Benchmarking in thermal Nanoimprint within the NAPA project

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After more than 10 years of nanoimprint (NIL) process development, a range of standard tools and materials is available from various professional providers. Many engineers get impressive results with different machine concepts (soft press, rigid stampers with compliance layer), however, not surprisingly, they often encounter difficulties when they have to use stamps provided from other institutes (e.g. with a different structure density or polarity), vary their own process parameters (e.g. use a thinner resist thickness) or need to consider boundaries given by a specific application (large area, combined micro- and nanostructures). Often it is not clear whether this is due to physical limitations of the process or simply by lack of process optimization. Networks of research institutes and industry as in the European Integrated Project NaPa [1] play a crucial role to establish a knowledge base on the NIL process for different applications. Real comparisons of processes, however, can only be made by benchmarking with defined rules and boundary conditions. In the last 3 years several rounds of benchmarking were performed, first starting with a standard generic stamp design with test microstructures. The results presented here are now based on demands of high resolution nanopatterning.
Stamps were fabricated at a single institute in order to keep process variations small, by using E-beam lithography and standard silicon plasma etching processes. They exhibit several structured areas, e.g. identical gratings at different stamp locations. SEM pictures of the 120 deep, 50 nm dense line mold patterns are presented in figure 1. The imprinted material is the mr-I 8010E polymer provided by micro resist technology GmbH. The resist thickness is around 100 nm, which should lead to a theoretical residual thickness of 50 nm. The molds were imprinted by all the partners, using different equipment and processes, as detailed in table 1. An example of the imprinted 50 nm lines is shown in figure 2. The patterns were also characterized by scatterometry. This non-destructive metrology technique allows measuring the residual thickness and the imprinted depth. The results presented in table2 demonstrate that the same residual thickness is obtained in different gratings, and that no bending occurs at the edge of the imprinted area. This paper will present the analysis of differences obtained by the different partners and a comparison of processes. It will be shown that the imprint of high resolution patterns requires applying specific rules during the imprint process.
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[1] NaPa (Emerging Nanopatterning Methods – EC funded NMP/FP6 Integrated Project). URL: http://www.phantomsnet.net/NAPA/index.php.

Standard processes and benchmarking in thermal NIL within NAPA

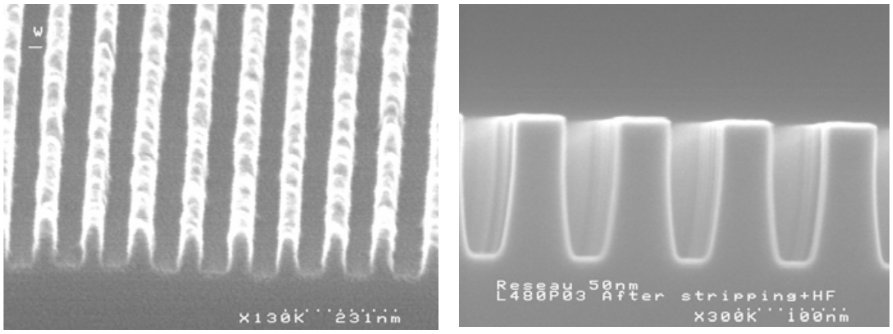

Figure 1: Mold fabrication: SEM cross sectional views of 50 nm dense line array in resist (left picture) and silicon (right picture)

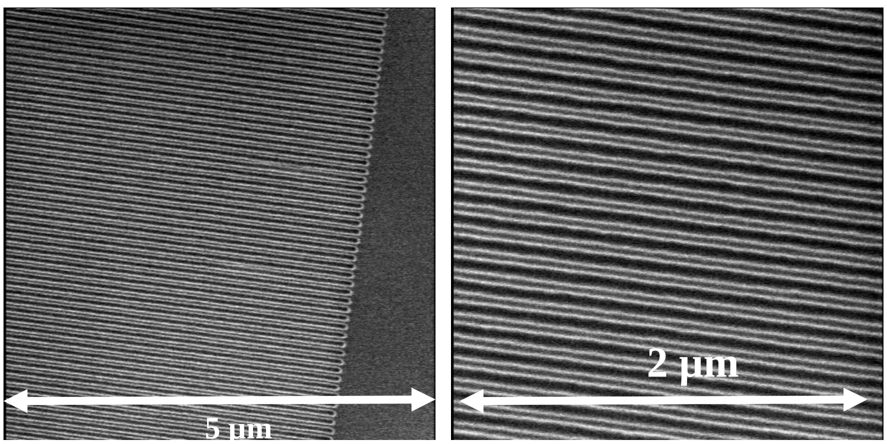

Figure 2: 50 nm dense lines imprinted in the mr-I8010E polymer.

Partner	**Equipment**
PSI	Jenoptik HEX03
TASC	Weber PW
MIC	EVG®520HE
CNM	OBDUCAT 4”
LU	OBDUCAT 6”
LTM/LETI	EVG®520HE
VTT	SÜSS NPS200 (step and repeat)

Table 1: Partners of the benchmarking

	hi (nm)	hr (nm)	CD (nm)
1x1 mm² n°1 center	100	50	46
1x1 mm² n°1 edge	101	55	40
1x1 mm² n°2	100	57	39
400x400 µm² n°1	103	53	41
400x400 µm² n°2	101	57	39
400x400 µm² n°3	101	57	38

Table 2: Scatterometry results in 50 nm dense lines

Imprinted depth (hi), residual thickness (hr) and line width (CD)