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Numerical simulation of topologically optimized open-pore metal foams using a phase-field approach

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The research project is located in the context of lightweight materials design and is concerned with the topology optimization of novel foams with regard to best possible foam structures under mechanical compressive/tensile load. The methods for topology optimisation are based on the computer-aided design and characterisation of digital foam structures. The focus of the project is to create a digital model that provides insight into the relation of microstructure and properties of open-pore metal foams, and which is intended to accompany the manufacturing process of these solid foams.
Controlling the microstructure formation in foams is key to tailoring the resulting structures with defined geometries and properties.
This requires understanding how different pore structures influence the set of physical properties associated with varying requirements on components and material, depending on the later application. In this work, the foam skeleton structure formation determined by curvature minimization is studied numerically. In order to generate topologically optimized foam structures, a digital model is utilized. To predict the microstructure evolution, we use a numerical simulation method based on a phase-field model to perform large-scale parallel simulations of 3D cellular structures. Phase-field simulations focusing on the generation of a large set of varying structures allow for investigation of the design and loading conditions relating to topology in the next project step. Considering this set of different structures, the impact of individual foam parameters like ligament size, overall density, or pore size distribution can be studied separately, with regard to their impact on overall morphology. The modeling approach yields data sets of optimized foam structures with different topological and morphological characteristics. Making use of the in-project applied database, the interlinking of experimentally determined requirements on mechanical properties and digitally generated structures can further enhance the optimization of the tailor-made foam structures.

Category

Solid State (Experiment)

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