BENDING STIFFNESS OF NACRE-LIKE HIERARCHICAL GRAPHENE NANOFILMS: A VORONOI-BASED MODELING APPROACH

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Abstract

Hierarchical “brick-and-mortar” structures, inspired by natural nacre, offer a powerful framework for developing advanced nanomaterials with exceptional mechanical properties. Among these, graphene nanosheets have emerged as a promising candidate due to their ultrathin geometry, high stiffness, and tenable interfacial interactions. However, despite having the same layered structure, the structural characteristics of flexible 2D membrane-like assemblies still differ significantly from those of natural nacre-like materials, such as larger thickness ratios of soft to hard phase materials and lower out-of-plane stiffness. This prevents the models developed in previous studies from accurately describing the mechanical properties of nacre-like flexible membrane materials, especially their bending properties. In this work, a finite element model based on Voronoi geometric structure was developed to investigate the bending stiffness of nacre-inspired hierarchical graphene films. The model interprets the film as a composite of ultrathin rigid graphene nanosheets (bricks) and interlayer van der Waals interactions (mortar). By systematically varying geometric and structural parameters, including nanosheet thickness and intralayer spacing, we reveal critical trends in bending performance. The results not only bridge a critical gap in understanding the bending mechanics of graphene-based composites but also offer practical guidance for optimizing their design for applications in flexible electronics, sensing membranes, and lightweight protective coatings. This study highlights the potential of graphene nanosheets as a building block for next-generation biomimetic materials, advancing their application in nanomaterials research and development.

References

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