Abrasion Test for Antisticking layer by Scanning Probe Microscopy

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Nanoimprint lithography (NIL) [1] is a useful technique for high throughput patterning of polymer nanostructures at high precision and low costs. The nanoimprint molds are in direct contact with the replication materials. Therefore, the molds are usually coated with an antisticking layer (ASL) to prevent the adhesion of replication materials and also to allow easy separation of the mold from the replication material. However, the ASL deteriorates with repeated nanoimprinting. In demolding process, the friction is occurred between the ASL and replication material, as shown in Fig. 1(a). We assumed that this mechanical friction is one of the causes for deterioration of the ASL.

Scanning probe microscopy (SPM) is a useful measurement to evaluate nanometer-scale adhesion and frictional forces. Previously, we reported the evaluation of them for the thin polydimethylsiloxane (PDMS) layer employing SPM [2]. This time, we evaluated the abrasion of ASL by contact mode-SPM because the cantilever is in direct contact with the ASL surface at contact mode-SPM. Figure 1(b) shows the experimental process diagram. In this experiment, we used the cantilever with attached SiO_2 glass microparticle. First, the ASL is rubbed with SiO_2 glass microparticle by contact mode-SPM. Then, we measured the adhesion and frictional forces on the rubbed surface by SPM. If the deterioration of ASL is due to friction between the ASL and SiO_2 glass microparticle, the adhesion and frictional forces are different before and after contact mode-SPM.

We formed a fluorinated self-assembled monolayer on SiO_2/Si substrate using (tridecafluoro-1,1,2,2-tetrahydrooctyl)trimethoxysilane (FAS-13) by dip-coating process. The SiO_2 glass microparticle diameter was 1 μm. We continued rubbing on 2.5 μm × 2.5 μm area by contact mode-SPM for 138 h. The contact force was about 300 nN. Figure 2(a) and (b) show the relationship between the (a) adhesion and (b)frictional forces, and rubbing time. At first, the adhesion force increased with increase in rubbing time. However, the adhesion force decreased after about 50 h. On the other hand, the frictional force decreased with increase in rubbing time from the start. After 138 h, the frictional force drastically increased; it was slightly higher than that before rubbing. After rubbing, we observed the rubbed area by frictional force microscopy, as shown in Fig. 3. We are able to recognize the rubbed area and the frictional force was slightly different between the rubbed and FAS-13 areas. This results indicate that the surface state of FAS-13 was changed by SPM rubbing.

We will perform the further tests to clean up the abrasion mechanism.

References

[1] S. Y. Chou, et al.: Appl. Phys. Lett., **67** (1995) 3114.

[2] M. Okada, et al.: J. Vac. Sci. Technol B, **29** (2011) 06FC09.

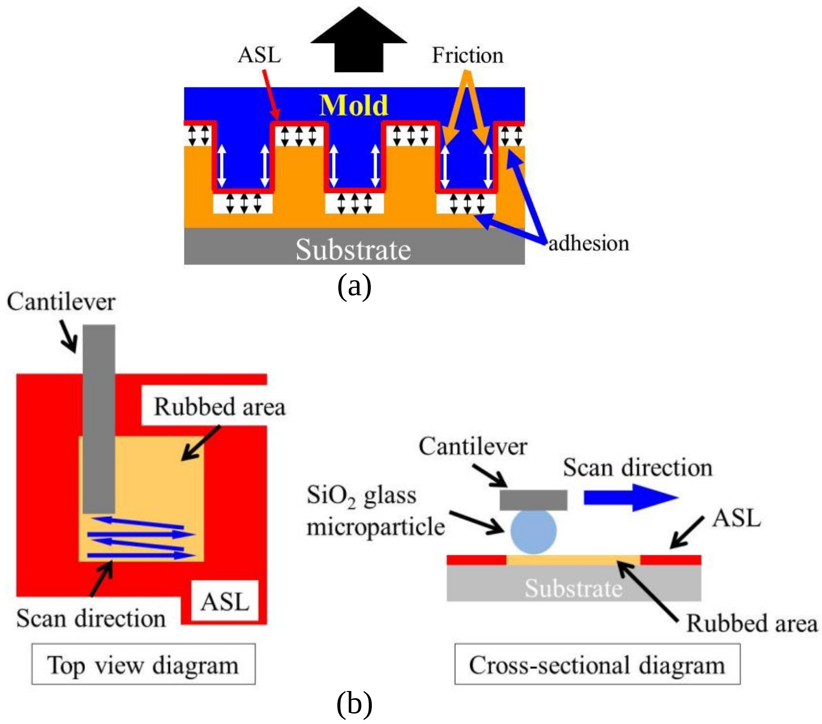

Figure 1. Illustration diagram of (a) demolding and (b) experimental processes.

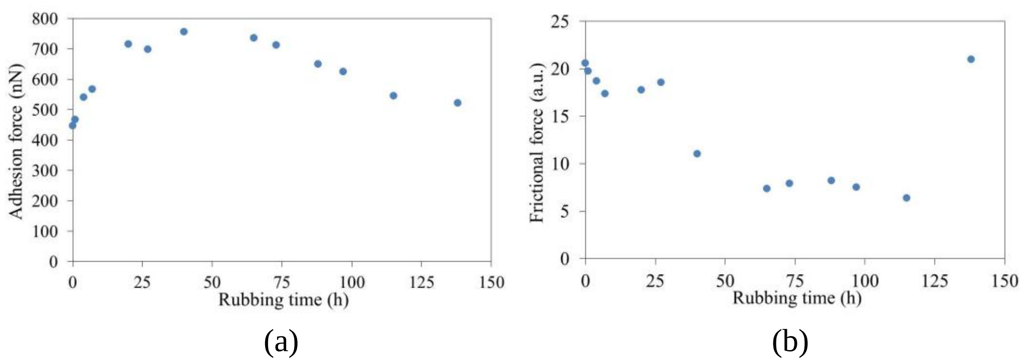

Figure 2. Relationship between (a) adhesion and (b) frictional forces, and rubbing time.

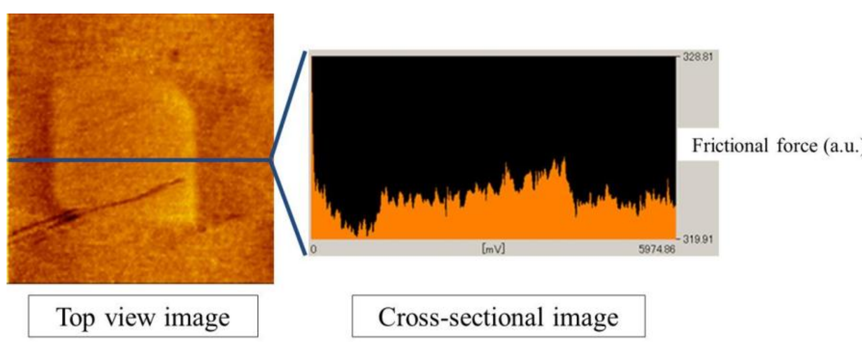

Figure 3.Friction image of FAS-13 after abrasion test by SPM.