Characterization of anti-sticking layers on UV-NIL molds by various scanning probe microscopies

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UV nano-imprint lithography (UV-NIL) is a promising candidate in next generation lithography due to its advantage in through put and cost effectiveness. It is one of key technologies to control mold/resist/substrate interfaces in order to realize the stable UV-NIL processes, because the UV-NIL is just a near-field method different from conventional optical lithography of the far field methods. For instance, fluoro-silanes, which were generally used as anti-sticking layers in the UV-NIL processes, can reduce the surface energy on the molds and thus release them from the resists easily. However, the releasing characteristics have been evaluated so far by macroscopic methods such as contact angle and adhesive force measurements. Recently local adhesive properties of anti-sticking layer were measured as pull-off forces (POFs) by AFM.[1-2] Therefore, we also adopted several types of scanning probe microscopies (SPMs)[3-5] such as frictional force microscopy (FFM) and pulsed-force-mode AFM (PFM-AFM) besides the POF measurments in order to evaluate further detailed characteristics of the surface of the molds microscopically. Not only adhesive forces but also frictional forces and other chemical properties on the mold surfaces can be obtained by these microscopies.

Figure 1 shows (a) measurement principle of local adhesive force measurements by AFM and (b) the measured adhesive forces on the surfaces of quartz and the molds modified with fluoro-silane type anti-sticking layers. The adhesive forces of the mold surfaces covered with fluoro-silane were drastically reduced compared with that of the quartz surface. Next these surfaces were characterized by FFM. Figure 2 shows (a) the principle of FFM and (b) the measured frictional forces on the three different surfaces. Then we measured macroscopic adhesive forces during the UV imprinting process by the apparatus[6] as shown in Fig.3. Trend of adhesive and frictional forces measured by SPMs in Figures 1 and 2 on these surfaces well corresponded with that of the macroscopic adhesive forces in Figure 3. In addition, (i) the measurements of film thicknesses and other physical dimensions of anti-sticking layers on their molecular patterns by AFM and (ii) the study of the resist surfaces after the imprint process using molds with optimized anti-sticking layers will be presented.

