Mechanical properties of UV-cured acrylate resin

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Introduction

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 Fig. 1 (left).

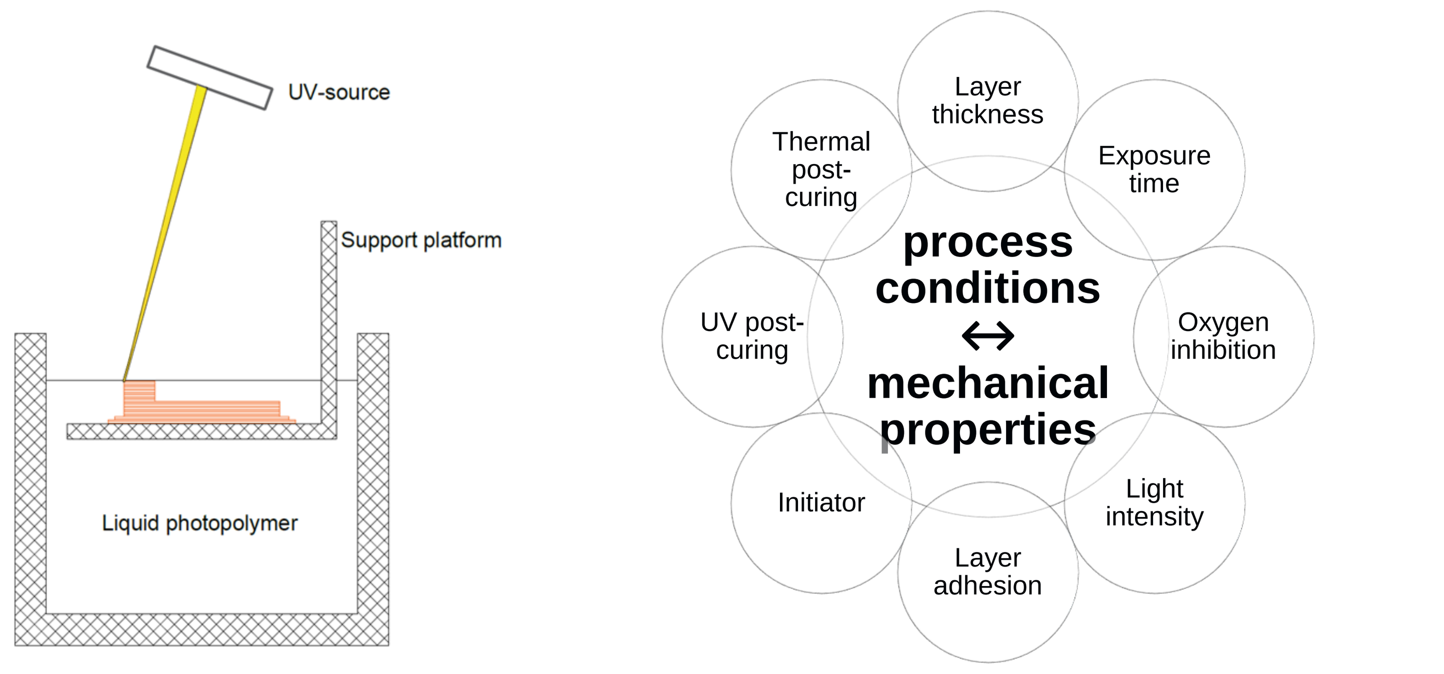

Figure 1: Diagram of SLA printing process (left) and process parameters involved in the process (right).

The goal of this research is to characterize the mechanical properties of photo-curable polymers used in the SLA process and to determine the influence of curing parameters on the mechanical properties, see Fig. 1 (right).

Simplification of complex process

To understand this complex process, the first step is to characterize the intrinsic mechanical properties which are representative for one single layer. Thereto, micrometer-sized cylindrical samples and dog-bone samples are prepared via UV-curing in a nitrogen atmosphere, see Fig. 2 (left). The starting liquid material is obtained by adding the initiator (2,2-dimethoxy-2-phenylacetophenone) to the acrylate monomer (bisphenol-A ethoxylate diacylate).

