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ABSTRACT:

Properties, Design and Engineering Applications of Cellular Materials

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Over the last decades, cellular materials and structures have found widespread use across numerous engineering fields, largely due to their remarkable mechanical characteristics including low weight, high strength, permeability, and excellent energy-absorption capability. Advances in additive manufacturing have further expanded this landscape, enabling the fabrication of novel engineered cellular architectures with unprecedented multifunctional performance. These enhanced properties arise in part from the complexity of their microscale designs, unlocking new opportunities in diverse applications, particularly within the biomedical domain.
Among cellular structures, metamaterials represent a highly functional and rapidly developing class. To fully optimize additively manufactured components, a deep understanding of the mechanical behavior of cellular architectures is crucial, as these insights directly shape the design process.

This contribution examines the fundamental macroscale mechanical properties of cellular materials, outlines key design principles, from classical engineering approaches to optimization techniques and biomimetic strategies, and presents representative engineering applications, including work developed by the author and his research team. Some outlines for future research directions in the field of cellular materials are also provided.