Computational study of induced stress during peeling release with various template stiffness in nanoimprint lithography

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Introduction

In order to minimize the defect formation during nanoimprint lithography, comprehensive studies of the releasing process are needed. According to experiments peeling release offers better results than the lift-off method, however while the lift-off method has been the subject of numerous of studies peeling is not very well theoretically characterized. In this study we simulated the releasing of a PDMS mold having imprinted a PAK01 resist using finite element method. We already obtained that kind of results for the silicon/PMMA couple and wanted to see if we would obtain the same tendencies with a softer couple of materials. We extracted the maximum demolding force and the maximum induced stress in the resist in regard to the stiffness of the material.

Modeling:

We simulated a mold with aspect ratio 1, the features height being 10nm. The resist is glued to an infinitely rigid substrate, everything else is deformable. Due to the small dimensions and low Young's modulus of the materials the stiffness of the ensemble is also very low, therefore we added a virtual layer above the mold that allows us to simulate a more rigid template closer to reality, without changing the mold properties. The mold part is glued to that additional layer. The model realized is shown Fig.1. The contact conditions are those of the silicon/PMMA simulation in order to be able to observe the influence of the material's properties change.

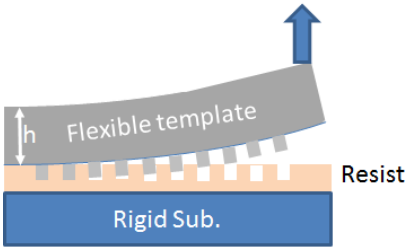

Figure 1: Numerical model

Results and discussion:

The results obtained are similar than those of the silicon/PMMA combination, the maximal release force increases with the template stiffness with a saturation whereas the induced stress decreases. However both the force and stress values are higher than what we observed before, results are shown Fig.2. This situation could be due to the low rigidity of both the resist and the mold that allow them to deform a lot before breaking contact. Thus letting the resist "follow" the mold further, and bending more than a more rigid resist like PMMA would. The situation with features about to be released from the mold is shown Fig.3. It seems that to minimize stress in the resist it is preferable to have rigid materials and a stiff template.

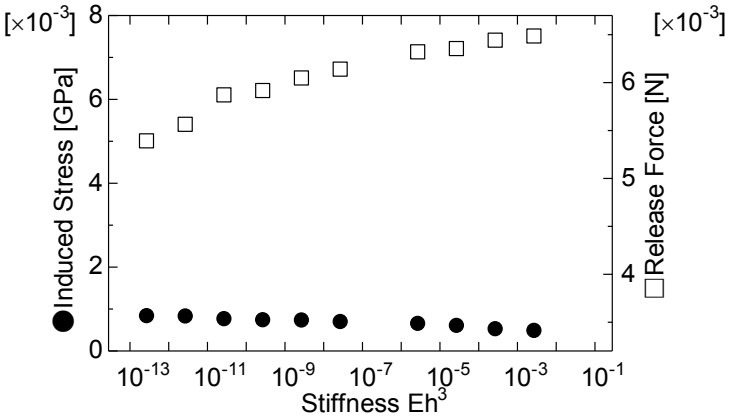

Figure 2: Induced stress and maximal demolding force in regard to the template stiffness

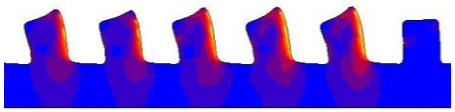

Figure 3: PAK01 resist bending, bright colours indicate stress concentration (deformation magnified)