TWO PHOTON LITHOGRAPHY FOR SYNTHESIS OF FRACTURE MECHANICAL SPECIMENS

Alexander Jelinek, Department Materials Science, Chair of Materials Physics, Montanuniversität Leoben, Austria
alexander.jelinek@unileoben.ac.at
Markus Alfreider, Department Materials Science, Chair of Materials Physics, Montanuniversität Leoben, Austria
Stanislav Zak, Erich Schmid Institute for Materials Science, Austrian Academy of Sciences, Austria
Daniel Kiener, Department Materials Science, Chair of Materials Physics, Montanuniversität Leoben, Austria

Key Words: Two-photon lithography, Micromechanics, Fracture Mechanics, Finite element modelling

The design process of any mechanically loaded device must be guided by material properties, which also includes fracture mechanical considerations. 3D lithographical techniques, such as direct laser writing through two-photon polymerization, therefore, enable completely new possibilities regarding device geometry, as well as for sample fabrication and materials testing.

Once specific aspects of the sample writing process are accounted, complex shaped specimen can be manufactured directly at the micrometer scale starting from a digital model. Therefore, identical writing parameters as for the final micro device can be used to derive all necessary mechanical properties. The combination of extraordinary reproducibility and production speed with high versatility is uncommon but highly desired along micromechanical material investigation.

Within this work a fracture mechanical material characterization is obtained from printed specimens through statistically validated experiments. For testing, push-to-pull devices are used, which incorporate double edge notched tension specimen. Therefore, experiments with variable ligament sizes can be conducted without demanding alignment procedures. With preliminary finite element analysis and in-situ SEM testing the deformation and fracture behavior is documented, thus ex-situ testing in air can be performed confidently. The individual testing procedure is performed with two loading cycles to obtain a compliance corrected signal for a subsequent fracture mechanical evaluation. An exemplary force vs. displacement graph is shown in Figure 1(a), while Figure 1(b) depicts the before mentioned specimen geometry after testing. Finally, all experimental results are assessed in terms of an essential work of fracture approach to demonstrate the fruitful combination of testing a high amount of miniaturized specimen with exact shape control for the evaluation of material properties.

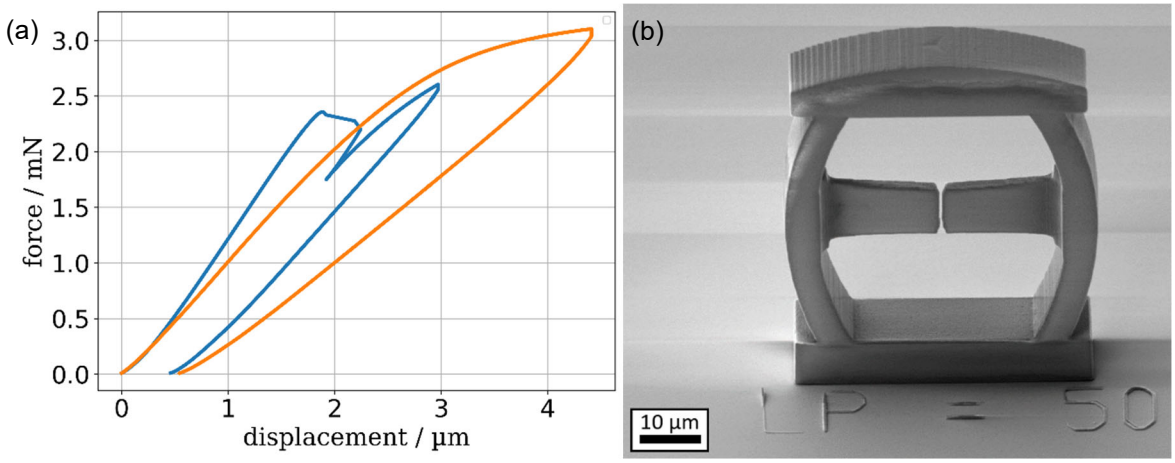

Figure 1: (a) Force vs. displacement graph of a push-to-pull device incorporating a double edge notched tension specimen, tested by a common nanoindenter. Note the fracture event along the first loading cycle (blue line) associated with a force drop, which is not precent at the second loading cycle (orange line). (b) SEM image of the associated specimen viewed under 45° inclination after testing.