Adhesive forces of fluorinated silica surfaces affected by surface coverage of tridecafluoro-1,1,2,2-tetrahydrooctyltrimethoxysilane

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UV nanoimprint lithography is considered to be a powerful tool for next generation nanofabrication at high throughput. It is pointed out as one of its issues that a release ability of an antisticking layer formed on a mold surface deteriorates during repeated UV nanoimprinting. We recently revealed that the self-assembled monolayer formed from tridecafluoro-1,1,2,2-tetrahydrooctyltrimethoxysilane (FAS13) on a silica surface by chemical vapor surface modification (CVSM) played a role of stable and small adhesive forces on repeated detachments from a UV-cured resin (Toyo Gosei, PAK-01). Using a fluorescent UV-curable resist [1-2], we showed that a very small amount of resin components were left homogeneously on FAS13-modified silica mold surfaces in comparison with widely used OPTOOL DSX-modified ones [3]. In this study, we investigated relationships of the surface coverage of FAS13 on a silica surface with adhesive forces on repeated resin detachments.

CVSM with FAS13 [3-4] was carried out at 150 ^{o}C. Surface coverages of FAS13 on silica surfaces were tuned by changing a CVSM period. The surface coverages were evaluated according to a Cassie and Baxter equation [5] using contact angles for water. Adhesive forces were measured using an acrylate-type UV-curable resin (Toyo Gosei, C-TGC-02z (Fig. 1)). Step-and-repeat UV nanoimprinting was carried out using a fluorescent UV-curable resist composed of C-TGC-02z [2].

We prepared three kinds of FAS13-adsorbed monolayers showing a contact angle for water of 73^{o}, 87^{o}, and 105^{o}, and the surface coverage of FAS13 on a silica surface (f_{FAS}) was estimated to be 0.46, 0.71, and 0.94, respectively. Figure 2 shows plots of adhesive forces on their repeated detachments from UV-cured C-TGC-02z. The results for FAS13-adsorbed monolayers with f_{FAS} = 0.46, 0.71, and 0.94 were indicated in Fig. 2a – 2c, respectively. The averaged adhesive force and the standard deviation were 36.5 N and 14.9 for f_{FAS} = 0.46, 1.8 N and 0.79 for f_{FAS} = 0.71, and 1.0 N and 0.32 for f_{FAS} = 0.94. It was obvious that low surface coverage caused increasing adhesive forces and enlarged the standard deviation. The contact angle measurement after 100 detachment suggested that the increased adhesive forces were attributed to resin adsorption to FAS13-modified silica surfaces. In the conference, we will discuss quantitative differences in resin adsorption studied by fluorescence intensity emitting from fluorinated mold surfaces during step-and-repeat UV nanoimprinting.

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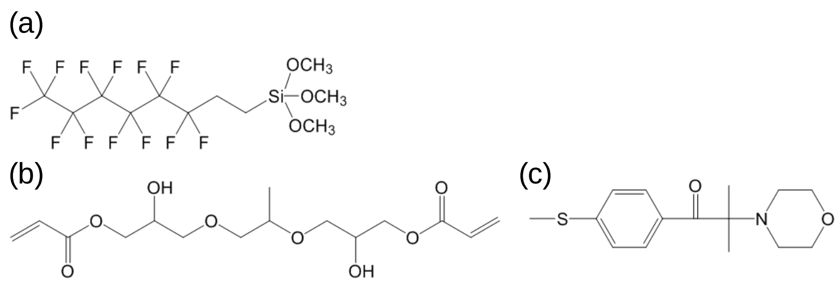

Fig. 1 Chemical structure of (a) an antisticking reagent FAS13 and a UV-curable resin C-TGC-02z composed of (b) a diacrylate monomer and (c) a photo-initiator.

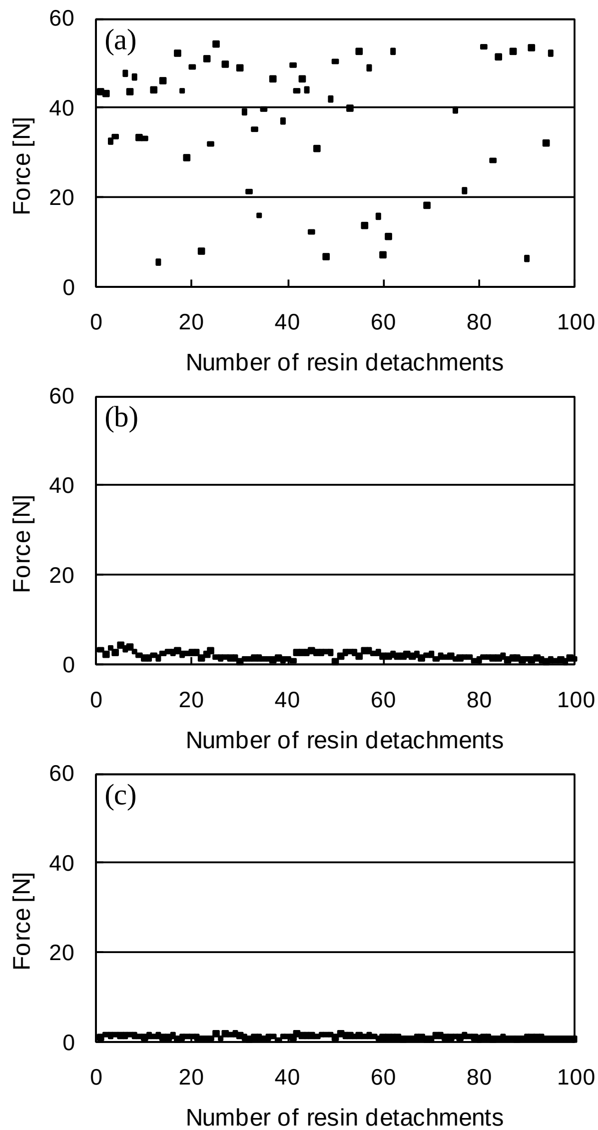

Fig. 2 Adhesive forces on repeated detachment of FAS13-adsorbed silica surface with a FAS13 surface coverage (f_{FAS}) of (a) 0.46, (b) 0.71, and (c) 0.94 from C-TGC-02z resin cured by exposure to UV light. The contact areas were approximately 50 mm^2.