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Interfacial Investigation and Chemical Bonding in Graphene Reinforced Alumina Ceramic Nanocomposites

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Abstract : Thermally exfoliated graphene nanomaterial was reinforced into Al2O3 ceramic and the nanocomposites were consolidated using rapid high-frequency induction heat sintering route. The resulting nanocomposites demonstrated higher mechanical properties due to efficient GNS incorporation and chemical interaction with the Al2O3 matrix grains. The enhancement in mechanical properties is attributed to (i) uniformly-dispersed GNS in the consolidated structure (ii) ability of GNS to decorate Al2O3 nanoparticles and (iii) strong GNS/Al2O3 chemical interaction during colloidal mixing and pullout/crack bridging toughening mechanisms during mechanical testing. The GNS/Al2O3 interaction during different processing stages was thoroughly examined by thermal and structural investigation of the interfacial area. The formation of an intermediate aluminum oxycarbide phase (Al2OC) via a confined carbothermal reduction reaction at the GNS/Al2O3 interface was observed using advanced electron microscopes. The GNS surface roughness improves GNS/Al2O3 mechanical locking and chemical compatibility. The sturdy interface phase facilitates efficient load transfer and delayed failure through impediment of crack propagation. The resulting nanocomposites, therefore, offer superior toughness.

Keywords : ceramics, nanocomposites, interfaces, nanostructures, electron microscopy, Al2O3
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