PLASMA TREATMENTS ON POLYMER NANOIMPRINT STAMPS

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Nickel or silicon stamps with an anti-adhesive coating are the most commonly used for Nanoimprint lithography (NIL) [1]. But the fabrication of these stamps for NIL is time consuming and expensive. Polymer stamps obtained by nanoimprinting could be an inexpensive alternative [2]. Polymers to be used for stamp preparation are required that withstand high temperature and pressure during the imprint process. Thermally or UV curing prepolymers with low Tg are to be used, which can be imprinted at lower temperatures. The polymers to be imprinted tend to adhere to polymer stamps due to their chemical affinity. Surface modification is needed for good release properties. This treatment should not modify the nanopattern or at least the modification should be lower than several nanometers.

A new route using plasma as a means of improving anti-sticking properties of polymer stamps for nanoimprint lithography has been developed. The surfaces and the corresponding anti-sticking properties for the coatings of fluorinated type were investigated using atomic force microscopy, contact angle measurement, X-ray photoelectron spectroscopy, and imprint tests. The surface energies and the friction constants for these modifications are found to be considerably reduced, indicating that an introduction of a C-F interlayer is most effective to achieve a good antiadhesive coating. This is also supported by simultaneous imprint tests with sinusoidal gratings of different aspect ratios, although the treatment is not active above certain temperatures.

RF and microwave (MW) plasma with SF6 or CF4 with Ar as reactive gases are applied to decrease the surface energy characterized by contact angle measurements on thermally and UV curing polymers. Surface roughness and etched depth were obtained by AFM. XPS was used to determine the modified depth as well as the functional groups introduced. Finally, SEM pictures were taken from the plasma-treated stamp patterns and the imprinted layers.

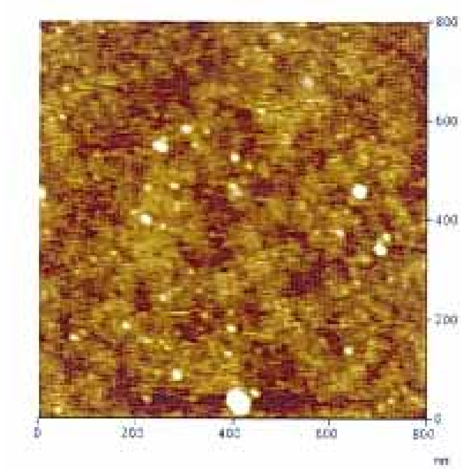
The result of those treatments is a nanolayer (less than 10nm) of Teflon-like on the surface of the polymer. The roughness increase is lower than 6nm or even a decrease could be observed. The chemical groups introduced are CF2 and CF3.

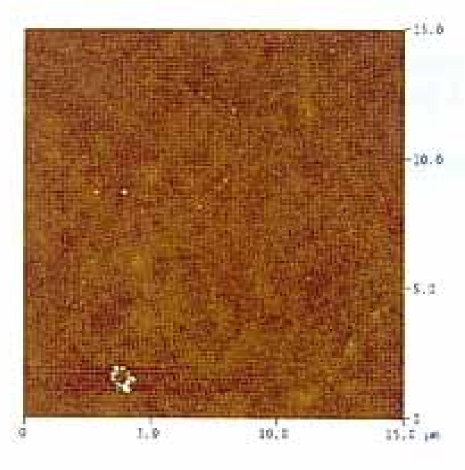
As a result of the experiments carried out we can assure that the modification of the nanopattern can be minimized by using CF4 RF plasma treatments[3]. The functionality of this method has been tested under standard NIL conditions on a standard NIL system and the lifetime of the treatment has been assessed to last longer than 1 month. Anyhow, at temperatures above 140ºC the modification is minimized, thereby there is a limitation on the polymers to be imprinted. We also found difficulties in very high aspect ratio moulds as reported on the poster.

[1] M. Keil, M. Beck, G. Frennenson, E. Theander et al ”Process development and characterization of antisticking layers on nickel based stamps designed for nanoimprint lithography“ J. of Vacuum Science and Tech. B 22 (6) 3283-3287 Nov-Dec 2004
[2] K. Pfeiffer et al “Polymer stamps for nanoimprinting” Microelectronic Engineering 61-62 (200) 393-398
[3] W. Besch, K. Schroder, A. Ohl „Access of plasma polymerization and plasma induced vapor phase grafting processes to high aspect ratio trenches in polymeric nanostructures analyzed by XPS” Plasma Process Polym. (2005), 2, 97-103

BEFORE TREATMENT

AFTER TREATMENT

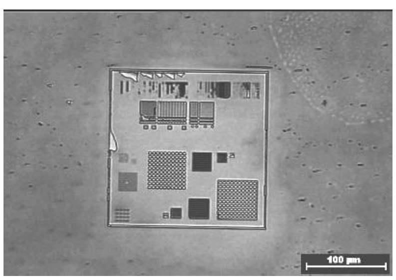


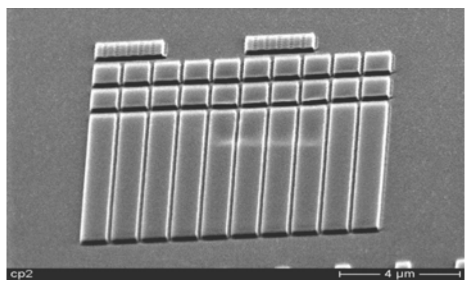


Ra = 0,62nm

Ra = 0,353nm

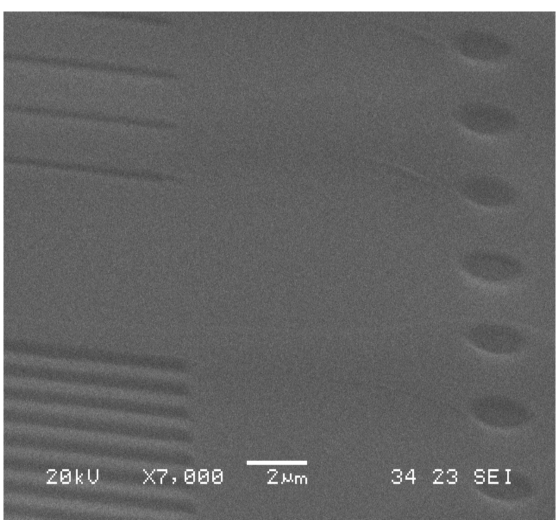
Imprints on mr-I 7000

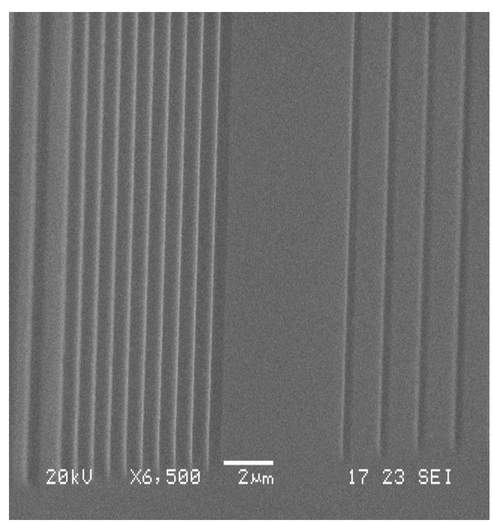




RF plasma treatment

MW plasma treatment





After imprint