Convenience of T-NIL with combined processing

H.-C. Scheer, S. Möllenbeck, A. Mayer, K. Dhima
University of Wuppertal, Rainer-Gruenter Str. 21, D-42119 Wuppertal, Germany

Thermal nanoimprint, the method proposed originally by Steven Chou[1] in 1995 and the forerunner of the wide variety of nanoimprint methods, which since have developed, has lost some of its initial credits through the ongoing progress of SFIL, where definition of typical lithography levels for the 32 nm node and beyond are pushed[2]. Besides its resemblance and similarity to optical lithography in terms of equipment and materials this is owed to the room temperature processing of UV-NIL, enabling easy alignment and short processing times.

Nonetheless, thermal imprint (T-NIL) still retains attractiveness due to its low cost and its potential for large area parallel processing. From a scientific viewpoint, T-NIL is attractive, as imprinting does not change the properties of the materials involved, whereas UV-NIL relies on the crosslink of the imprinted layers. Thus T-NIL is the process of choice for e.g. patterning of functional polymers[3], for easy-to-strip single layer lithography and for combined processing.

An interesting option is the combination of T-NIL with optical lithography, where the sub-micron patterns are defined by imprint and the micron to millimeter patterns are defined by simple optical lithography. This is in particular attractive when, in contrast to CNP[4], negative tone and positive tone resists can be used as well, when conventional photo-masks and conventional stamps prepared from Si can be applied, and, beyond that, when both patterning steps are performed in a single resist layer (hybrid process[5]).

Though appearing simple at first sight, such a combination turns out to be challenging. One aspect is temperature choice for imprint, as photo-resists are not designed for temperature processing beyond the soft-bake. A further aspect is, that lithography has to be performed over a pre-patterned surface. This results in interesting features observed along the lithography edges - examples are given in Fig. 1. A further aspect refers to imprintability – molecular weight and chemical structure of conventional photo resists differs substantially from the one of typical imprint polymers like PMMA or PS. The presentation will address and discuss some of these typical aspects as well as their consequences.

---

[1] S.Y. Chou et al, APL 67 (1995) 3114-3119
[2] E. Thompson et al, Microelectronic Engineering 86 (2009) 709-713
[3] J. Wang et al, APL 75 (1999) 2767-2769
[4] X. Cheng et al, Microelectronic Engineering 71 (2004) 288-293 and 277-282
[5] M. Wissen et al, SPIE Proc. 6792 (2008)

* email: Scheer@uni-wuppertal.de

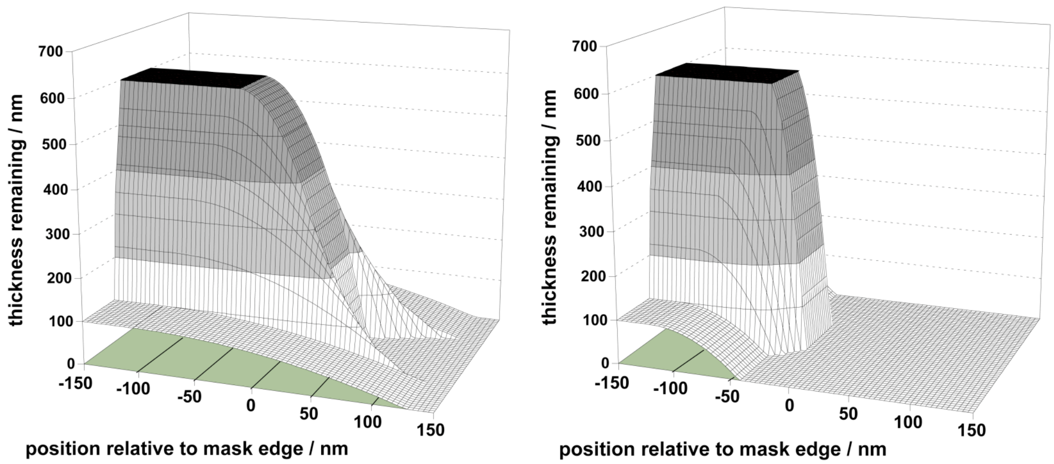

Fig.1: Calculated shape of the lithography edge (mask edge at position x = 0 from front to back, left part of pattern was shaded from exposure) for an UV-lithography step performed over a previously imprinted line pattern (line width 400 nm, space 400 nm, from left to right). Imprinted line height is 500 nm, residual layer height after the imprint is 100 nm. The imprint was performed in a positive tone resist.

Left: At low exposure dose the lithography edge is soft. The resulting hybrid pattern edge is located in front of the mask edge (at $x > 0$). Due to the difference in proximity distance caused by the imprint (proximity distance of residual layer is 500 nm higher than the proximity distance at the top of the imprinted line) the pattern edge of the residual layer extends farther into the mask window than the pattern edge of the line itself. At the transition from residual height to top height the specific shape of the imprinted line cross section induces wedges.

Right: At high exposure dose (strong over-exposure) the lithography edge becomes much steeper. Now the hybrid pattern edge is located behind the mask edge ($x < 0$), where, in contrast to the low exposure dose, the pattern edge of the residual layer is retracted more than the one of the imprinted line. No wedges develop.

* email: Scheer@uni-wuppertal.de