ABSTRACT

Cellular Metamaterials with Encoded Disorder: Computer Design, 3D-Printing and Properties

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Cellular materials are ubiquitously used in many branches of technology, from lightweight structures to biomedical implants and electrodes. These materials derive their properties from their internal porous architecture, which is often poorly controlled via conventional manufacturing routes (e.g. replication, templating). Additive manufacturing coupled with computer design can help overcome this issue enabling the fabrication of porous materials with complex, yet precisely-controlled, geometrical features. They are colloquially referred to as cellular metamaterials.

Here, we explore the potential offered by encoding structural disorder in metamaterials design. To do so, we first present a palette of numerical methods that enable the design of metamaterial architectures with random pore features and then show how these materials can be realized experimentally by means of additive manufacturing technologies. Both polymer 3D-printing and metallic laser powder bed fusion technologies are examined, and the main challenges underlying each manufacturing process are discussed. Finally, we demonstrate experimentally the intriguing properties offered by cellular metamaterials with encoded disorder [1,2], and highlight the suitability of the design approach in the field of electrochemical energy storage.

[1] Tarantino, MG. et al. Acta materialia 175 (2019): 331-340.
[2] Salvi, L. et al. International Journal of Mechanical Sciences 281 (2024): 109612.