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# Characterization of anti-adhesive self-assembled monolayer for nanoimprint lithography

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ABSTRACT

In nanoimprint lithography process, resist adhesion to the mold was usually self-assembled and a release agent on the mold surface to detach easily from the imprinted resist. In the paper, the commercially available silane, 1*H*,1*H*,2*H*,2*H*-perfluorodecyltrichlorosilane ($CF_3$–$(CF_2)_7$–$(CH_2)_2$–$SiCl_3$ or FDTS) was used to investigate the anti-adhesion for UV-nanoimprint lithography. A water contact angle as high as 113.11 was achieved by self-assembled monolayer (SAM) deposited on the quarter mold by vapor evaporation, which is desirable for a good anti-adhesion agent between the fused silica and the curing resist. The homogeneous monolayer was also evaluated by AFM and XPS. UV-NIL using FDTS-coated fused silica process good pattern transfer fidelity. It is shown that the FDTS is an excellent and promising release agent material for UV-nanoimprint lithography.

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## 1. Introduction

Nanoimprint lithography (NIL) promising high-throughput patterning of microstructure has attracted much attention in comparison with other conventional techniques such as optical lithography, EBL and focused ion beam lithography. Its capability of nanoimprint lithography makes it a very useful technique in many device applications that require precision patterning of large areas with nanoscale structures, including application in photonics, display, molecular electronics and data storage [1]. For example, 1 kbit A crossbar memory circuits at 30 nm half on both top and bottom electrodes were fabricated by UV-NIL technique combined with metal lift off and Langmuir–Blodgett (LB) film deposition [2]. Lee et al. reported the result of fabrication of $Ge_2Sb_2Te_5$-based phase change memory cell device at 60 nm scale by using UV-NIL, which showed on/off resistance ratio up to 3000 [3]. The light extraction of LED can be enhanced greatly by photonic crystal fabricated by NIL [4]. The novel nanoimprint technology would be used intensively for the IC production and related application at the 32 nm node and beyond, and have an enormous prospect in the field of nanofabrication.

In the UV-NIL process, a low viscosity and photocurable resist (for example AMONIL, PAK01) was spin-coated on the substrate, and a transparent rigid or flexible mold is applied on the photocurable resist and then cured by the desired pressure and UV exposure. The NIL patterns could be obtained after the separation of the mold and UV-curable resin. However, the features precision of resists would be maintained during the demolding. Usually, the mold should be modified in virtue of self-assembled monolayer (SAM) of a fluorinated silane release agent or other methods. A low surface energy monolayer on mold surface not only helps to enhance nanoimprint qualities, but significantly increase the mold lifetime

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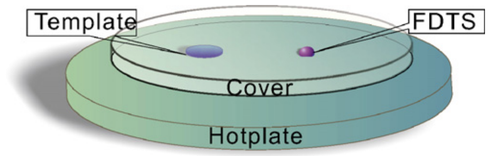


**Fig. 1.** Schematic of self-assembled monolayer on mold.

by preventing surface contamination. Jaszewski et al. used plasma polymerized $CF_4/H_2$ microwave discharge or ion sputtering from $CHF_3$ plasma to form anti-adhesive PTFE-like films for the replication of microstructures [5]. More recently, the researchers from IBM research center indicated that an ion-beam deposited diamond-like carbon (DLC) coating is a useful alternative for fluorosilane layers. Although the DLC layer has higher surface energy, it is possessed of stability in reactive environment and lower adhesion [6,7]. Among these reported papers, many researchers used a commercially available $F_{13}$-OTCS (tridecafluoro-1,1,2,2-tetrahydrooctyl trichlorosilane) or octadecyltrimethoxysilane (OTMS) to deposite anti-adhesive coating on the surface of $SiO_2$ or Si stamp [8–12]. It was also reported that solution phase-based release agent cannot replicate faithfully with sub-100 nm pitch features [13] and vapor phase-based anti-adhesion is appealing for modification of the imprint mold.

In the paper, a SAM of 1*H*,1*H*,2*H*,2*H*-perfluorodecyltrichlorosilane (FDTS) is deposited by vapor phase instead of liquid phase. The SAM on the fused silica mold was characterized by X-ray photoelectron spectroscopy (XPS), atomic force microscope (AFM) and contact angle. The imprinted patterns were fabricated by UV-NIL with a silica mold-coated monolayer of FDTS, and their patterns were analyzed and characterized.