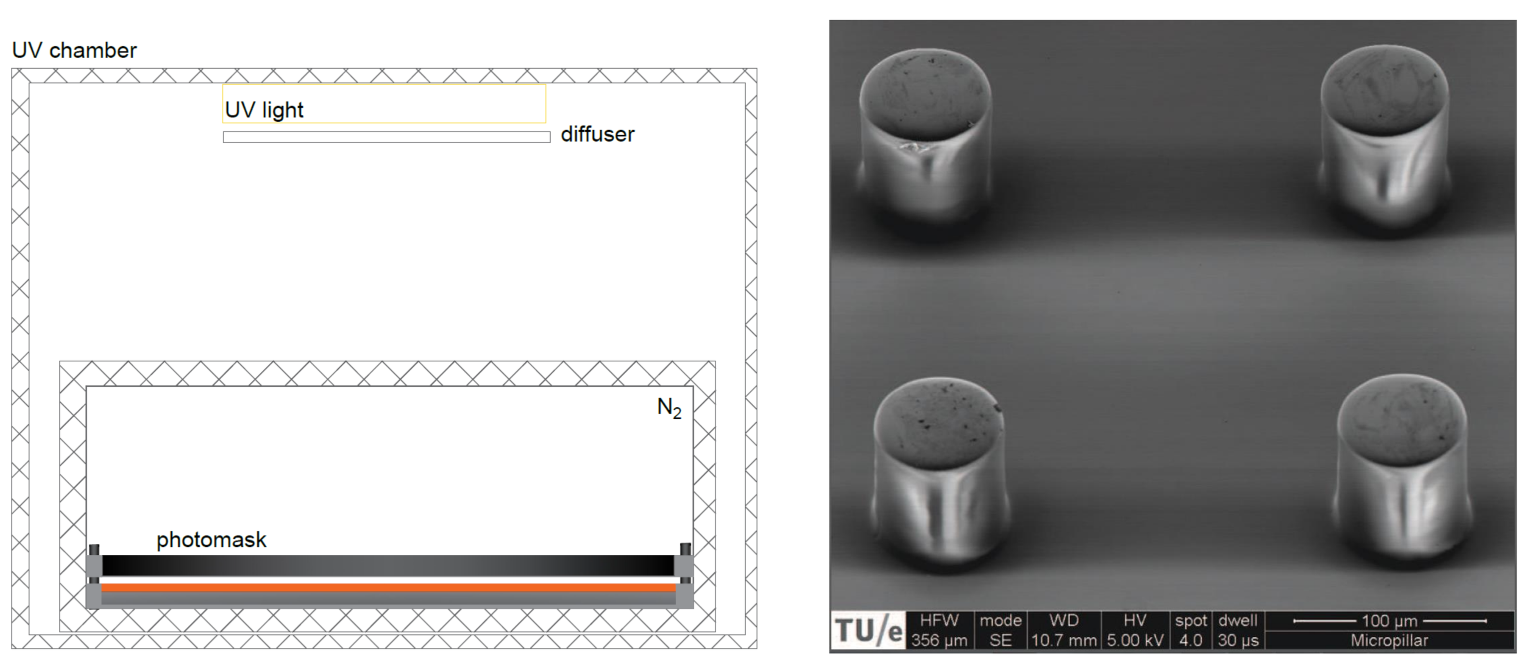

Figure 2: Schematic representation of UV chamber (left) and SEM images of the array of micropillars (right).

An exposure time of 1.5*s* for a formulation of 3wt% of initiator is used to obtain perfectly cylindrical micropillars, see Fig. 2 (right). UV and thermal post-curing treatment are then performed to study their effects on the mechanical properties.

Results

The influence of UV and thermal post-curing is studied by observing how the exposure time affects the tensile behavior. The change in stress-strain response for samples UV and thermally post-cured (T_{PC} = 150˚C) is shown in Fig. 3.

