Topology optimization of metamaterials for extreme elastic modulus

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ABSTRACT

Mechanical metamaterials are manufactured structures with extreme mechanical properties that do not exist in nature. It is the array of microstructures designed to provide specific properties with unique geometrical configurations of the unit cell instead of the material properties. This study aims to economically develop metamaterials using topology optimization, which has improved elastic modulus properties. The elastic modulus quantifies a material's ability to withstand deformation when subjected to an external force. Materials possessing a high elastic modulus exhibit greater stiffness and rigidity, whereas those with a low elastic modulus tend to be more flexible. The results demonstrate that topology optimization can significantly increase the microstructure's properties. Maximizing the elastic modulus of metamaterials can have various applications in engineering. These include structural reinforcement to enhance the load-bearing capacity and minimize structural failure in bridges, tunnels, and buildings. High elastic modulus metamaterials can also be used to create high-strength materials for construction purposes. Moreover, they can contribute to the design of earthquake-resistant structures, minimizing deformations during seismic events.