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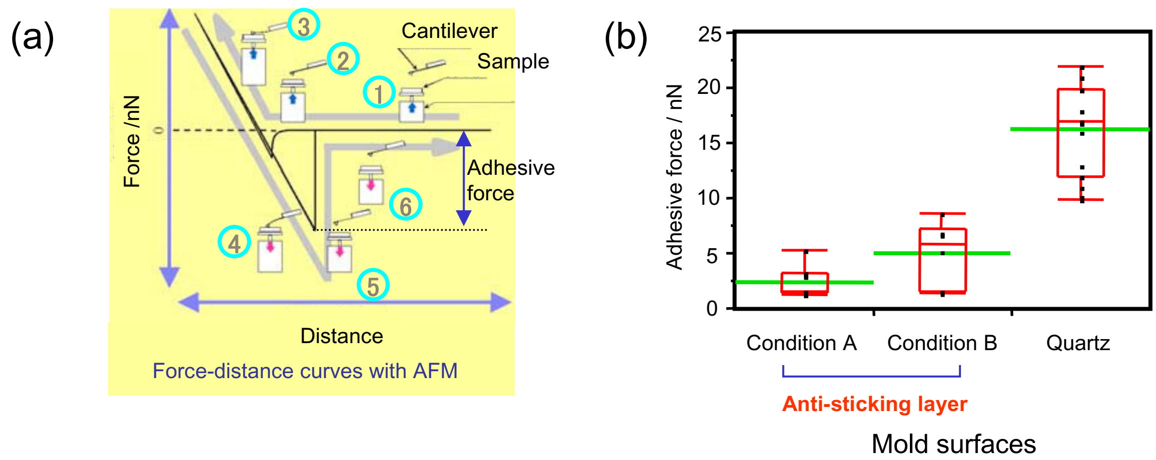
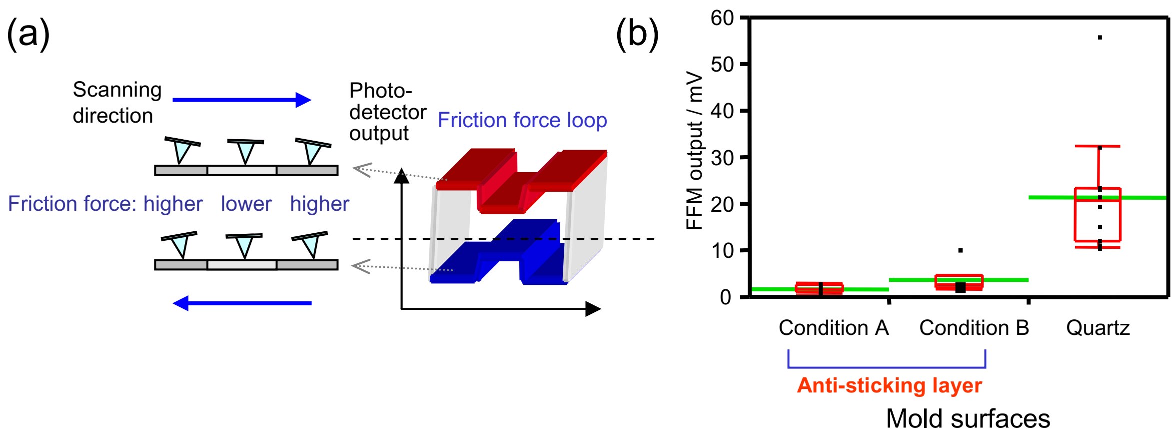
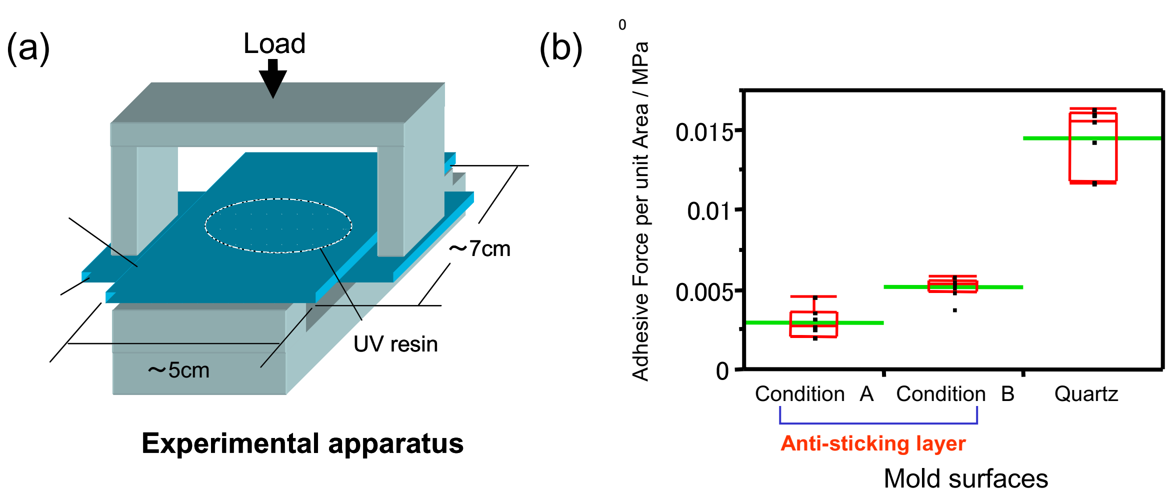


Figures 1 (a): Measurement principle of adhesive forces with AFM and (b): the measured adhesive Forces on the surfaces of quartz and anti-sticking layers consisted of fluoro-silanes



Figures 2 (a): Measurement principle of FFM and (b): the measured frictional forces on the surfaces of quartz and anti-sticking layers consisted of fluoro-silanes



Figures 3 (a): Experimental apparatus for measurement of adhesive forces and (b): the measured microscopic adhesive forces after UV imprinting process