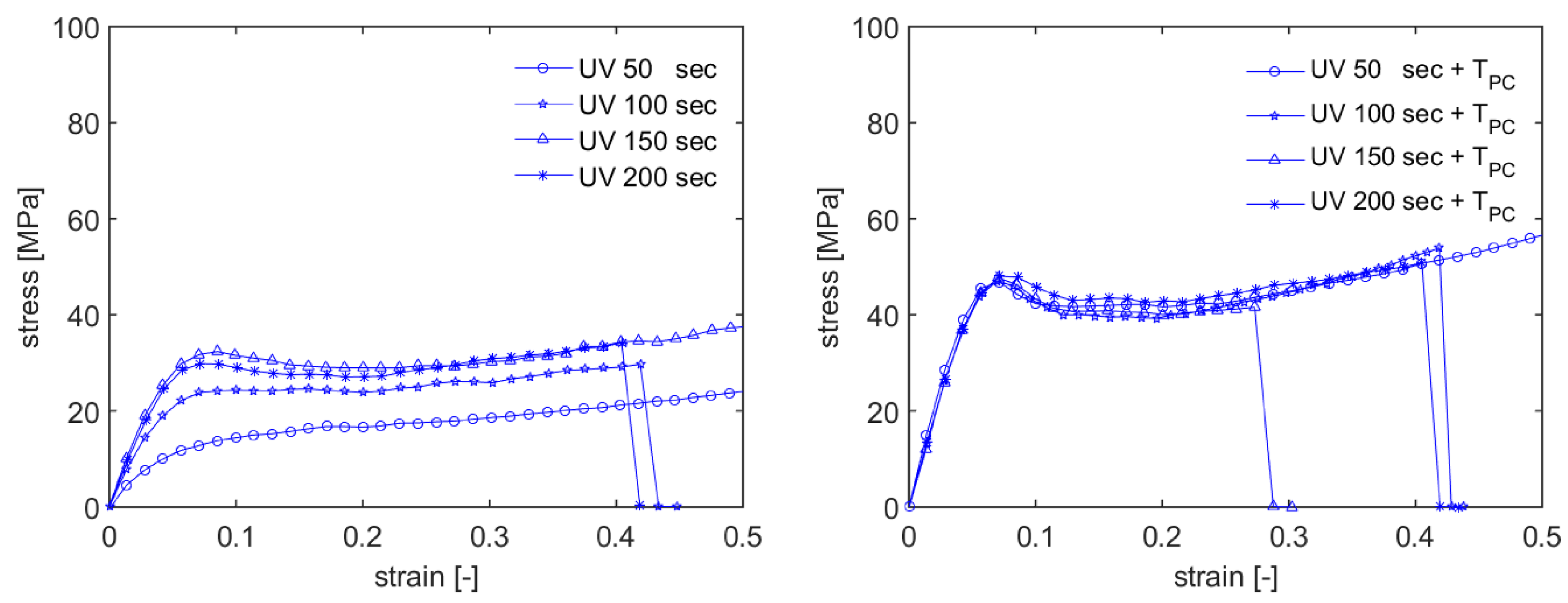

Figure 3: Engineering stress as a function of strain for UV (left) and UV and thermally post-cured samples (right).

The intrinsic mechanical properties of the polymer are studied using compression experiments on the NanoIndenterXP. Micro-compression tests on the micropillars with a diameter and height of 40, 60 and 80 µm are performed to study the size effect, Fig. 4 (left). The yield kinetics of post-cured 80 µm pillars is shown in Fig. 4 (right).

