Strengthening and toughening mechanisms of a GNS/Mg composite with layered structure

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Abstract

Metal matrix composites often face a trade-off between strength and toughness, limiting their applications. Inspired by the shell nacre's unique "brick-and-mortar" structure, we designed a laminated GNSs/Mg composite by utilizing graphene nanosheets (GNSs) as nano-layers and magnesium (Mg) as micro-layers. Despite magnesium's low plasticity at room temperature, the micro-nano layered structure exhibits ultra-high strengthening and toughening efficiencies. Surface modification of GNSs and a strategic deposition process lead to effective densification, achieving a simultaneous improvement in strength and ductility. In-situ tensile testing, microstructure observation, molecular dynamics simulations, and electron backscatter diffraction analysis are employed to elucidate the mechanisms behind the enhanced properties. The study provides valuable insights into stress concentration, local strain, and crack propagation, offering a promising avenue for the development of lightweight, high-strength materials with improved ductility.

Keywords: Magnesium matrix composites, Graphene, Layered structure, Molecular dynamic simulation, Strengthening and toughening mechanisms

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