



Editorial: Multiscale Lattices and Composite Materials: Optimal Design, Modeling and Characterization

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Editorial on the Research Topic

Multiscale Lattices and Composite Materials: Optimal Design, Modeling and Characterization

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The Research Topic “Multiscale lattices and composite materials:” (MLCM) is focused on the optimal design, modeling, and characterization of novel lattices, composite materials, and structures at different scales, through the control of the internal architecture of the system.

A fundamental goal of this article collection is the study of mechanical metamaterials that are able to form next-generation cellular solids; lattice materials, multiscale composites; and structural-scale systems. The collection took inspiration from the peculiar behaviors exhibited by structured materials at multiple scales (Bosia et al., 2018). The latter include, for example, high stiffness, strength, and toughness at extremely low densities (Meza et al., 2014), phononic bandgaps (Lu et al., 2009), sound control ability (Cummer et al., 2016); negative effective mass density (Liu et al., 2000); localized confined waves (Theocharis et al., 2013), to name but a few examples. The research reported devoted special attention to the creation of complex mechanical systems with properties derived mainly from their geometric design rather than their chemical composition (Cummer et al., 2016; Bertoldi et al., 2017). Also investigated was the use of multiscale lattices to optimally design reinforcing elements for novel composite materials (Fleck et al., 2010; Li et al., 2014). The chosen modeling and experimental approaches were able to predict and characterize the intrinsically complex mechanical behavior of the analyzed systems through multiscale techniques.

The papers forming the MLCM collection can be grouped into two basic categories. The first of these is centered around the design, modeling, and characterization of lattice structures at different scales, through the maximization of the frequency bandgap width at suitable center frequencies (Arretche and Matlack; Bacigalupo et al.); the optimal design and mechanical modeling of tensegrity metamaterials (De Tommasi et al.), superstable pre-stressed networks (Kelly et al.), graphene sheets (Genoese et al.); dome-shaped auxetic metamaterials (Easey et al.); and solar façades that employ dynamic sunscreens with tensegrity architecture (Babilio et al.). This first group of papers also includes contributions dealing with the development of non-destructive testing and structural health monitoring techniques that make use of guided elastic waves (Miniaci et al.), as well as the experimental characterization of the microstructure of the Nephila dragline silk (Stehling et al.).

A second category focuses on the modeling and characterization of novel composite materials, with emphasis on the mechanical properties, for example, of bamboo fiber-reinforced composites (Javadian et al.); the effects of defects, porosity, and damage on the mechanical properties of metallic materials to be employed in additive manufacturing processes (Goodall et al.); the macroscopic response of micropolar continua with anisotropic microstructure (Fantuzzi et al.); the addition of lattice-shaped inclusions to metaconcretes (Briccola et al.); and the propagation of pressure waves in three-dimensional arrangements of coated spheres (Dupont et al.).

Our hope is that the research presented in this collection will stimulate new and exciting research in the fields of mechanical metamaterials and multiscale composite materials and structures, through an integrated approach that includes the design and the mechanical modeling of real-scale, or reduced-scale prototypes; the optimal control of suitable design variables; and the experimental validation of the theoretical predictions.

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