Anti-wetting surfaces fabricated by Reverse Nanoimprint Lithography on Silicon and metal-coated substrates

Ariadna Fernández[1], Juan Medina[1], Cristian Benkel[3], Markus Gutteman[3], Brian Bilenberg[4], Theodor Nielsen[4], Clivia Sotomayor Torres[1,2], Nikolaos Kehagias[1]

[1]*Catalan Institute of Nanoscience and Nanotechnology (ICN2), ICN2 Building,*
UAB Campus, 08193 Bellaterra, Barcelona, Spain,
[2] *ICREA, Institució Catalana de Recerca i Estudis Avançats, 08010 Barcelona, Spain*
[3] *Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1*
Building 307, D-76344 Eggenstein-Leopoldshafen, Germany
[4]*NIL Technology ApS Diplomvej 381, DK-2800 Kongens Lyngby, Denmark*

nikos.kehagias@icn.cat

Reverse Nanoimprint Lithography (RNIL) is a well-established lithography technique which has been used to selectively imprint thin polymer films over flat and/or pre-patterned surfaces[1]. The unique feature of this modified nanoimprint lithography technique is the possibility to control the presence or not of the residual layer. Moreover it has demonstrated the capability of sequential imprinting over pre-patterned surfaces resulting in three dimensional structuring[2]. In this paper we further develop the RNIL technique to pattern micro/nano scale polymer patterns over metal substrates (with no residual layer) and test these as anti-wetting surfaces.

In this work we demonstrate that RNIL is a feasible and flexible lithography technique applicable to transfer micro and nano polymer structures with no residual layer over cm^2 areas on silicon and metal substrates. In our experiment we have used a two different flexible Polydimethylsiloxane (PDMS) stamps (one with positive and the other with a negative relief) which had honey comb-like hydrophobic features. Despite the fact that our stamp had a design which repels water we were able after fine tuning of the surface properties of the PDMS stamps to uniformly deposit the resist on the PDMS stamps. In this regard, surface functionalization of the flexible stamp through organic solutions has proven to be useful, reducing the contact angle between the resist and the stamps surface by 31%, leading to a clear improvement of the RNIL results (Figure 1*)*.

We present RNIL results of anti-wetting surfaces which were imprinted using the commercial resist mr-NIL6000E (*microresist technology GmbH*) over silicon wafers (Figure 2) and over Nickel coated steel wafers having no residual layer. Moreover we discuss the imprinting parameters and alleviate some of the main problems that have been reported, such as: residual layer or pattern distortion. Specifically, our imprinting temperature was set to a value close to that of the resist's glass transition (T_g = 40 ^{o}C) and pressure was kept as low as 2 bar, reducing the undesired spread and pattern alteration. Small pressures exhibit also the benefit of minimizing the so called "sagging" phenomenon, which is directly responsible for the presence of residual layer[3]. Both positive and negative patterns of honeycomb lattice features were successfully transferred showing hydrophobic properties, with contact angles 115° and 91°, respectively.

Acknowledgment

PLAST-4-FUTURE is funded by the European Commission (FP7-2012-NMP-ICT-FoF) under Grant Agreement number 314345 (www.plast4future.eu).

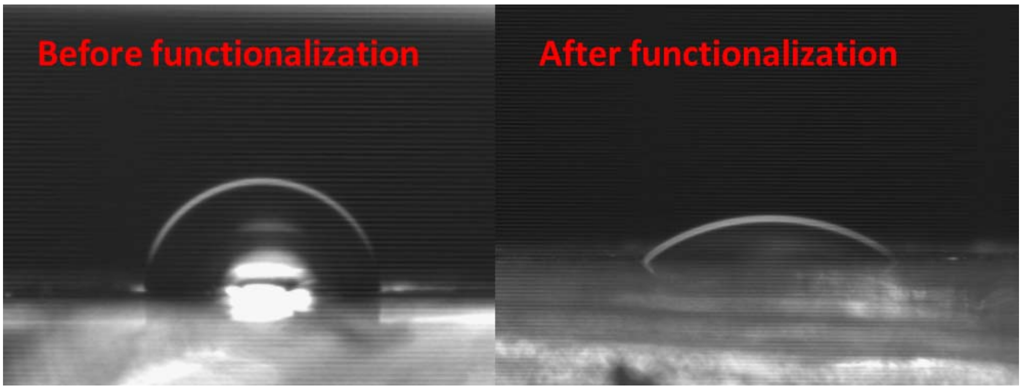

Figure 1: Contact angles between the resist and the PDMS stamp before (left) and after (right) the surface functionalization.

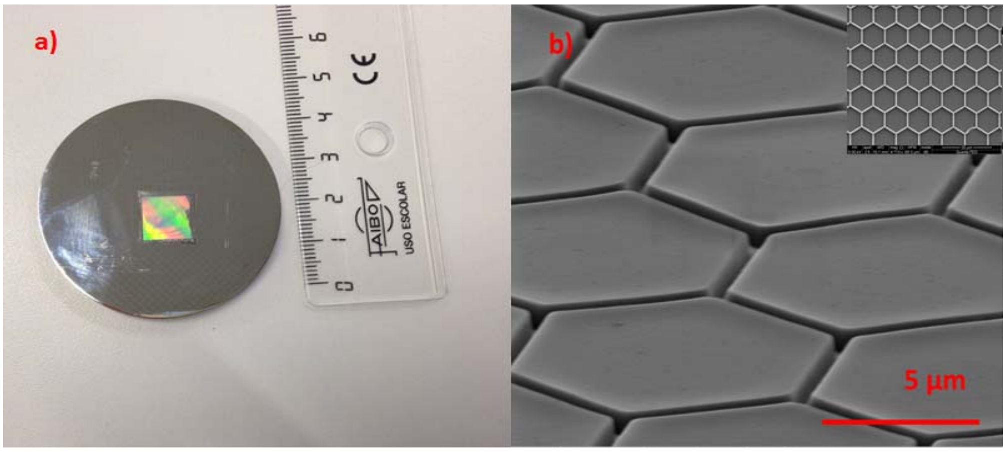

Figure 2: a) Photograph of a 1.2 x 1.2 cm^2 pattern transferred on a Nickel-coated steel substrate, b) tilted scanning electron microscope (SEM) image of a positive hydrophobic pattern transferred by RNIL on a silicon wafer with no residual layer (insert: top view SEM image showing the transfer of a negative anti-wetting surface with patterned line widths of 500 nm and no residual layer).

1. L.-R. Bao et al., J. Vac. Sci. Technol. B 20, 2872, (2002).
2. N. Kehagias et al. J. Vacuum Science and Technology B 24 (6) 3002, (2006)
3. B-D. Chan et al. Microelectron. Eng. **86**, 586 (2009)