On the microstructure of the pressureless sintered $TiC-TiB_2$ composite.

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1. Introduction

TiC and TiB_2 materials commonly have a metallic character, high melting point (~3000℃), high thermal and electrical conductivity and high hardness. However, the monolithic phase of these materials is not favorable to be used in many applications bacause of their poor sinterability. Prolonged heat treatment at high temperature results in an exaggerated coarsening and therefore causes the internal cracking induced by the internal stress during the cooling process after the sintering process. TiC exhibits relatively high resistance to fracture because of five independent slip systems and TiB_2 is used as a major constituent of highly wear- and temperature-resistant structural ceramics. Therefore, the excellent materials properties would be expected by the combination of these components.

2. Experimental results

Three different compositions of the $TiC-TiB_2$ mixtures with the different amounts of the sintering aids (Ni and Fe) were pressurelessly sintered at the temperatures of 1600℃, 1800℃ and 2000℃, respectively.

2.1 Sintered densities of the $TiC-TiB_2$ composite.

The maximum sintered density reached to about 95% of theoretical density. Sintered densities increase with the sintering temperature and the amounts of sintering aids added. However, the addition of sintering aids more than 1.0wt% Fe and 3.0wt% Ni decreased the sintered densities (see Table 1).

Table.1 Relative densities of the sintered specimens (% of the theoretical).

Composition		Sintering conditions			
		1600℃-2hours	1800℃-2hours	2000℃-2hours	2000℃-20hours
Hypoeutectic	HO1	82.79 (0.40)	86.98 (0.32)	89.02 (0.29)	90.53 (0.31)
	HO2	-	-	-	93.17 (0.15)
	HO3	-	-	-	94.18 (0.08)
	HO4	-	-	-	92.49 (0.24)
Eutectic	E1	81.50 (0.46)	86.01 (0.62)	88.11 (0.54)	89.32 (0.04)
	E2	-	-	-	94.46 (0.46)
	E3	-	-	-	94.48 (0.11)
	E4	-	-	-	93.12 (0.23)
Hypereutectic	HR1	82.50 (0.16)	87.02 (0.18)	88.66 (1.29)	88.86 (0.08)
	HR2	-	-	-	94.81 (0.07)
	HR3	-	-	-	94.44 (0.10)
	HR4	-	-	-	93.65 (0.26)

2.2 Microstructure of the TiC+TiB_2 composite.

Figure 1 is backscattered SEM images of the samples which exhibited the maximum sintered densities of three different compositions. It is seen that TiB_2 grains are distributed homogeneously as discontinuous phases in the TiC matrix and their grain growth was retarded by TiC matrix.

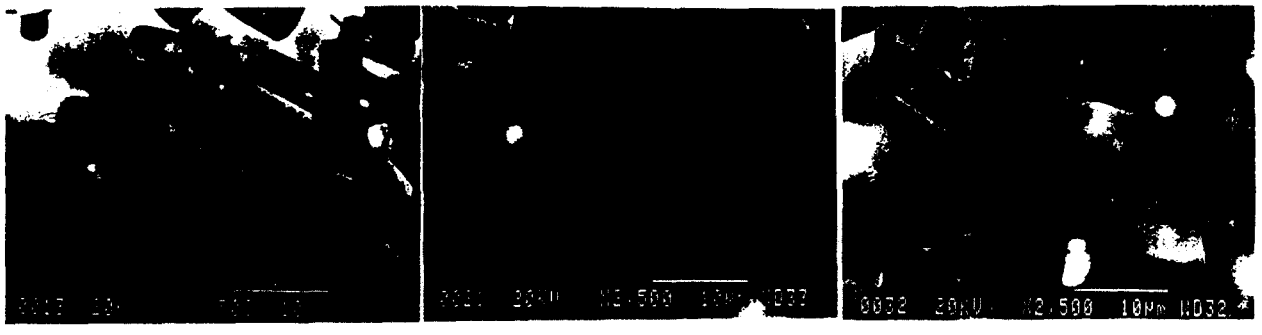

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Fig.1 Backscattered SEM of the samples showing the maximum densities.

TEM analysis was performed to characterize the well developed phase boundaries and microdefects of these TiC-TiB_2 composites. It was found that Ni-rich phases were found on the triple junction of TiC grains (see Figure 2(a)) and on the phase boundary between a discontinuous TiB_2 phase and continuous TiC matrix phases (see Figure 2(b)). It could be explained by the assumption that these Ni-rich phases

had been present in liquid phase during the sintering process and were solidified to a Ni-rich phase during the cooling process. This explanation was reinforced by the fact that there were many waved and/or step grain (or phase) boundaries which are usually found in the presence of the liquid phases, present in the microstructure of the specimens (see Figure 3).

It was also found that these Ni-rich phases, which are nanometer-sized, play a role on generating the dislocation formation in the matrix grains (see Figure 4).

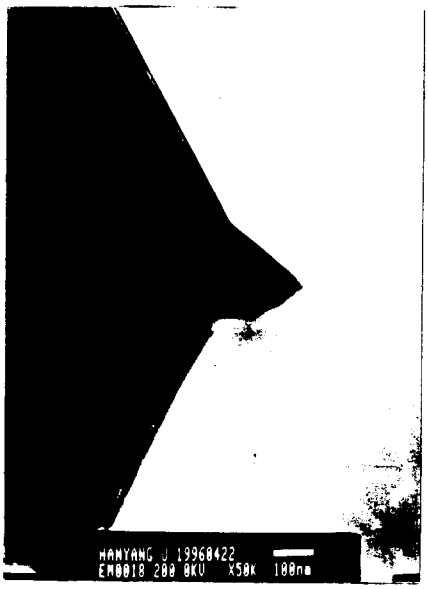

Fig.2(a) Ni-rich phases precipitated on the triple junction of TiC grains.

Fig.2(b) Ni-rich phases precipitated on the phase boundary between TiB_2 phase and TiC matrix.

Fig.3 Waved and step grain(or phase)boundaries.

Fig.4 Ni-rich phases providing the origin of the dislocation formation.