Mechanical properties of UV-cured acrylate resin

polymer technology

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Introduction & Objectives

In past decades, several rapid-prototyping technologies have been developed, stereolithography (SLA) is one of them. Here the liquid starting material is converted into a solid product by light-activated polymerization, see Figure 1 (left).

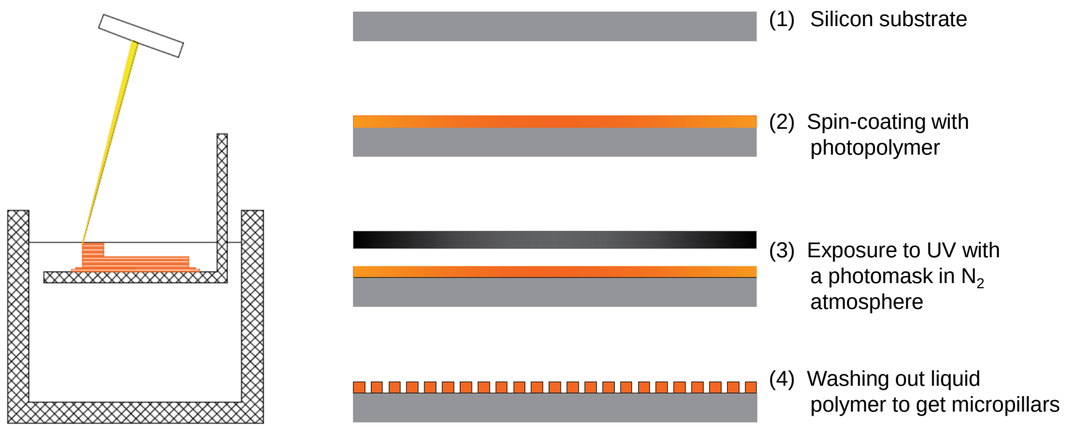

Figure 1: Diagram of SLA printing process (left) ans steps followed for micro-fabrication of pillars (right)

Unfortunately the final products show poor mechanical performance and shrinkage. The goal of this research is to characterize the mechanical properties of photopolymers. Therefore the first step is to characterize the intrinsic mechanical properties which are representative for one single layer and to determine the influence of UV-curing parameters on the mechanical and thermal properties.

Fabrication of micropillars

A photoinitiator (2,2-Dimethoxy-2-phenylacetophenone) is added to the acrylate monomer (bisphenol-A ethoxylate diacylate) to initiate the photopolymerization. Micrometer-sized cylindrical samples are prepared via UV-curing in a nitrogen atmosphere, see Figure 1 (right). An exposure time of 1.5s for a mixture of 3wt% of initiator is used.

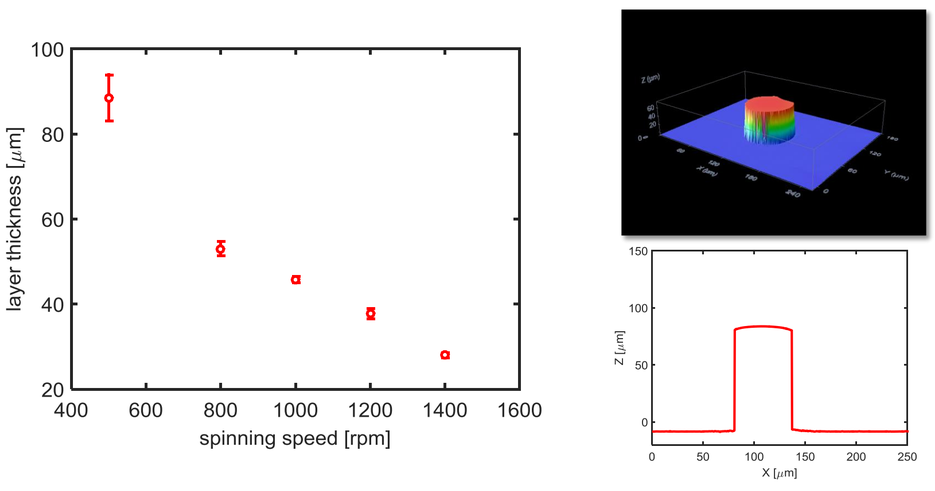

Figure 2: Relation between spin speed and thickness of resin (left) and example of confocal microscope output of a micropillar (right)

The layer thickness is a function of the spin-coating speed, see Figure 2. By changing the speed from 500 to 1400rpm, the thickness of the resin can be varied from 90 to 25 um.