## 2. Experimental

The schematic of vapor phase deposition was presented in Fig. 1. Before vapor deposition, the fused silica was first soaked in a piranha solution at 90 °C for 30 min and thoroughly rinsed with deionized (DI) water and dried with $N_2$. The glove box was flushed with $N_2$ after the mold and FDTS was put in. After it being fully with $N_2$ (ca 2 h), a drop of FDTS is syringed on the Petri dish and the coating is placed on the Petri dish. After 3 h, the hotplate is cooled to room temperature and the excess is washed by anhydrous hexane to prevent FDTS polymerization. The as-deposited fused

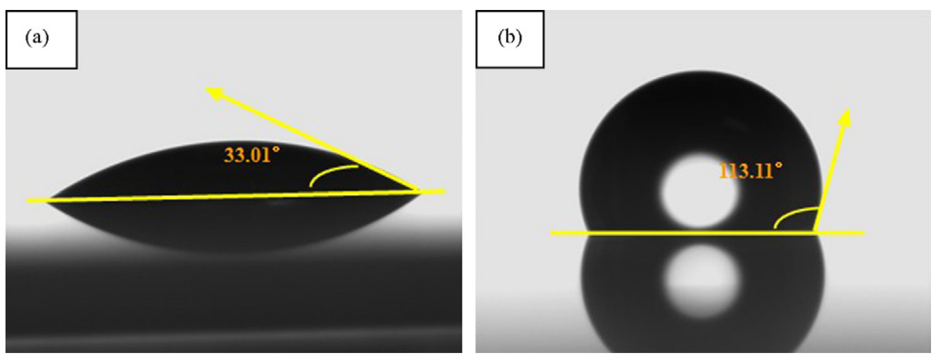


**Fig. 2.** Photos of water droplet on (a) blank mold surface (b) SAM coated mold surface.

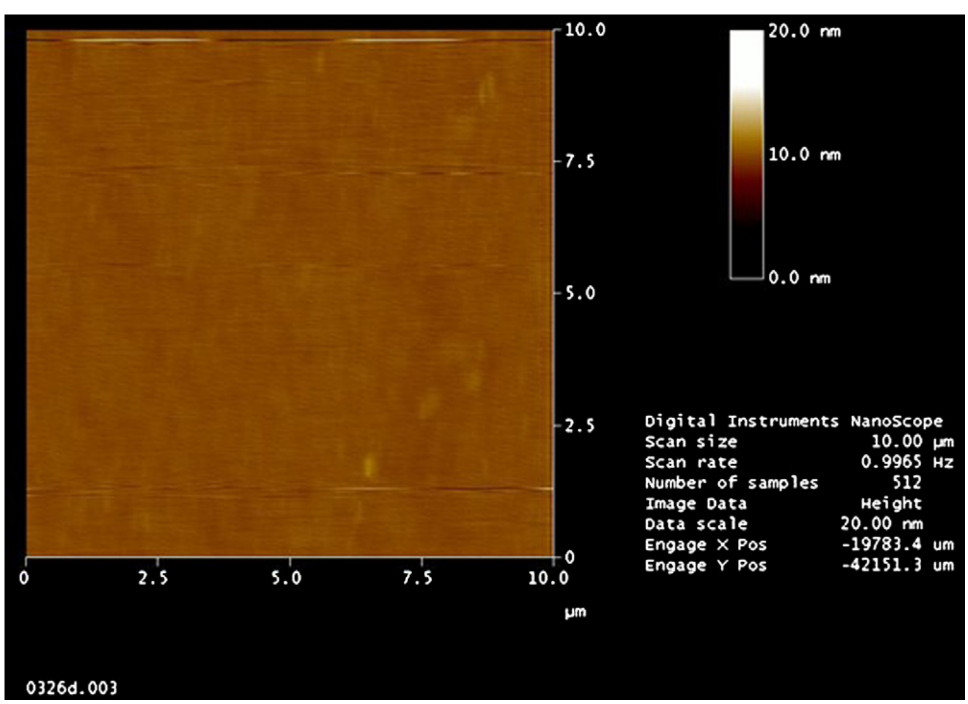


**Fig. 3.** AFM images of the FDTS coated fused Silica surface.

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