A flexible hybrid stamp for T-NIL based on OrmoStamp

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High pressure is necessary with thermal nanoimprint lithography (T-NIL) to get a conformal contact between the stamp and the substrate due to the limited flatness of both. But a high pressure induces high stress in the imprinted material which may result in a recovery of the imprinted structures after stamp removal[1,2]. Therefore, replacement of the ordinary silicon stamps by more flexible stamps[3] is advised to reduce the imprint pressure required.

A number of solutions has been proposed, although developed under different aspects, e.g. for roll-to-roll processing. The standard stamps for a roll-to-roll process are made from Ni, where the flexibility is controlled by the foil thickness. In addition, hybrid stamps consisting of OrmoStamp and a Ni-foil as a backplane[4] were demonstrated.

We introduce 50µm thick hybrid stamps for T-NIL at reduced pressure. These stamps consist of 20µm OrmoStamp on a 30µm thick PI-foil as a backplane (Fig. 1). PI has a modulus of 2.5 GPa, is available with thicknesses of 10µm to 150µm and has a good thermal stability. The thermal expansion of OrmoStamp and a PI backplane are comparable. This fact reduces the stresses between the two layers when used at elevated temperature.

To get an idea as to which extent the imprint pressure can be reduced with hybrid stamps from 20µm OrmoStamp with a backplane, we compared different backplane materials and backplane thicknesses with a 500µm thick stamp made from silicon. Fig. 2 shows the pressure reduction as a function of the backplane thickness. Pressure reduction is quantified as a ratio of pressures, the pressure required to deform a 500µm thick Si-stamp compared to the pressure required to deform the hybrid stamps. The different curves result from the different stiffnesses and not from the modulus exclusively. Obviously, the most important issue is the stamp thickness. Fig. 3 shows the pressure required to compensate a temperature induced bending as a function of the backplane thickness of the hybrid stamps. The temperature difference assumed is 100°C and the OrmoStamp top layer has a thickness of 20µm again. The theoretical basis of the comparison as well as the consequences for T-NIL will be discussed and details on hybrid stamp preparation as well as on the imprint behavior of the stamp will be given.

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[3] M. R. Sonne, J. H. Hattel, Microelctron. Eng., B106, 1 (2013)
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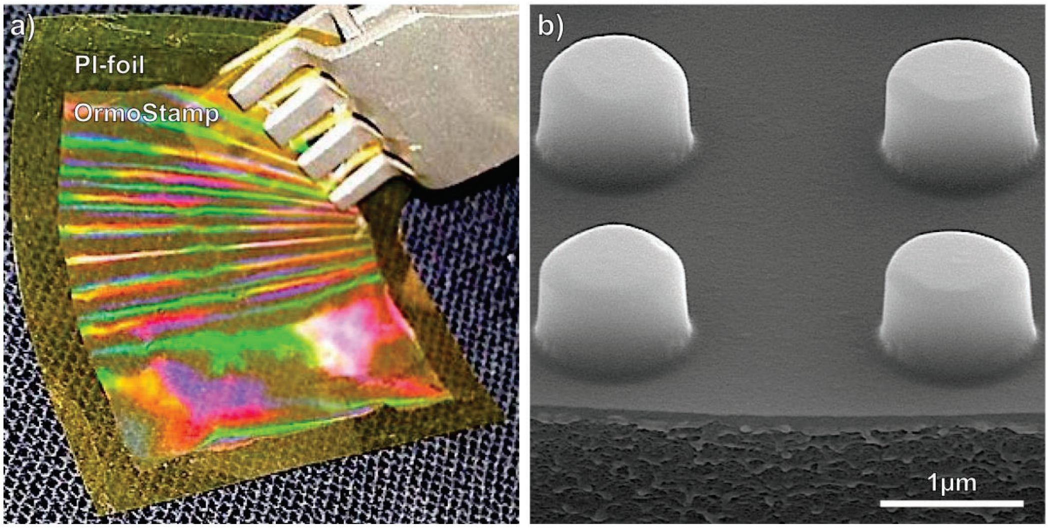

Fig. 1 a) Hybrid stamp consisting of a 20µm thick structured top layer from OrmoStamp and a 30µm thick backplane from PI. Because of the low overall stamp thickness the hybrid stamp is very flexible. The structured field consists of 1µm wide and 1µm high test structures which are imprinted in PS as shown in b).

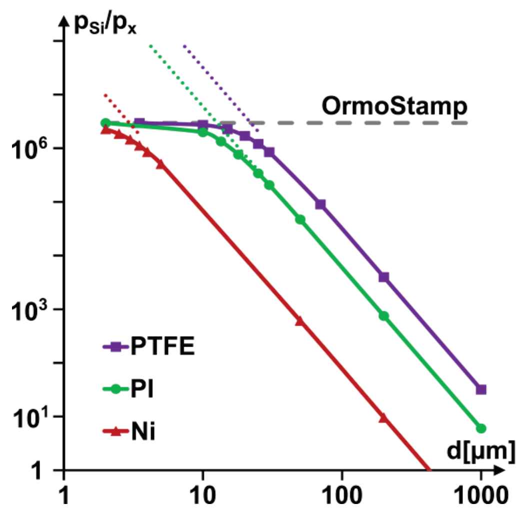

Fig. 2 Pressure reduction provided with two-layer hybrid stamps (OrmoStamp on a backplane) compared to 500µm thick Si as a function of the thickness of the backplane for different backplane materials. The OrmoStamp features a typical thickness of 20µm. The dashed line indicates the limit set by the OrmoStamp layer; the dotted lines are for single layer stamps without OrmoStamp layer.

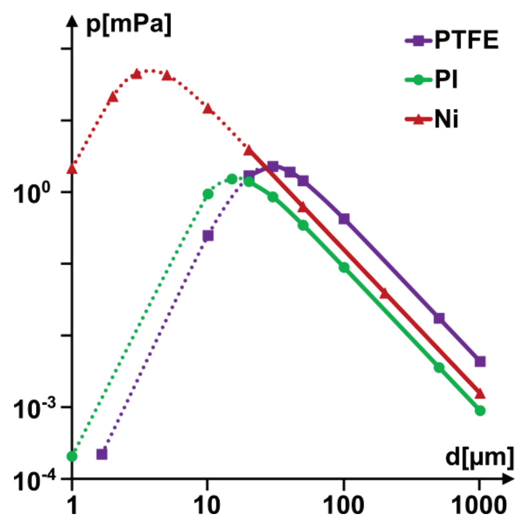

Fig. 3 Pressure required to compensate a temperature induced bending as a function of the backplane thickness for two-layer hybrid stamps; top layer: OrmoStamp, 20µm thickness; temperature difference: 100°C. The dotted lines are of theoretical interest only; there are no foils available below a thickness of 10µm.