width in the mold. Solid line in Fig.3 shows corrected line width for the mold pattern and triangles show simulated line width by the shrinkage pattern correction. The effects of the shrinkage pattern correction are well verified.

We are approaching to 3-dimentional pattern corrections such as hole and novel rectangular patterns. We believe the SPC system will be indispensable for fine and precious patterning in advanced nanoimprint lithography.

References.

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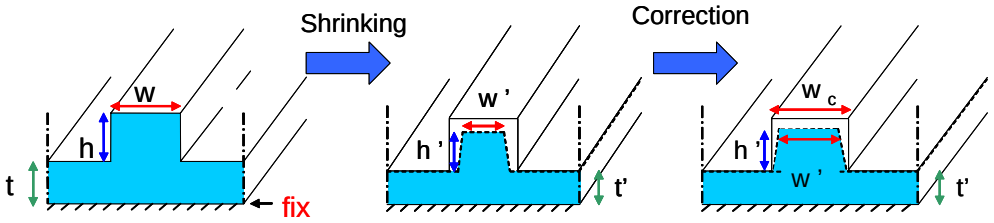

Figure 1. Schematic of the resist shrinkage and pattern correction.

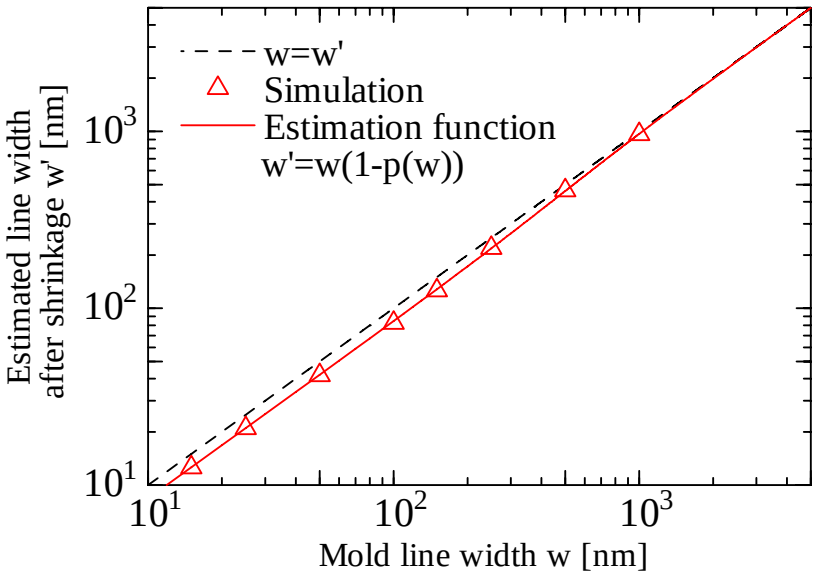

Figure 2. Estimated line width after shrinkage by estimation function p(w).
(w_0=500nm, n=2, k=1.6, α =10%, h=50nm, t=25nm)

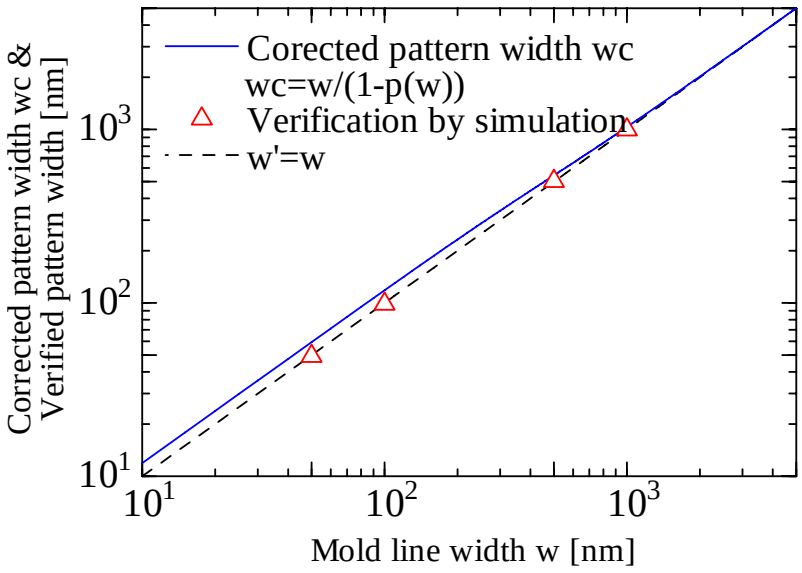

Figure 3. Pattern correction and verification.