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Graphene-Reinforced Silicon Oxycarbide Composite with Lamellar Structures Prepared by the Phase Transfer Method

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Abstract : Graphene was successfully introduced into a polymer-derived silicon oxycarbide (SiOC) matrix by phase transfer of graphene oxide (GO) from an aqueous (GO dispersed in water) to an organic phase (copolymer as SiOC precursor in diethyl ether). With GO concentrations increasing up to 2 vol%, graphene-containing flakes self-assembled into a lamellar structure in the matrix leading to composite with the anisotropic property. Spark plasma sintering (SPS) was applied to densify the composites with four different GO concentrations (0, 0.5, 1 and 2 vol%) up to ~2.3 g/cm3. The fracture toughness of SiOC-2 vol% GO composites was significantly increased by ~91% (from 0.70 to 1.34 MPa·m$^{1/2}$), at the expense of a decrease in the flexural strength (from 85MPa to 55MPa), compared to SiOC-0 vol% GO composites. Moreover, the electrical conductivity in the perpendicular direction ($\sigma^{\perp}$=3×10^{-1} S/cm) in SiOC-2 vol% GO composite was two orders of magnitude higher than the parallel direction ($\sigma^{\parallel}$=4.7×10^{-3} S/cm) owing to the self-assembled lamellar structure of graphene in the SiOC matrix. The composites exhibited increased electrical conductivity ($\sigma^{\perp}$) from 8.4×10^{-3} to 3×10^{-1} S/cm, with the increasing GO content from 0.5 to 2 vol%. The SiOC-2 vol% GO composites further showed the better electrochemical performance of oxygen reduction reaction (ORR) than pure graphene, exhibiting a similar onset potential (~0.75V vs. RHE) and more positive half-wave potential (~0.6V vs. RHE).

Keywords : composite, fracture toughness, flexural strength, electrical conductivity, electrochemical performance
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