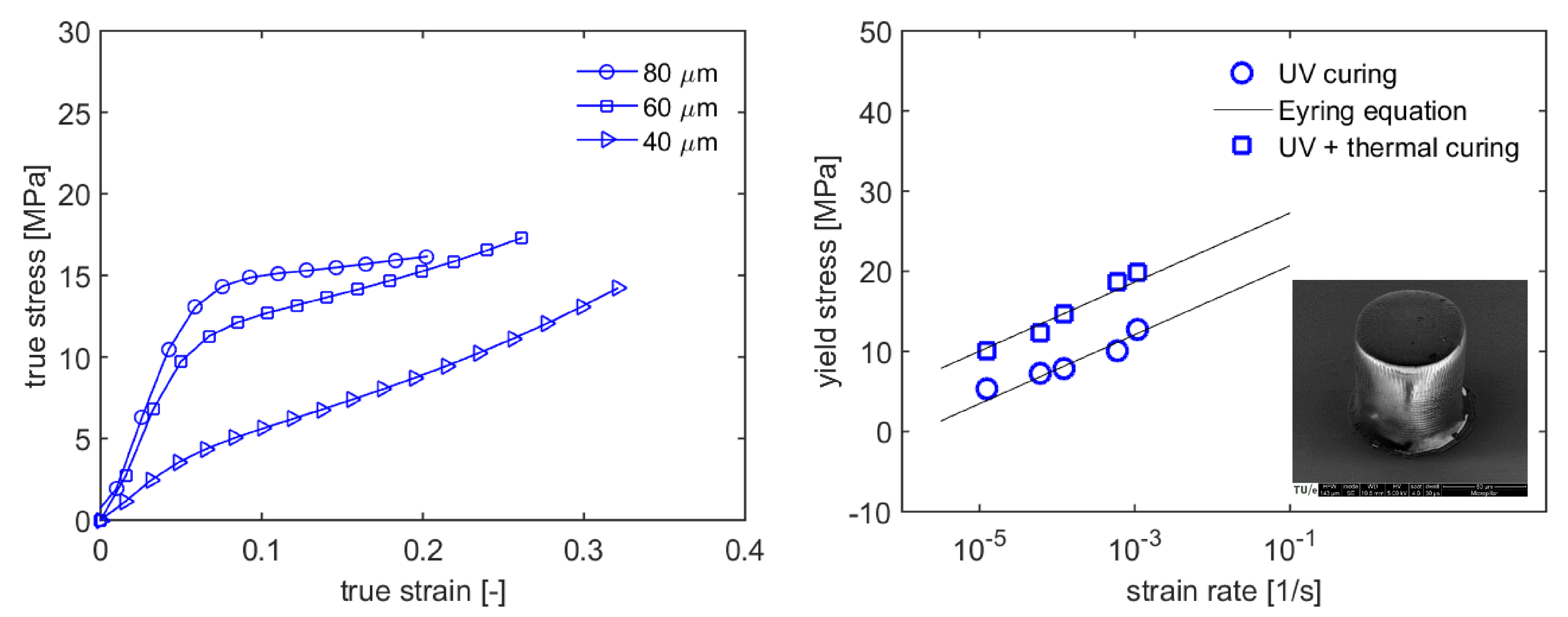

Figure 4: True stress-true strain response of post-cured pillars of 80, 60 and 40 µm (left) and the yield kinetic of micropillars of 80 µm (right)

Conclusions

- Micro-compression results show a reduction in yield stress and an increase of strain hardening for smaller pillars.
- Tensile measurements show higher yield stress values, when compared with compression tests.

This effect can be attributed to the rinsing with acetone during the processing that leads to a removal of monomer from the crosslinked network.

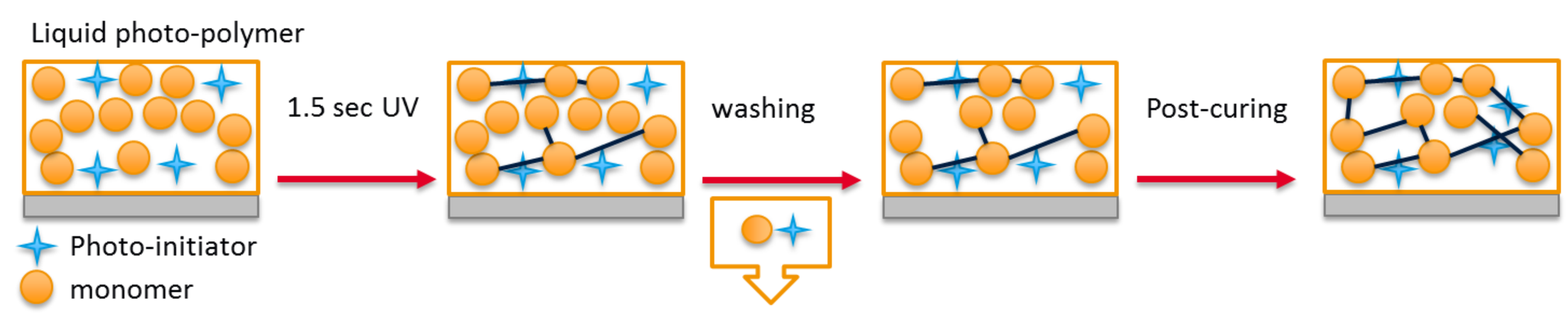

Figure 5: Schematic representation of the formation of the UV network.