SINTERING AND MECHANICAL PROPERTIES OF TITANIUM DIBORIDE WITH SILICON CARBAIDE AS A SINTERING AID

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INTRODUCTION

The intrinsic brittleness is a key problem in the widespread application of the ceramic materials. In order to reduce the brittleness and to increase the strength and the toughness, varieties of toughening mechanisms , such as the crack deflection, crack bridging, crack branching, crack bowing, crack pinning, microcracking, thermal residual stress toughening, transformation toughening and the synergism toughening, etc. have been proposed in the past decades [9]. Titanium diboride (TiB_2) is well known as a ceramic material with relatively high strength and durability as characterized by the relatively high values of its melting point, hardness, strength to density ratio, and wear resistance [10]. However, the use of this single phase ceramic, even fully densified, in structural or wear applications is limited by its poor flexural strength and fracture toughness [8]. To improve TiB_2 sinterability, transition metals such as iron, nickel, and cobalt have been used as sintering aids. However, the presence of metallic phases at the grain boundaries after sintering are not desirable for hard and stiff ceramics. Many attempts have been made to improve the mechanical properties and sinterability of TiB_2 by adding nonmetallic secondary phases such as SiC, titanium carbide (TiC), and boron carbide (B_4C) or oxides such as alumina (Al_2O_3) and zirconia (ZrO_2) [5-7]. reinforcing component is often in the form of particles or whiskers [8].The primary role of these additives is the removal of the oxide layer (titania, TiO_2) that exists on the surface of the TiB_2 starting material. The sinterability and the mechanical properties improved remarkably when SiC or Si_3N_4 was added [6].

EXPRIMENTAL PROCEDURE

A monolithic TiB_2 was used as the baseline sintering material. As a sintering aid, SiC powder was added in various amounts up to 30 vol.%. SiC is an extremely hard and wear resistant material which has, furthermore, excellent corrosion, thermal shock and oxidation resistance. All of these properties together with its good high temperature strength allow the use of SiC for numerous structural and wear applications, e.g. heat exchangers, metal working parts and nozzles. However, the moderate fracture toughness of SiC limits its use [11]. The physical properties of TiB_2 and SiC used to fabricate TiB_2/SiC composites are summarized in Table 1 [8]. The micro powders were mixed by wet planetary milling for 2 h and using alcohal as the grinding media. After mixing, the slurry was dried in a magnetron and passed through a 60-mesh screen. The powder mixtures were isostatic pressed under an applied pressure of 120 Mp and sintered at 1600 °C for 1 h. The grain-boundary phases were identified using an X-ray diffractometer. Specimens for mechanical testing were cut from the isostatic Pressed disks and machined into rectangular bar. Each specimen was ground with a diamond wheel and polished with diamond slurries. The specimens' edges were chamfered to minimize stress concentration effects from machining flaws. At the end mechanical testing, density, Vickers

Table 1: physical properties of TiB_2 and SiC [8].

Material	Density (g/cm^3)	Young's modulus (GPa)	Poisson ratio	Melting point (°C)	Thermal expansion (10^{-6}/K)	Purity (%)
TiB_2	4.52	530	0.28	2790	8.1	>99
SiC_w	3.29	550	0.14	2540	4.7	>99

hardness, bend strength, and fracture toughness of the TiB_2/SiC composites were measured by different methods.

RESULTS AND DISSCUTION

Jin et al. have ever studied the size effect of the reinforcement phase in composite ceramic materials. They pointed out that the smaller size ratio between the dispersed particles and the matrix grains will result in the higher strength of the material [9]. When 5vol% SiC was added, densification behavior of TiB_2 were improved. The densities of the composites decreased with increase of the SiC. This shown that the sintering ability of SiC was lower than that of TiB_2. The lack of increase in flexural strength of the composites with increasing volume fraction of SiC whisker can be explained by a decrease in relative density associated with SiC agglomerate. Unlike flexural strength, fracture toughness increased by crack deflection and whisker bridging. The crack deflection and whisker bridging were thought to be caused by the thermal expansion and elastic modulus mismatch between SiC and TiB_2 in the composites. Morphologies of the composites were observed by SEM. It shown The densification was further improved when the amount of SiC was increased to 5 vol.%. However, too much SiC (≥5 vol.%) did not help the material's densification and secondary phases was appeared at grain boundaries. The specimen compositions were analyzed using the XRD patterns. these patterns were shown the secondary phases.

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