Positive and negative counterpart working stamps for Soft UV-NIL using one master design

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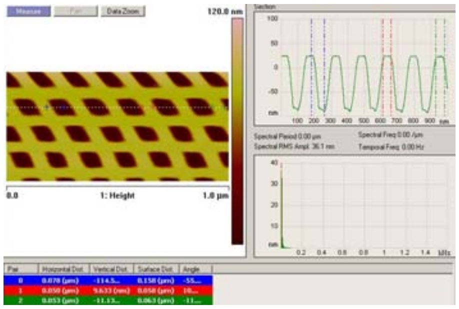
Soft UV-Nanoimprint Lithography (Soft UV-NIL) is a process for nano patterning on wafer scale in one imprint step [1]. The UV NIL process which has proven its applicability as a low cost patterning method, uses a template for nanoimprint lithography often designated as master. Masters for soft stamp replication are usually fabricated by e-beam lithography or other high resolution patterning techniques, followed by reactive ion etching and surface coating with an anti sticking agent. These high resolution master fabrication techniques are extremely expensive and the costs increase rapidly with higher pattern density, wafer size and resolution, which makes a hard stamp master almost inestimable using it for direct imprinting. Rigid masters are chemically robust and solvent resistant, but the lack of flexibility create problems when releasing the master from a rigid substrate and the missing flexibility could result in non-uniform imprints due to different thickness variations of master and substrate.Soft UV-NIL stamps are cheap disposable materials with a fast fabrication time compared to the production of the master and additionally these soft templates can also produce multiple replicas [2]. The main advantages are based on a high transparency flexible stamp polymers which does not require surface treatment due to the anti sticking nature of the molecules end group of the stamp material. The driving force for the surface segregation of master and replica comes from the anti sticking properties, the large difference in surface energy between the polymer and master material. The polymer stamp material is designed for highest adhesion on a particular backplane such as metal, metal oxide, glass, or quartz to bond the working stamp polymer for handling and replication and lowest possible adhesion on the imprint material. Moreover the polymer properties can be adjusted concerning Young’s modulus, viscosity to fabricate robust and high resolution soft working stamps. Low viscosity working stamp polymers enable perfect filling of high resolution features, at the same time there is a decrease of thickness variation compensation due to a thinner compliant layer. Therefore multi layer stamps with a compliant under layer and a high resolution top layer were fabricated in order to achieve high resolution full field imprints [3]. The created soft working stamp constitutes a negative counterpart from the used master which continuatively ends up in a clone of the master design after replication. Also positive and negative counterpart imprints of one master design can be performed using different soft working stamp polymers demonstrated for features down to 50 nm as shown in Figure 1 and 2 as well as micro lens manufacturing (> 500 µm lenses diameter) demonstrated in Figure 3 and 4 [4]. Positive and negative soft working stamp fabrication using one master design enables especially big advantages for the micro lens master machining processes due to the fact, that concave and convex lenses can be replicated simultaneously from one lens design. The same soft stamp polymers employed for micro lens manufacturing (> 500 µm lens diameter) can be used for structures down to 50 nm and smaller.

[1] S.Chou, et. al, Nanoimprint Lithography, J.Vac. Sci, Technol. B 14 (6), 1996

[2] T. Glinsner, et. al., Soft UV-based Nanoimprint Lithography for Large Area Imprinting Applications, Proceeding of SPIE Advanced Lithography, 2007, in press.

[3] U. Plachetka, et. al., “Comparison of multilayer stamp concepts in UV-NIL“ Microelectronic Engineering 83 (2006) 944-947.

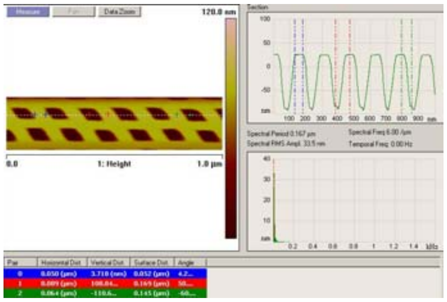
[4] Markus Rossi, et. al., Optical Module Fabrication using Nanoimprint Technology, Micromachining for micro-optics and nano-optics technology IV, presented at the SPIE conference on MOEMS-MEMS 2006.



Spectral Period 0.00 µm
Spectral Freq 0.00 /µm
Spectral RMS Ampl. 36.1 nm
Temporal Freq 0.00 Hz

Pair	Horizontal Dist	Vertical Dist	Surface Dist	Angle
0	0.078 (µm)	-114.5...	0.158 (µm)	-55...
1	0.050 (µm)	9.633 (nm)	0.058 (µm)	10...
2	0.053 (µm)	-11.13...	0.063 (µm)	-11...

Figure 1: Atomic force microscope (AFM) picture of a positive counterpart imprint (crossbars 50 nm in width and 98 nm in height) using a negative tone working stamp



Spectral Period 0.167 µm
Spectral Freq 6.00 /µm
Spectral RMS Ampl. 33.5 nm
Temporal Freq 0.00 Hz

Pair	Horizontal Dist	Vertical Dist	Surface Dist	Angle
0	0.050 (µm)	3.718 (nm)	0.052 (µm)	4.2...
1	0.089 (µm)	108.04...	0.169 (µm)	50...
2	0.064 (µm)	-110.6...	0.145 (µm)	-60...

Figure 2: Atomic force microscope (AFM) picture of a negative counterpart imprint (crossbar 50 nm in width and 100 nm in height) using a positive tone working stamp

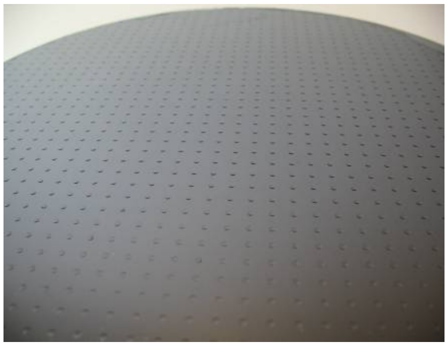


Figure 3: Photograph of an array of microlenses (diameter of lenses: 1 mm, height of lenses: 500 µm) imprinted with working stamp on 200 mm glass wafers

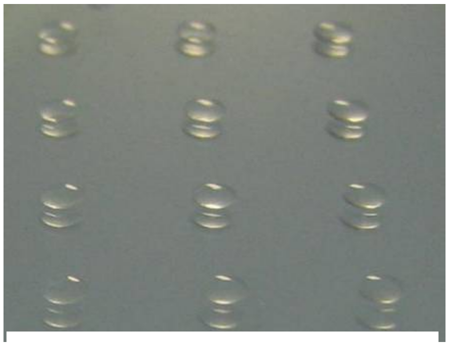


Figure 4: Optical micrograph of an array of microlenses imprinted with working stamp on 200 mm glass wafers (close-up from figure 3)