Merging Nanoimprint with other Polymer Technologies

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Functional surface topographies are receiving increasing attention for adding value to polymer products by providing them with special surface properties. These range from modified wetting behavior, altered frictional and/or haptic properties, to designed optical functions, decorative, anti-counterfeit or even holographic elements.

In order to implement such topography-defined functions into the injection molding process, structuring of the tools on the micro- and nanoscale is the common approach. Various technologies are available for different size ranges of surface topographies and successful replication is all about mastering the process conditions.

However, tool structuring adds substantial costs to mold manufacturing and the implemented surface topography is final in the sense that it cannot be changed anymore once implemented in the mold if adaptions are required. What if we could prepare surface topographies ex-situ and implement them on a part without the need for tool structuring? As an alternative route, we have explored the *back injection molding of functional micro- and nanostructured films*, previously prepared by nanoimprint lithography, an gained interesting insights [1-2].

In another attempt, we successfully demonstrated the merging of nanoimprint lithography with additive manufacturing to create *suspended polymer membranes* (SPM, Fig. 3) [3-5]. The latter find use as solid supports in serial protein crystallography, which is a powerful new method for protein structure determination at X-ray free electron lasers (XFELs) and synchrotrons [6-7], being of tremendous relevance for the pharmaceutical industry and personalized medicine.

References:

[1] Wollmann, S.; Kristiansen, P.M.; “Back me up without squeezing please – on the back injection molding of functional micro- and nanostructured films”, International Conference Polymer Replication on Nanoscale, Copenhagen (DK), May 18-19, 2015.
[2] Funding from Innosuisse (Project 26884.1 PFNM-NM, 2018-2019) is acknowledged.
[3] Padeste, C.; Karpik, A.; Kristiansen, P.M.; Martiel, I.; “Solid supports for serial protein crystallography: from silicon to polymer technology”, International Symposium on Structure Biology for Drug Discovery at SwissFEL, Villigen PSI (CH), June 25-27, 2019.
[4] Funding from Forschungsfonds Aargau (Project PoS4PX, 2019) is acknowledged.
[5] EP patent pending.
[6] Boutet, S. et al.; “High-resolution protein structure determination by serial femtosecond crystallography” Science 2012, 337(6092) 362-364.
[7] Weinert, T. et al.; “Serial millisecond crystallography for routine room-temperature structure determination at synchrotrons” Nature Communications 2017, 8: 542.

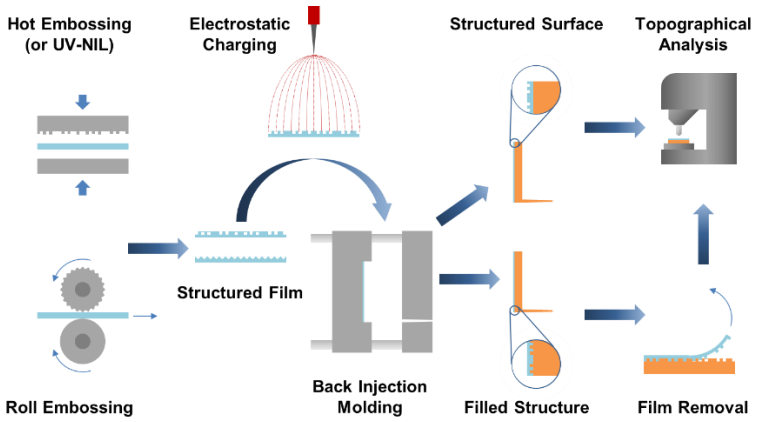

Figure 1. Process scheme for the back injection molding of functional micro- and nanostructured films, consisting of i) imprinting a surface topography onto a polymer film, ii) placing said film in an open mold, and iii) back injection molding (preferably with similar material and the surface topography of the film facing towards the mold).

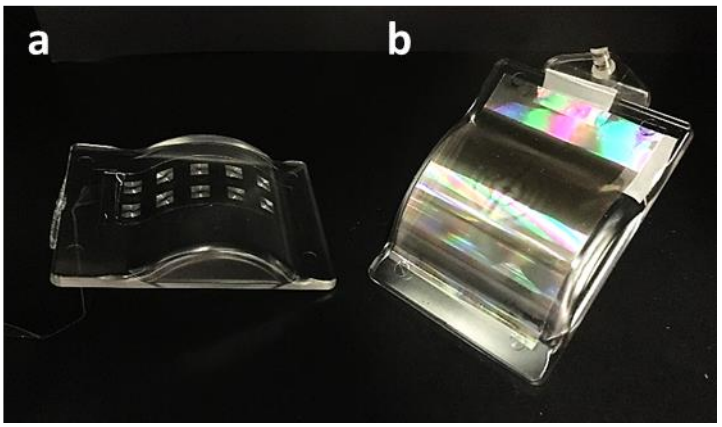

Figure 2. Demonstration examples of back injection molded functional films on curved surfaces. a) Fresnel lenses prepared by UV-NIL in a proprietary UV lacquer on PMMA, b) sub-micron silver wires prepared by capillary-driven filling of narrow channel systems prepared by hot embossing.
[left sample: courtesy of Helmut Schift (PSI) and Jerome Werder (FHNW)].

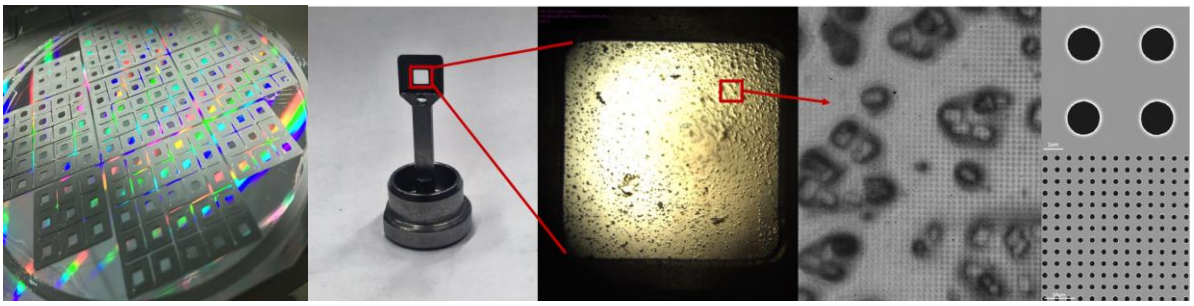

Figure 3. (from left) Wafer-scale production batch of polymer supports for serial protein crystallography by nanoimprint and subsequent 3D-printing; single support mounted on a holder ; optical image of blotted and flash-cooled crystal suspension on the chip ; view of the crystals on a mesh (for prelocation) ; SEM images of a 3 µm COC film structured with an array of 2 µm diameter holes. [courtesy of Agnieszka Karpik (FHNW), Isabel Martiel and Celestino Padeste (PSI)]