Journal of Alloys and Compounds

Spark plasma sintering of Ti-Ni-TiCN composites: Microstructural characterization, densification and mechanical properties

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https://www.sciencedirect.com/science/article/pii/S0925838820329236

Abstract

Ti–Ni–TiCN composites with varying TiCN contents (5, 10 and 15 wt%) were consolidated using the novel spark plasma sintering technique at a sintering temperature of 1100 °C, for 10 min holding time under a vacuum condition of lower than 4 Pa, 100 °C/min heating rate and applied pressure of 50 MPa. The effects of Ni additive and TiCN nanoceramic reinforcement content on densification, microstructure and mechanical properties of the developed composites were investigated. Scanning electron microscopy (SEM) equipped with energy dispersive X-ray spectroscope (EDS) and X-ray diffraction (XRD) techniques were employed to study the morphology and phases present in the developed composites. SEM results revealed the presence of undissolved particles and lamella arrangements of phases within the matrix of the sintered composites which were confirmed by the EDS and XRD results as undissolved TiCN particles, in-situ formed TiN and Ti(sub2)Ni intermetallic phases. The relative density of the sintered compacts decreased from 99.3% to 98.23% with increase in the reinforcement content. The hardness of the sintered composites was found to increase with increasing reinforcement content. Compressive test results indicated that Ti–Ni–TiCN composites displayed improved compressive strength than the pure Ti samples. The optimum properties were obtained in Ti–6Ni–10TiCN composite with Vickers hardness of 398 HV(sub1.0), compressive yield and ultimate strengths of about 998 MPa and 1156 MPa respectively.