

A Comparison of the Microstructural and Tribological Properties of TiB₂–TiC Composites Doped with Graphene Nanoplatelets and Hexagonal Boron Nitride

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Titanium diboride (TiB₂) is an important advanced-technology ceramic for applications requiring high-temperature and wear resistance, based on its high melting temperature, hardness, and chemical stability. However, its low fracture toughness and limited sinterability behavior restrict the use of TiB₂ in monolithic form. In this study, the effects of graphene nanoplatelets (GNPs) and hexagonal boron nitride (hBN) additions on the densification behavior, microstructure, mechanical properties and wear resistance of TiB₂–TiC composites were investigated comparatively. Composites prepared by adding GNPs or hBN (2 and 3 vol.% separately) into the TiB₂–TiC matrix containing 80% TiB₂ in volumetric ratio were produced using the spark plasma sintering (SPS) method at the temperature of 1700 °C, under a pressure of 40 MPa, and with a dwell time of 5 min. XRD analyses revealed no crystalline phases other than TiB₂ and TiC. While a relative density of 99.9% was achieved in the matrix, this value remained above 99% in the GNPs-incorporated composites, whereas it decreased to approximately 97.9% in the hBN including specimens. Microstructural evaluations revealed that the additives were agglomerated in some areas within the matrix and that residual porosity formed, particularly in the hBN-doped composites. The Vickers hardness values of the composites containing 2 vol.% GNPs and hBN were 24.0 and 22.4 GPa, respectively, compared with 24.9 GPa for the TiB₂–TiC matrix composite. It was found that both additives resulted in no significant improvement in fracture toughness. Wear tests revealed that the GNPs-reinforced composite exhibited behavior similar to that of the unreinforced matrix, while the hBN reinforcement had a negative effect on wear resistance. The results indicate that, among the ternary composites, the addition of 2 vol.% GNPs is more advantageous in terms of maintaining the density and mechanical properties.

Keywords: TiB₂–TiC composites, layered additives, UHTC, spark plasma sintering (SPS)