The impact of preparation conditions on the properties of replica stamps

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Replica stamps are more and more common in nanoimprint to replace costly templates during processing. Typically, templates are molded by a crosslinking material. During molding the layer is covered by a backplane, which may or may not be removed after curing. Additionally, this backplane offers the option to control the final layer thickness, either by inserting distance holders or by precisely approaching the backplane via µm-screws[1]. A constant, reproducible layer thickness is of impact to ensure identical properties of the replica stamps.

Besides the layer thicknesses, the stamp properties depend on the Young's modulus of the layer materials; for the latter, typically, literature values are used[2]. Such values e.g. depend on the crosslinking temperature[3], the layer thickness[4] and the curing set-up. In particular, when the final layer thickness is adjusted by holding the distance between backplane and mold constant the degree of freedom during crosslinking is reduced. This must result in a change of the modulus obtained. A constraint of freedom will lead to a reduced modulus.

This investigation addresses the impact of the preparation conditions, the crosslinking temperature and the layer thickness on the mechanical characteristics of replica stamps. Especially, we focus on the variations of the modulus obtained. Therefore 4-inch Si wafers were prepared with molding materials of different thicknesses, which were crosslinked on a hotplate with and without distance holders according to Fig. 1 at different curing temperatures. The replica materials investigated are PDMS, OrmoStamp and SU-8. After crosslinking the borofloat backplane was removed and the deflection of the two-layer samples was measured at different temperatures (Fig. 2a). To identify the maximum deflection the measured data were averaged (Fig. 2b). The maximum deflection is used to evaluate the modulus[5].

As the focus is not on the evaluation of the modulus itself, but on evaluating the impact of the preparational differences on the modulus, further analysis used the mean values of the curves measured at different temperatures; this procedure also helps to reduce the 'noise' of the measurements, in particular with a low layer thickness. The results in Fig. 3 indicate that in fact a different modulus is obtained under different preparation conditions. We will discuss such results for the different replica materials investigated.

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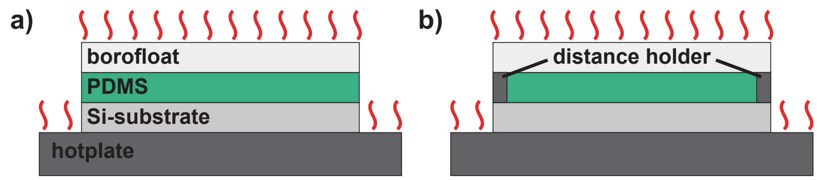

Fig. 1. Crosslinking of PDMS between thin hard plates on a hotplate.
Volume shrinkage due to crosslinking can occur almost freely a) but is hindered when spaced by distance holders b)

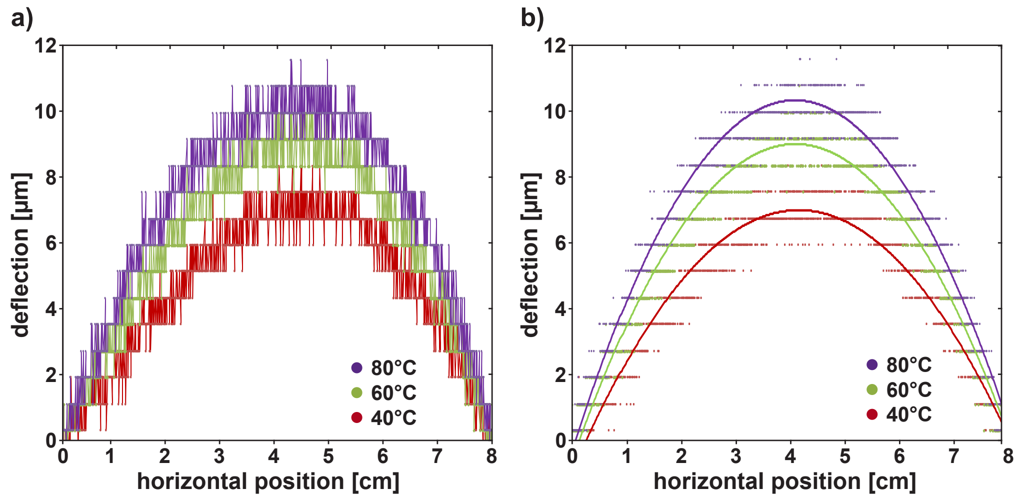

Figure 2. Procedure of deflection evaluation.
A 4 inch sample was measured at 40°C, 60°C and 80°C; the curves indicate the difference with respect to room temperature.
(1 mm PDMS on Si, cured at 120°C for 30 min, without distance holders.)
a) Measurement as recorded, b) averaged curves.

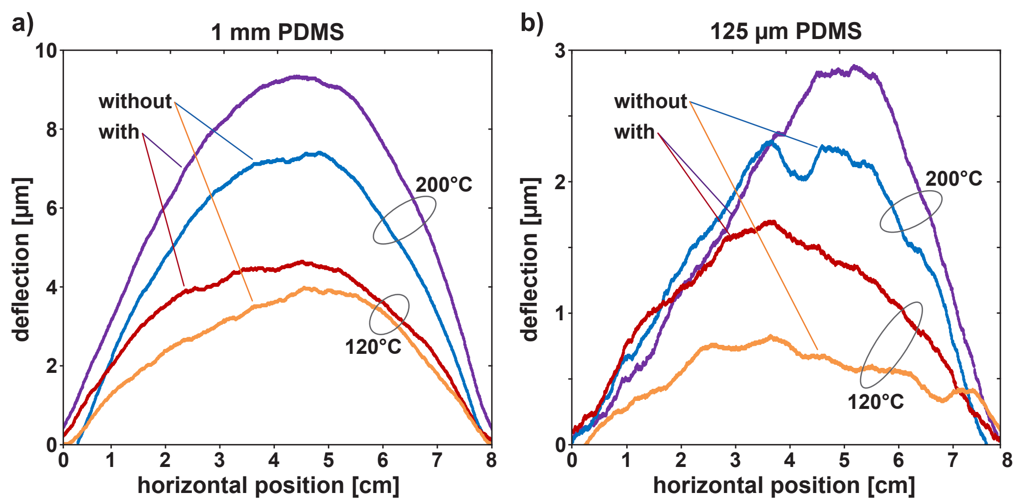

Figure 3. Impact of crosslink temperature and distance holders
The respective curves represent the mean of curves measured at different temperature (similar to Fig. 2 a), crosslinked at 120°C or 200°C, with and without distance holders.
a) 1 mm thick PDMS, b) 125 µm thick PDMS.