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The development of whisker and cubic boron nitride reinforced titanium carbide ceramic matrix composites

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ABSTRACT

TiC as the matrix in ceramic matrix composites (CMC's) is limited due to its poor fracture toughness. In order to increase their use in interrupted cutting applications, it is necessary to improve their fracture toughness and hardness. The purpose of this study was to improve the fracture toughness of TiC without causing a decrease in its other mechanical properties by adding SiC whiskers to the starting TiC powder before Spark Plasma Sintering (SPS). To improve the hardness cBN was also added as a secondary hard phase prior to sintering. The reinforced powders where then sintered at temperatures between 1550°C and 1650°C, under pressures of 50-70 MPa and hold times between 5-20 minutes. The resulting materials were then characterized by density, hardness, fracture toughness, biaxial strength, sliding wear testing and scanning electron microscopy.

Analysis of the hardness and fracture toughness of the sintered TiC matrix compacts with/without SiO_2 concluded that the sintered sample with the highest hardness was found to be 90TiC-8Al_2O_3-2Y_2O_3 SPS'd at 1625°C, 70MPa and the sintered sample with the highest fracture toughness was determined to be 90TiC-8Al_2O_3-2Y_2O_3 SPS'd at 1625°C, 50MPa. From the XRD results we observed that the SPS material with the highest fracture toughness had formed YAP instead of YAG during sintering.

The 77.8TiC-6.9Al_2O_3-1.7Y_2O_3-14 (20 vol.%) SiCw composition had the greatest ultimate fracture strength of 152.67 GPa and a Weibull modulus of 26.973 which is higher than unreinforced engineering ceramics but similar to other CMC's reinforced with ceramic fibres. Out of all the compositions tested the 78.6TiC-3.5Al_2O_3-5.6Y_2O_3-4.9SiO_2-7.5 (10 vol.%) cBN removed the most material and had the lowest frictional coefficient making it suitable for use as a cutting blade.