Results

The influence of UV post-curing is studied by observing how the exposure time affects the glass-transition temperature, Tg, and the monomer conversion. The change in Tg, monomer conversion, and the evolution of the absorbance peak at 810 cm^{-1} (FTIR analysis) are shown in Figure 3.

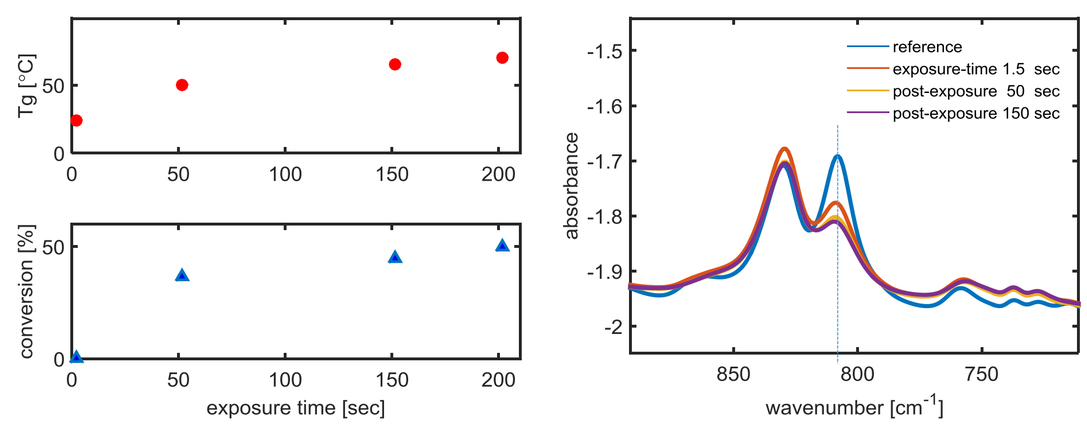

Figure 3: Evolution with time of T_g and monomer conversion (left) and the number of acrylate functions polymerized (right)

The intrinsic mechanical properties of the resin are studied, using compression experiments on the NanoIndenterXP. Micro-compression tests on the micropillars with diameter and height of 80 μm are performed for various deformation rates.

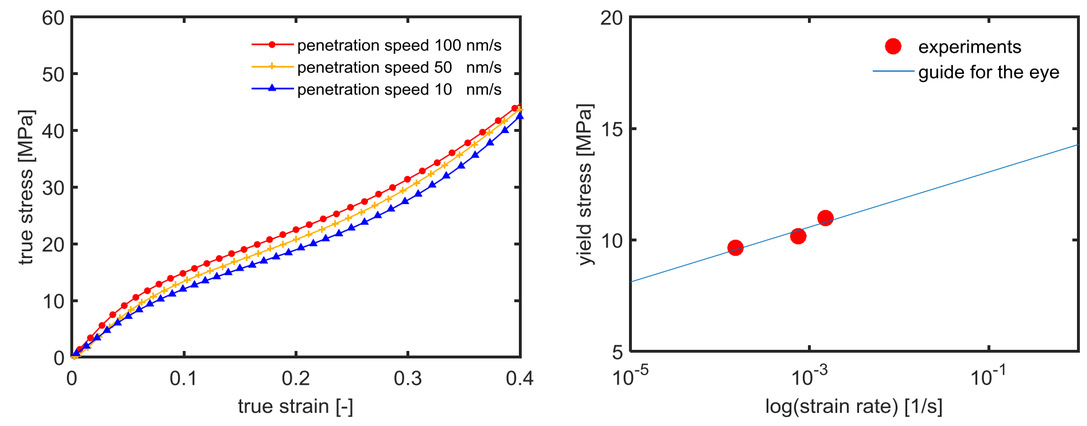

Figure 4: Stress strain behaviour (left) and strain-rate dependence (right)

Conclusions & Future work

The setup for the sample preparation is built: the wafer and the photomask are aligned in a box under UV light. The box prevents oxygen inhibition by working in nitrogen atmosphere. By varying the process conditions, light intensity and exposure time, it is possibile to optimize the sample preparation. So far the evolution with time of Tg and conversion is studied and nano-indentations on maximally post-cured resin are performed. In the next step compression tests on micropillars with different sizes will be performed to investigate if the micropillars show size effects [1].

Reference

[1] T.S. Guruprasad, S. Bhattacharya, S. Basu, *Polymer,* **98** (2016).