

Understanding the role of defects in mechanical metamaterials

The goal of this doctoral research project is to understand the role of defects in microarchitected materials. This project will contribute to thrust C2 and focus on mechanical metamaterials.

Different microarchitectures will be prepared by 3D direct laser writing as polymer structures, with strut diameters in the micrometer range. The properties of such microarchitectures are in general determined by both the properties of the base materials and the specific architecture. The deformation and failure behavior will depend on the details of the architectural features and is critical for the applicability of mechanical metamaterials. It is not yet well understood, though. Effects to be studied include localization of deformation and damage, load shedding, and the role of structural variation with the goal of optimizing mechanical metamaterials.

Both the properties of the base materials including new materials developed within the cluster (research area A) as well as different microarchitectures will be investigated. In particular the carbonization of different 3D polymer-based mechanical metamaterial architectures will be studied to determine the influence of the original polymer composition on the strength and deformability of the structures. For the design and optimization of the architecture, collaboration with the Gumbsch group is planned.

For the characterization of the materials and structures the following methods will be employed: micromechanical testing using a nanoindenter both ex situ and in situ in a scanning electron microscope, helium ion microscopy for high resolution characterization of the structures, and X-ray microscopy to observe the interior of the microarchitectures. The experimental work will be accompanied by finite element simulations.

Collaboration with the groups of P. Gumbsch and F. Gräter within C2 and the group of R. Schroeder (B3) have already been discussed and outlined. Links to other research areas are anticipated.