Comparison of surface condition of nanoimprint antisticking layers formed by CVD and dip-coat methods

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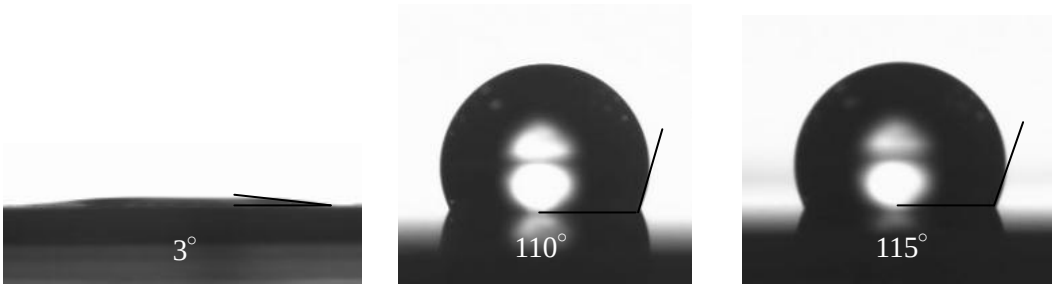
Nanoimprint lithography (NIL) is a very useful technique to fabricate nanostructure devices with low cost and high throughput. In NIL, the antisticking layer on molds is indispensable, because molds are in direct contact with replication materials. The antisticking layer is formed onto the mold surface by chemical vapor deposition (CVD) or dip-coat methods. In this study, we compared the surface condition of anti-sticking layers on silicon substrate formed by CVD method and dip-coat methods.

In both methods, we used a self-assembled monolayer of a silane coupling agent with a fluoropolymer (Daikin Industries OPTOOL HD-1100TH) as an antisticking agent and HD-TH as a rinse agent. A Si substrate was treated by O_2 plasma. In CVD method, the substrate was placed in a vacuum chamber. Then, the chamber was evacuated and the substrate was heated around 180 ^{o}C. Following, the antisticking agent was introduced into the chamber. The deposition time of CVD was about 1 h. Finally, the substrate was cleaned with the rinse agent in an ultra-sonic bath. On the other hand, in the case of dip-coat method, first, a Si substrate was immersed in the solution of antisticking agent for 2 minutes. Following, the mold was placed in a high humidity environment for 1 hour and an ultrasonic clean was carried out in a solution of rinse agent.

To evaluate the releasability of mold coated the antisticking layer, we measured the water contact angles of sample surfaces, as shown in Fig. 1. A bare Si substrate after O_2 plasma treatment showed a hydrophilic surface with a contact angle of less than 3°. The contact angles increased up to about 110° and 115° for the antisticking layers formed by CVD and dip-coat methods, respectively. The result indicates that the antisticking layers formed by CVD and dip-coat method have enough releasability.

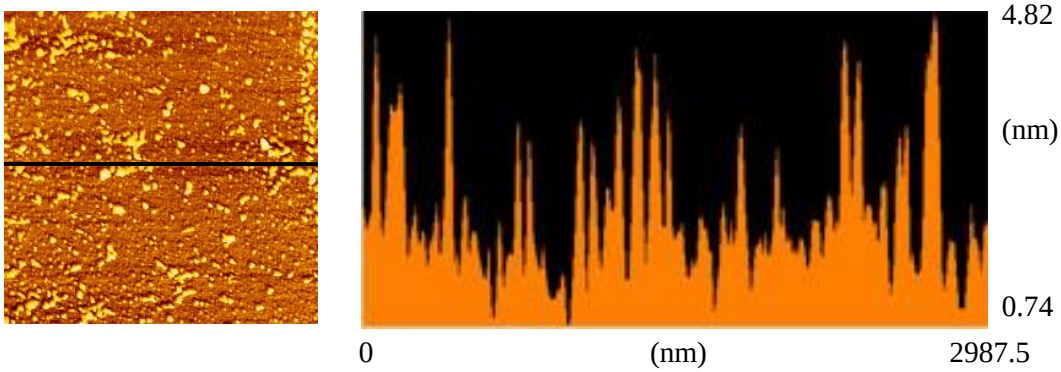
The surface morphology of antisticking layers formed by CVD and dip-coat methods was compared by atomic force microscopy (AFM) observation, as shown in Fig. 2. The surface roughnesses of antisticking layers formed by CVD and dip-coat methods were about 0.35 nm and 0.78 nm at root mean square (RMS), respectively. The surface roughness of the anti-sticking layer formed by CVD method is smaller than that formed by dip-coat method.



(a) Si (b) CVD method (c) dip-coat method

Fig.1 Water contact angles on surfaces of (a) Si, and antisticking layers formed by (b) CVD and (c) dip-coat methods.

(a) CVD method



(b) dip-coat method

Fig.2 AFM images of surfaces of antisticking layers formed by (a) CVD and (b) dip-coat methods.