Effect of Elastic Modulus of UV Cured Resist on Demolding Force

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One of the issues for UV nanoimprint lithography (UV-NIL) is the defect generation in demolding process. If resists strongly adhere to the mold surface, the resist sticks on the mold surface. This causes the defect of patterns on substrates. Adhesive strength of the UV cured resist to mold depends on the interaction force between mold surface and cured resist surface. Some papers on viscoelasticity of UV cured resists and demolding force have been published.[1-3] In this paper we report the effect of elastic modulus of UV cured resist on the demolding force measured by an in-situ process.

Several UV resists including PAK-01 (Toyo Gosei) were used. Dynamic modulus of the UV cured resists and release force were measured using a rheometer (Anton Paar MCR 301) equipped with xenon flash lamp (40W, Hamamatsu LF1). UV exposure was done without a filter at 25 ^{o}C. The quartz surface was conventionally treated with Optool DSX. Figure 1 shows schematic measuring systems for (a) dynamic modulus and stress of UV curable resist and (b) release force and strain of cured resist. In this study UV curing of the resist, stress of the cured resist due to shrinking, and demolding force were measured by an in-situ process.

Storage modulus (G') measured by an oscillating mode (frequency 5Hz and distortion 1%) using a parallel-plate configuration increased with UV exposure dose. Since the G' values gradually increased after exposure due to the subsequent dark reactions of the resists, the final G' values were evaluated after the dark reactions for a given time. A normal force (NF) change profile for the UV curing and demolding process is shown in Fig. 2. The NF value decreased with UV irradiation time and reached a constant value. This is due to the shrinking of the resist. The demolding force (release force) was determined as the maximum tensile stress where the separation occurred at the interface between the quartz plate surface and cured resist layer. The strain of the cured resist at the release point was 8~60%, depending on the G' value of the cured resist and on the type of resist. Figure 3 shows the relationship between release force and storage modulus of UV cured resist. Although, in the case of the quartz plate with plain surface, the release force decreased with G' value, the release force increased with G' value in the case of the quartz plate with L/S patterned surface. This finding suggests that the demolding force can be reduced by changing the G' values of cured resists.

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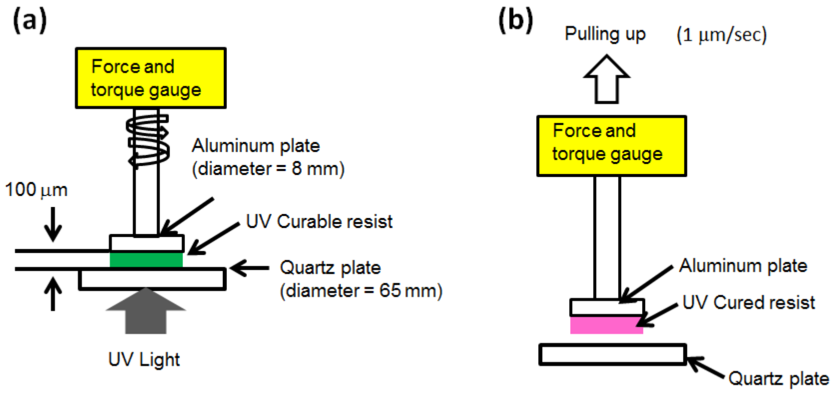

Figure 1. Schematic measuring systems for (a) dynamic modulus and stress of UV curable resist and (b) release force and strain of cured resist.

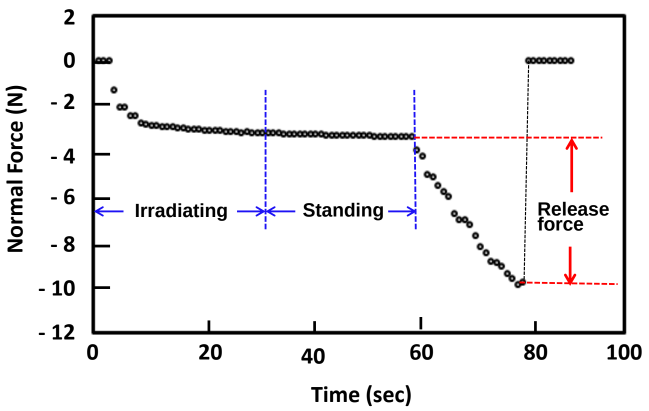

Figure 2. Normal force (NF) change profile for UV curing and demolding process. Resist: PAK-01 (100 μm thick).

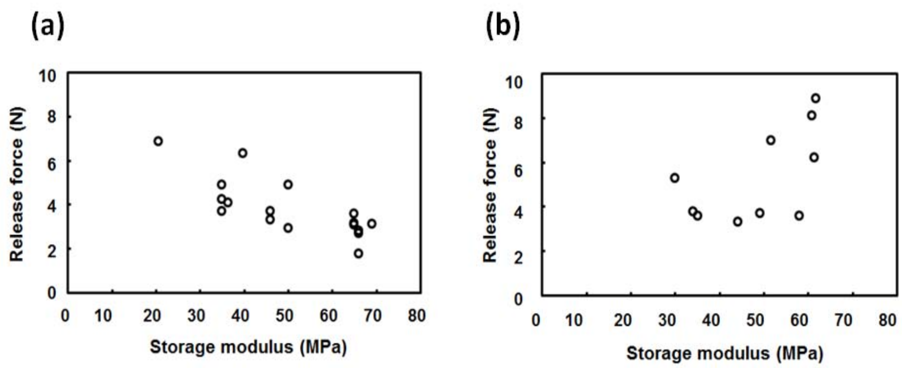

Figure 3. Relationship between release force and storage modulus of UV cured resist. Mold: (a) quartz plate with plain surface and (b) quartz plate with patterned surface (L/S=6/2 μm, line height=1.2 μm). Resist: PAK-01 (100 μm thick).