Mechanical behavior and material design of graphene-based nanocomposites

HengAn Wu*

Key Laboratory of Mechanical Behavior and Design of Materials, Department of Modern Mechanics, CAS Center for Excellence in Nanoscience, University of Science and Technology of China, Hefei, Anhui 230027, China

*Presenting author: wuha@ustc.edu.cn

Abstract

Graphene, the first two-dimensional (2D) atomic crystal available to us, is a one atom thick and closely packed 2D sp^2-bonded carbon honeycomb lattice. Due to a large number of its material parameters are supreme, such as mechanical stiffness, strength and elasticity, very high electrical and thermal conductivity, etc., graphene has attracted much attention from the scientific research community and graphene-based composites have shown immense potential in various applications. To break the limitation of graphene applications in engineering, subtle and ingenious macro/nano structural design has given rise to intense interest in graphene-based composites, which can significantly manipulate the mechanical and electronic properties of materials. In our recent studies, it is found that the graphene interface manifests strong/weak duality in composites under shock loading due to the in-plane and out-of-plane difference of strength. In graphene-copper lamellar nanomaterials, the copper layers impede the out-of-plane displacement of graphene monolayers, which highly improve the shear strength and toughness of composites. The strong in-plane sp^2-bonded graphene monolayers constrain the dislocations of copper layers, resulting in the remarkable self-healing ability of graphene-copper lamellar nanomaterials. Self-adaptive strain-relaxed electrode through crumpling of graphene to serve as high-stretchy protective shells can greatly improve and optimize the energy storage in lithium battery materials. The super-elastic and fatigue resistant carbon material with lamellar multi-arch microstructure demonstrates that many mature theories in structural mechanics for macrostructures can provide guidelines for developing microstructures to achieve unique mechanical properties. The essential tendency and insight obtained in our investigations might provide a valuable guideline for design and application of graphene-based macro/nano composites.

Keywords: graphene-based composites, nanomechanics, material design, molecular dynamics simulation