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Short Communication

Effect of SiC whisker addition on the microstructures and mechanical properties of Ti(C, N)-based cermets

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ABSTRACT

Ti(C, N)-based cermets with addition of SiC whisker (SiC_w) were prepared by vacuum sintering. The microstructures of the prepared cermets were investigated by using X-ray diffractometry (XRD) and scanning electron microscopy (SEM). Mechanical properties such as transverse rupture strength (TRS), fracture toughness (K_{IC}) and hardness (HRA) were also measured. It was found that the grain size of the cermets was affected by the SiC whisker addition. The cermets with 1.0 wt.% SiC whisker addition exhibited the smallest grain size. The porosities of the cermets increased with increasing SiC whisker additions. The addition of the SiC whisker had no influence on the phase constituents of the cermets. Compared with the cermets with no whisker addition, the highest TRS and fracture toughness for cermets with 1.0 wt.% SiC whisker addition increased by about 24% and 29%, respectively. The strengthening mechanisms were attributed to finer grain size, homogeneous microstructure and moderate thickness of rim phase. The toughening mechanisms were characterized by crack deflection, whisker bridging and whisker pulling-out.

1. Introduction

Ti(C, N)-based cermets have excellent wear-resistance, high hardness at high temperature, perfect chemical stability, very low friction coefficient to metals, superior thermal deformation resistance [1–3]. At present, Ti(C, N)-based cermets have been successfully introduced in the metal cutting industry and are now competing, in prices and properties, with conventional hard metals at high speed cutting, finishing and milling operations [4,5]. However, the low fracture toughness has long prevented the cermets from being used with wide application. Its susceptibility to brittle fracture can lead to unexpected catastrophic failure.

SiC whiskers combine high strength, high elastic modulus and good thermal stability, thereby increasing attention has been paid to composites reinforced by the SiC whiskers since the report by Becher and Wei in 1984 [6]. In previous studies, SiC whiskers have been successfully used as reinforcements incorporated into ceramic materials [7–11]. Incorporation of a second phase to the matrix, such as whiskers, fibers or carbon nanotubes, offers an effective toughening increase for ceramic matrix composite [12–14]. However, Ti(C, N)-based cermets reinforced and toughened by SiC whiskers have not been reported up to date.

In the present study, the effects of SiC whisker addition on the microstructures and mechanical properties of Ti(C, N)-based cermets were investigated. The strengthening and toughening mechanisms were also studied.

2. Experimental procedure

Commercially available TiC (0.51 μm), TiN (0.52 μm), WC (0.85 μm), Mo (2.60 μm), Ni (1.70 μm), Cr_3C_2 (3.2 μm), C (5.5 μm) and SiC_w were used as raw materials. The SiC whiskers used here have an average diameter of 0.1–2.5 μm and a length of 50–500 μm supplied by Xuzhou Hongwu Nanometer Material Co., Ltd., China. The compositions of cermets with different SiC whisker additions considered in the present study are given in Table 1.

These powders without the SiC whiskers were dispersed homogeneously and mixed for 22 h in a QM-1SP planetary mill with a mass ratio of cemented carbides balls to mixture being 7:1, and the rotational speed being 260 rpm (rotations per minute). Then, the SiC whiskers, which were dispersed in alcohol for 30 min by ultrasonication, were mixed with the milled powders for 2 h. After milling, the slurries were dried at 353 K in an infrared stove, and then sieved through 80 mesh. The powders were pressed into green compacts with dimensions 39 mm × 8 mm × 8 mm at 100 MPa for 30 s. The green compacts were sintered at 1723 K in vacuum for 1 h. The vacuum was controlled at 10^{-2} to 1 Pa during liquid sintering.

The hardness and TRS at room temperature were measured. The fracture toughness (K_{IC}) of the sintered cermets were determined by measuring the crack length near the indent made by Vickers

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