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Graphene Origami Enabled Mechanical Metamaterials

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Abstract

Mechanical metamaterials have emerged as a new class of functional materials with unusual material properties. An important example of mechanical metamaterials is auxetic material with tunable negative Poisson's ratio. Such materials are attracting considerable interests due to their promising applications in various engineering sectors. Although enormous studies have been performed to present negative Poisson's ratio properties in various materials, research work on the auxetic behavior of graphene reinforced metal nanocomposites is still at its early stage. The present work develops a graphene origami structure to tune the negative Poisson's ratio in graphene reinforced metal nanocomposites. Various graphene origami structures, including Miura pattern, Waterbomb pattern, and Yoshimura pattern, are formed with the assistance of surface hydrogen functionalization in graphene sheet. The shape of the graphene origami can be tuned and controlled by changing the content and width of H adatoms in the creases. The designed graphene origami is embedded into a metal matrix to achieve the tunability of negative Poisson's ratio. Our results demonstrate that a higher content of graphene origami in composites can lead to a larger negative Poisson's ratio. In addition, the ambient conditions have considerable effects on the auxetic behaviors of metal/graphene metamaterials. To facilitate structural analysis and engineering design, a modified micromechanics model capable of accurately predicting the mechanical properties of the nanocomposites is also developed based on physics embedded machine learning technique.