Imprinting of residual-layer-thickness optimized large micro-structures enabled by the new organic UV-patternable resist «mr-NIL210SF»

Martin Messerschmidt *[1], Nadja Heidensohn[1], Susanne Grützner[1], Mirko Lohse[1], Arne Schleunitz[1], and Gabi Grützner[1]

[1]*micro resist technology* GmbH
Koepenicker Strasse 325
12555 Berlin, Germany

E-mail: m.messerschmidt@microresist.de

Today, miniaturized devices like micro-optical components, microfluidic elements, sensing components, functional surface structures etc. have been widely adopted in rather different areas and application fields [1]. As a relevant processing step in their overall fabrication chains specifically imprint patterning techniques turned out to be highly suitable, since they are very cost-efficient and are moreover very versatile in terms of applicable pattern designs like complex micro-nano hierarchical structures. However, the defect-free imprinting of quite large micrometer-sized patterns comes often along with some cavity filling issues as the capillary forces in microstructures are much less pronounced compared to analogous nanostructures. This becomes even more challenging when very thin residual layers are necessary or desirable for the dedicated application. In order to accomplish a complete cavity filling it is thus rather beneficial to use gas-permeable imprint stamps like PDMS-based specimens, so that the entrapped air within the stamp cavities is capable to escape via permeation through the stamp matrix. Consequently, also the applied UV-curable resist materials need to be compatible with such stamp materials like it is the case for the already established mr-NIL210 nanoimprint resist series [2]. However, as the current formulations of this series contain all solvent, the maximally achievable resist film thickness is therefore intrinsically limited to ca. 15 µm (via spin-coating). Hence, in order to prepare much thicker films featuring thicknesses in the region of several tens of microns a new solvent-free version of this resist series - namely the «mr-NIL210SF» - needed to be developed. Although this solvent-free version shares some commonalities with the corresponding solvent-containing formulations, it also differs in some profound modifications, specifically in terms of admixed stabilizers and the type and the amounts of applied photo-initiators that were required in order to obtain ultimately a stable formulation featuring a sufficient shelf-life of at least six months. By applying this new formulation film thicknesses in the range between 15 µm and approx. 90 µm could be readily achieved via using the spin-coating technique. Prepared films indicated excellent film forming and film stability characteristics, very good film thickness homogeneities and a low edge bead formation. Even thicker films of several hundreds of µm could be easily prepared via an additional drop-casting of resist material onto already spin-coated films. In exemplarily performed imprint experiments a large array of hexagonal micrometer-sized columns could be defect-free imprinted (as depicted in Figure 1) revealing no cavity filling defects while still having a comparatively low residual layer thickness. This performance could be only achieved by applying a proper combination of relevant parameters like the PDMS imprint stamp, the new tailored UV-curable resist material «mr-NIL210SF» and the right and specific imprint settings of the applied imprint tool.

References:

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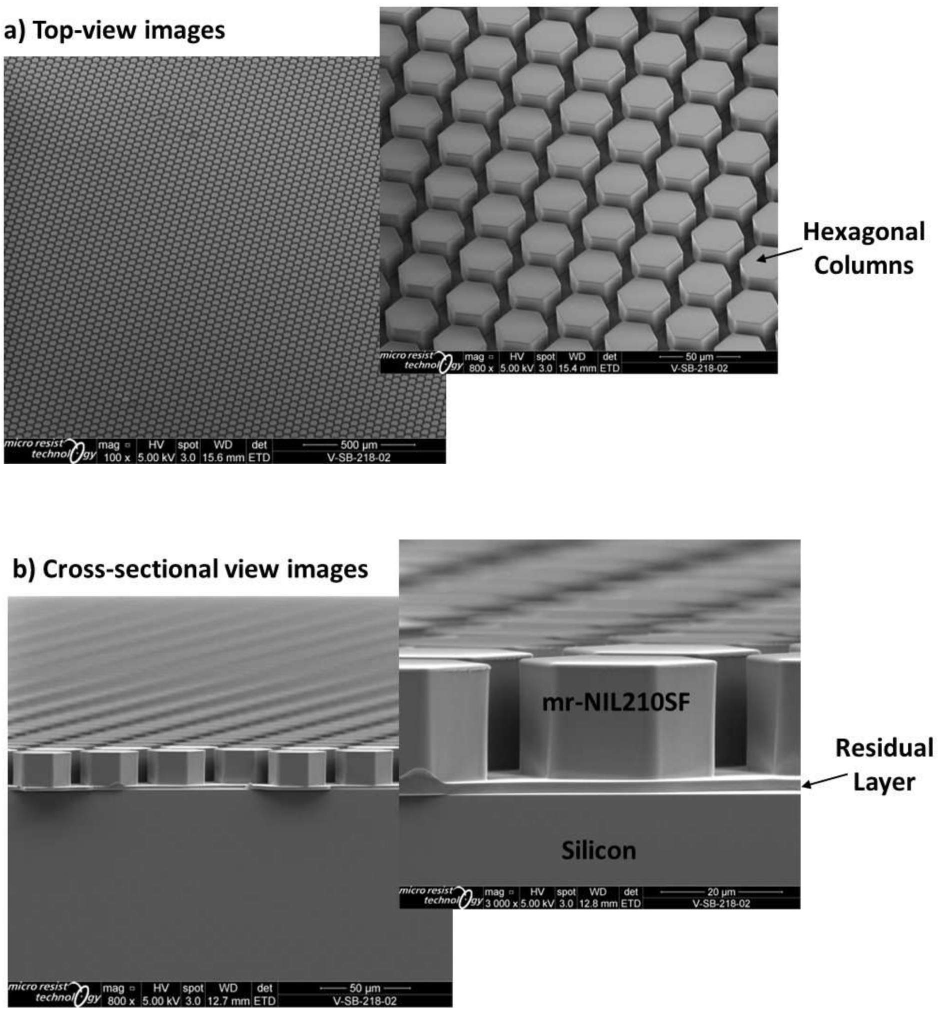

Figure 1. Top-view SEM images (a) and cross-sectional SEM images (b) of a defect-free imprinted array of micrometer-sized hexagonal columns (height: 19 µm, width: 32 µm) onto a Si-wafer equipped with a thin layer of ADPROM-1B as primer. Applied imprint tool: Compact Nanoimprint Tool - CNI v2.0 from NILT ApS; applied stamp material: UV PDMS from Shin-Etsu, Imprint parameters: t = 10 min. (for cavity filling applying also vacuum mode of imprint tool), p = 0.1 bar, LED UV-exposure @ 365 nm: t = 2 min. @ 53 mW/cm^2, p = 0 bar (no pressure applied during illumination step).