Impact of exposure doses on de-molding process in UV-NIL

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1. Introduction

De-molding process in nanoimprint lithography (NIL) is essential not only for cost-efficiency. There have been published several reports on the de-molding issues such as de-molding force measurement[1-3].

In this paper, we newly report on experimental evaluation of de-molding force in UV nanoimprint lithography dependent on exposure dosages of UV exposure.

2. Experiment and discussion

The de-molding forces are measured in UV NIL process for various UV exposure dosages. In the experiments, the anti-sticking layer is deteriorated where the surface energy of the mold is increased to be around 35mJ/m^2 by UV-Ozone irradiation [3], because the mold is easily detached without de-molding force.

Figure 1 shows schematic diagram of the experimental system. We used a flat Si mold and a quartz substrate. Resist is UV curable polymer PAK01(Toyo Gosei) and UV is irradiated through the quartz substrate. The de-molding force (adhesive force between the mold and the resist) for various exposure dosages is measured[4].

Figure 2 shows the dependence of polymerization rate of the UV curable resist and the modulus of elasticity of PAK01 on exposure dosages. The elastic modulus of the resist is stabilized around 10mJ/cm^2 however the polymerization rate is saturated over 30mJ/cm^2. From those results, 10 mJ/cm^2 is though to be enough to hard the resin for nanoimprint usages.

Figure 3 shows the measurement results of the de-molding forces in for various exposure dosages. Below 30 mJ/cm^2, the de-molding forces are unstable, however de-molding force is stabilized over around 50 mJ/cm^2. This is because the resist is not stable in mechanically under lower polymerization rate even if the elastic modulus is stable.

Figure 4 shows experimental results of UV NIL for various dosages. Under uncompleted curing condition (25 mJ/cm^2), the resist is pealed from the substrate and the de-molding failure occurs, which is consistent to the above investigation results.

3. Conclusions

Elastic modulus, polymerization rate and de-molding force for UV curable resin are evaluated in various exposure dosages. We have been demonstrated that under lower polymerization rate, the de-moding process is not stable even if elastic modulus is stabilized by UV curing.

Those investigations give essential criteria for optimization for UV NIL process and materials in high throughput processes.

Acknowledgement
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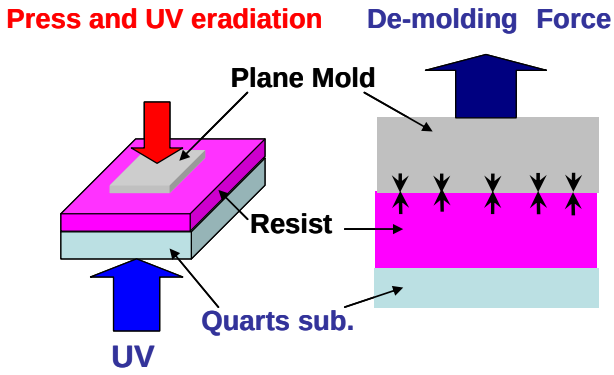


Fig.1. Schematic diagram of the experiment of UV NIL

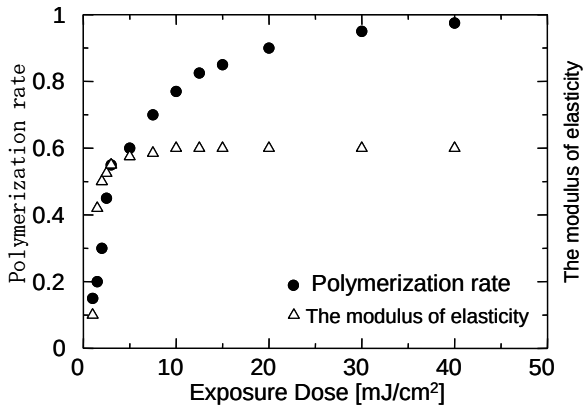


Fig.2. Dependence of Polymerization rate and the elastic modulus of UV curable resin (PAK01) on various exposure dosages.

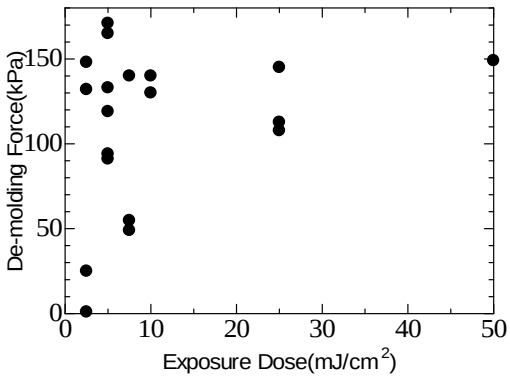
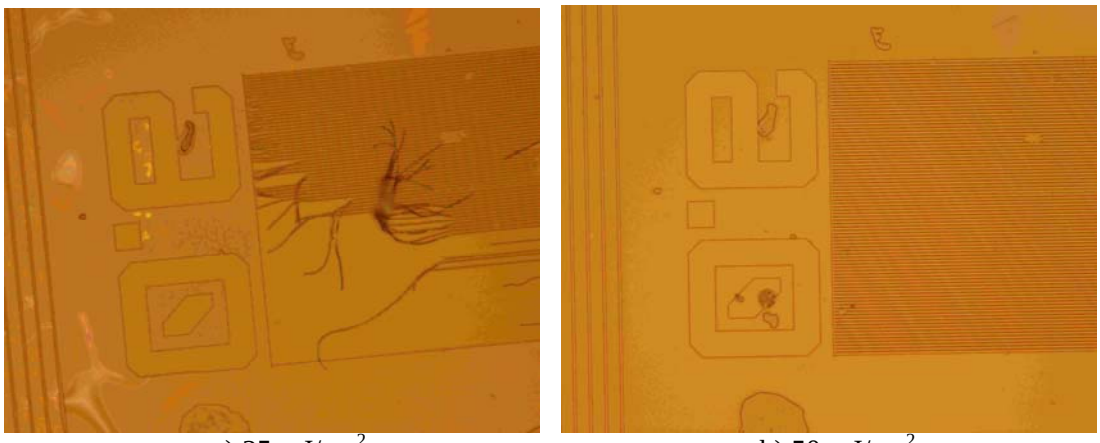


Fig.3. De-molding force using plane Si mold for various UV exposure dose.
(The surface energy of the mold is around 35mJ/m^2, which is equivalent to be 70 degree in contact angle for water droplet).



a) 25 mJ/cm^2 b) 50 mJ/cm^2

Fig.4. Nanoimprint results for various exposure dosages
(The surface of the mold is degraded by Ozone exposure before NIL process, 600nm in line width)

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