

Computational Design and Additive Manufacturing of Mesoscale Architectures for High Performance Materials

Opportunity

Material properties are governed by the chemical composition and spatial arrangement of constituent elements at multiple length scales. This fundamentally limits material properties with respect to each other creating trade-offs when selecting materials for a specific application. There is an opportunity to decouple these property relationships to obtain previously unobtainable performance.

Meso Challenge

The design challenge is to find solutions to multi-variable and multi-scale problems in order to decouple various structural and functional properties. The fabrication challenge is to build these architectures, which often are multi-dimensional, multi-scale, and multi-material.

Approach

We are combining advanced microstructural design, using flexure and screw theory as well as topology optimization, with new additive micro- and nano-manufacturing techniques to create novel material systems with previously unachievable property combinations. Much of this enhanced performance is achieved by tailoring material architecture at micron-to-millimeter size-scale.

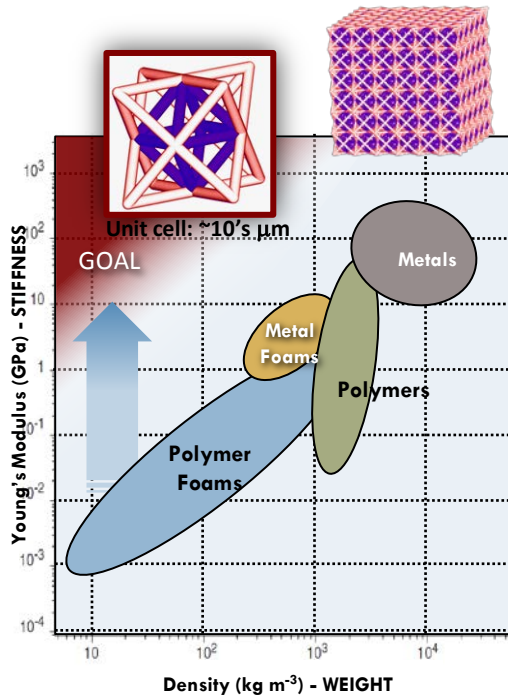
Impact

Our approach is capable of reliably producing designed architectures that are highly three-dimensional, multi-scale, and often composed of multiple constituent materials for both structural (e.g., strength, stiffness, thermal expansion, Poisson ratio) and functional (e.g., electronic, optical, magnetic, and energy) applications.

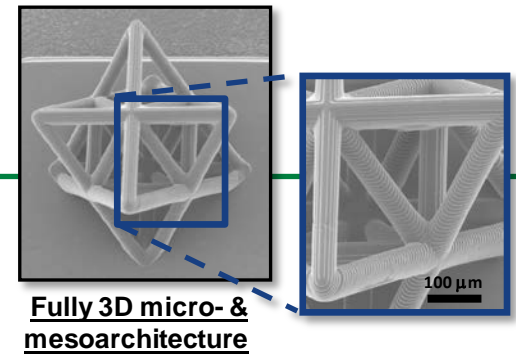
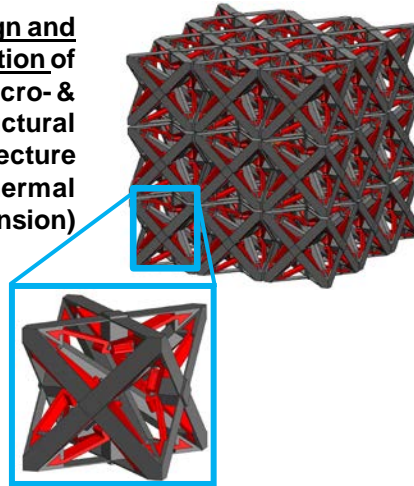


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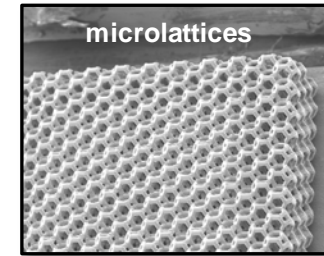
Previously unachievable material property combinations (eg. high-stiffness, low-weight)



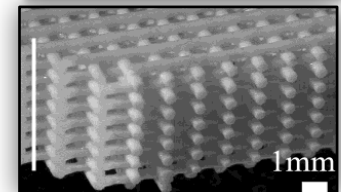
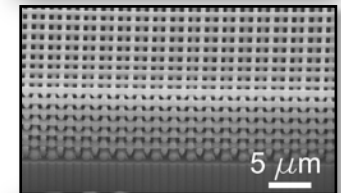
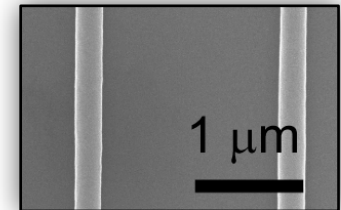
Design and optimization of micro- & mesostructural architecture (negative thermal expansion)



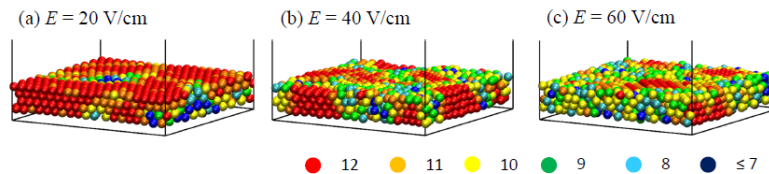
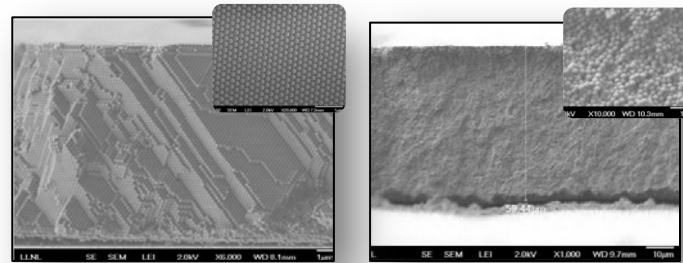
Fully 3D micro- & mesoarchitecture



Multi-Scale



Controlled material nanostructure



Nano-to-meso