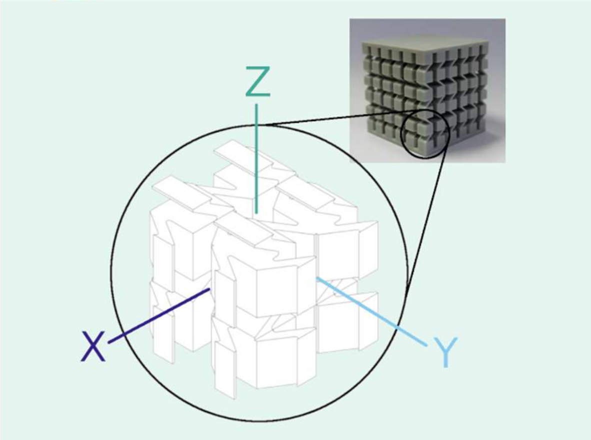
SUCCESS STORY

Chemitecture
Imparting new functions in digitalized polymers by bridging CHEMIstry with macroscopic archiTECTURE

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: COMET-Module

Type of project: Project 1.4 – Design of mechanical metamaterials, 2020-2023, multi-firm



©PCCL; Metamaterial with independently tunable stiffness

MECHANICAL METAMATERIAL WITH INDEPENDENTLY TUNABLE STIFFNESS IN THREE DIMENSIONS

A NEW METAMATERIAL HAS BEEN DEVELOPED ENABLING A CUSTOMIZED STIFFNESS DISTRIBUTION FOR ADVANCED STRUCTURAL APPLICATIONS

Mechanical metamaterials combine geometry and material to obtain special mechanical properties. These properties include, but are not limited to, lightweight, foldability, auxetic behavior and varying stiffness. The properties are mainly defined by the geometry of their design. By varying the geometric parameters of a structure, different properties can be achieved and tailored to the needs of an application.

Within the COMET Module Chemitecture we have developed a new kind of bending-dominated mechanical metamaterial. The design allows to vary the stiffness independently in each spatial direction across several orders of magnitude with a single material. This is achieved with a grid of cubes, connected by alternating struts. The stiffness of the structure can then be tuned by increasing or decreasing the thickness of the struts. In addition to the independent tunability, local and gradual stiffness variations can also be incorporated in the design.

The design is suitable for different additive manufacturing techniques and materials. So far, we successfully manufactured structures with filament-based (FFF), resin-based (DLP) and powder-based (SLS) techniques with polymers. Non-polymer materials, such as metals or ceramics, are also possible to be processed with this design.

The design process is accompanied by the development of simulation tools to further optimize the metamaterial itself and components based on it.

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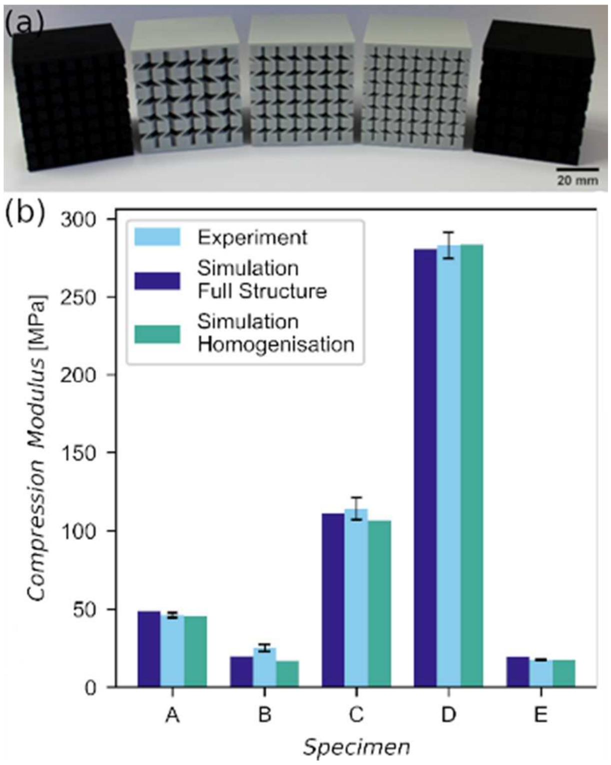
Impact and effects

The proposed metamaterial design permits to create a customizable stiffness distribution across several orders of magnitude, based on simple geometric parameters. This opens the possibility to create components for complex load and/or boundary conditions with a single material, reducing the need for multimaterial and composite designs. Single material structures simplify the design process and improve the recyclability of a component.

Since the structures can be produced with various additive manufacturing techniques and their respective materials, the possible applications range from soft, dampening to stiff, load bearing structures.

The development of simulation and optimization tools allow for an automated design workflow. By specifying the geometry, loads and boundary conditions, an optimal distribution of unit cells can be obtained.

A patent for the design of the structure is pending (reference number: A 50098/2021) and a peer-reviewed paper has been published (DOI: 10.1016/j.mtadv.2021.100155).



©PCCL; (a) Different additively manufactured structures made from polylactic acid (black) with FFF and resin (grey) with DLP used for mechanical testing. (b) Comparison of experimental results obtained from compression tests and two different simulation models.

Project coordination (Story)
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