

Improved release strategy for UV nanoimprint lithography

S. Garidel, M. Zelsmann*, N. Rochat, P. Michallon, N. Chaix*, P. Voisin*, and J. Boussey*
CEA Leti-MINATEC & LTM-CNRS*, 17 rue des Martyrs, 38054 Grenoble Cedex 9, France

The adhesion between the fused silica mould and the resist is a key issue in UV nanoimprint lithography to ensure a reproducible and defect-free pattern transfer. Antisticking layers (ASL) are generally based on a self assembled monolayer (SAM) of fluorinated chlorosilanes deposited in liquid or in vapour phase¹.

In this paper, we present results on monolayers of Tridecafluoro-1,1,2,2-tetrahydrooctyltrichlorosilane (F₁₃-TCS) deposited in vapour phase and of a commercial product, *Optool DSX*, from *Daikin Chemical*, deposited in liquid phase. Several deposition conditions (deposition pressure and duration, presence of water and number of cycles) are investigated and characterized on fused silica moulds. The structural morphology of the formed SAM is investigated using FTIR-ATR. This technique allows us to determine the orientation angle of the molecules and to estimate the density of the layer. This way, we can define key parameters of the deposition processes².

Surface energies, determined by contact angle measurements, are as low as 11 mN/m for both types of ASL. Nevertheless, AFM roughness measurements (Fig. 1) show better results for the vapour phase deposition (RMS roughness of 0.22 nm) than for the liquid phase deposition (RMS roughness of 2.4 nm).

The stability of this formed layer during NIL processes is the main important issue and is tested on an EVG step and repeat UV nanoimprint equipment using an acrylate-based resist. After only 50 prints, we observe a high increase in the surface energy of the mould (Table 1). First XPS measurements show that fluorine is removed from the mould surface. Detailed XPS experiments are under progress to determine the exact chemical rearrangement. This surface modification is attributed to free radicals created during UV cure of the resist that easily cleaves fluorocarbon chains. Indeed, when using a SiOC inorganic release layer, we observe almost no change in surface energy. This is confirmed by the fact that the polar component of the surface energy is increased by a larger factor than the dispersive one.

We choose to continue working with organic SAM, but with resists containing a fluorine surfactant that migrates towards the mold / resist interface. To characterize the mould / resist interaction, we developed an original setup (Fig. 2) that directly measures the adhesion force. Almost no degradation of the organic ASL is observed in terms of surface energy and fluorine density after more than 50 prints when using a sufficiently high amount of surfactant in the resist.

This work is supported by the MEDEA+ project FANTASTIC.

1. G-Y. Jung and al., *Langmuir*, 21, 2005, p. 1158-1161.
2. S. Garidel and al., to be published, *SPIE Advanced Lithography*, proceedings of SPIE Vol. 6517, Mars 2007.

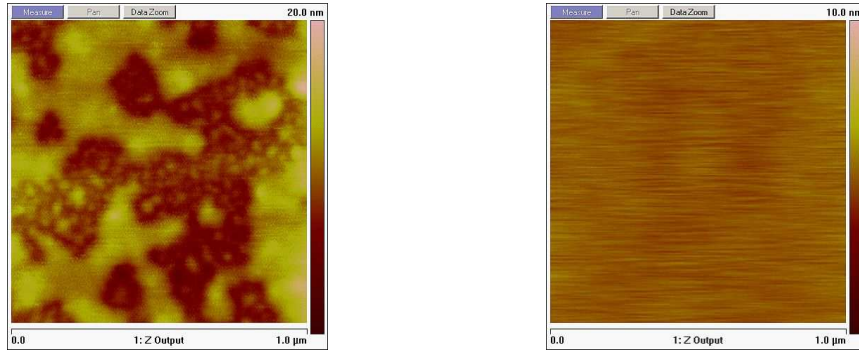


Fig. 1. AFM roughness measurements of our organic anti-sticking layers (left: Optool DSX wet, right: F₁₃-TCS vapour)

	ASL	γ_S (mN/m)	γ_S^d (mN/m)	γ_S^p (mN/m)
Newly treated	Optool DSX wet	10.6	10.5	0.05
	F ₁₃ -TCS vapour	11.2	9.6	1.6
	SiOC	20.7	20.2	0.5
After 50 prints	Optool DSX wet	42.6	37.3	5.3
	F ₁₃ -TCS vapour	40.4	33	7.4
	SiOC	22.4	22.3	0.12

Table 1. Surface energies γ_S (and their dispersive and polar components) for our anti-sticking layers when newly treated and after 50 prints

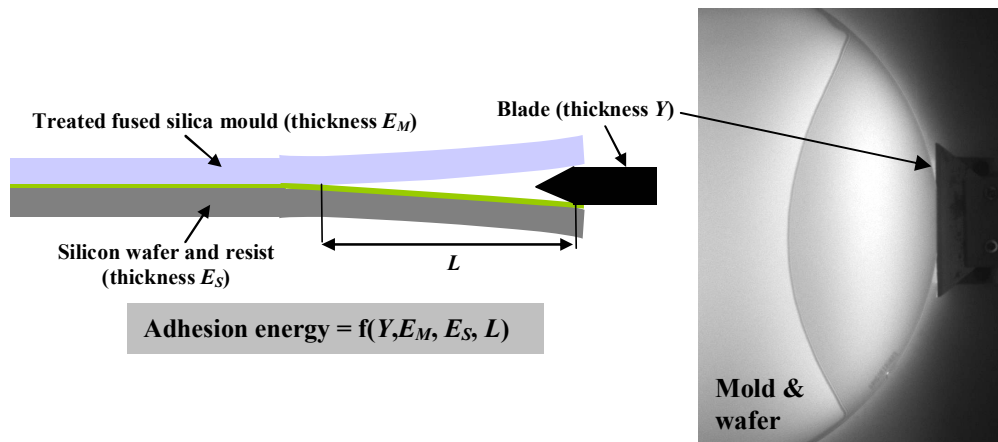


Fig. 2. Adhesion energy measurement setup on 200 mm wafers