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Effect of Chopped Carbon Fiber on Mechanical Properties of ZrB2-SiC Composite

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1- Introduction

Zirconium diboride belongs to the refractory transition metal deboride from the fourth to the sixth group of the periodic table. Most of these diborides have melting point above 3000 °C, making them potential candidates for thermal protection structures for leading-edge parts on hypersonic re-entry space vehicles at over 1800 °C.

Nonetheless its low fracture toughness has long prevented this material from being used in wide applications. Its susceptibility to brittle fracture can lead to unexpected catastrophic failure. One major research direction has been to increase its fracture toughness by incorporating fibers into the base material to form a ceramic matrix composite due to their reduced weight and damage tolerant behavior. Carbon fiber reinforced ZrB_2-based composites are interesting materials for these applications, due to their reduced weight and damage tolerant behavior. Main reason for the lack of large scale applications is the high cost of manufacturing composites reinforced with continuous carbon fibers. This limitation can be partly alleviated by use of carbon short fibers. So, in this research, the effect of short carbon fiber on fracture toughness of ZrB_2-SiC composite were studied.

2- Experimental

The initial powders were prepared in the first step. Specification of powders are given in Table 1. Then the powders, according to Table 2, were mixed by wet ball-milling at 200 rpm for 3 h in a zirconia bottle, using zirconia balls and ethanol as media.
The mixtures were then dried. The powder mixture was put into graphite die lines with graphite foil with an inner diameter of 50 mm and sintered using SPS apparatus (SPS-20T-10, China). The sintering was performed at 1800 °C, under the pressure of 40 MPa and holding time of 6 min.

The graphite layer was removed by polishing. For fracture toughness evaluation, the polished samples were cut in dimension of 3*4*22 mm^3. SENB method was applied for fracture toughness evaluation. The hardness was measured by Vickers. For this purpose, five correct indents were created on composites by using 30 Kg force.

Table 1 Specification of powders

Powder	Grain size mμ
ZrB_2	20
SiC	25
C_f	T800, 5

Table 2 Composition of composites and their symbol

ZrB_2, vol%	C_f, vol%	SiC, vol%	Symbol
70	10	20	$ZS10C_f$
60	20	20	$ZS20C_f$
50	30	20	$ZS30C_f$
40	40	20	$ZS40C_f$

3- Results and Discussion

Fig. 1 shows the carbon fiber dispersed in matrix of $ZS10C_f$ composite. Carbon fibers are shown by red arrows. Time-Temperature-Displacement curves of all composites are given in Fig. 2. It can be seen by carbon fiber ascent content, the shrinkage was reduced.

Effect of C_f on relative density and open porosity is shown in Fig. 3. Carbon fiber has negative effect on relative density and resulted in increased open porosity. Fig .4 shows C_f effect on hardness.

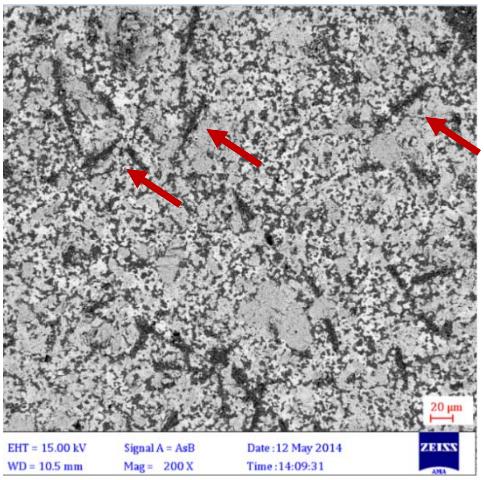

Fig. 1 SEM image of $ZS10C_f$

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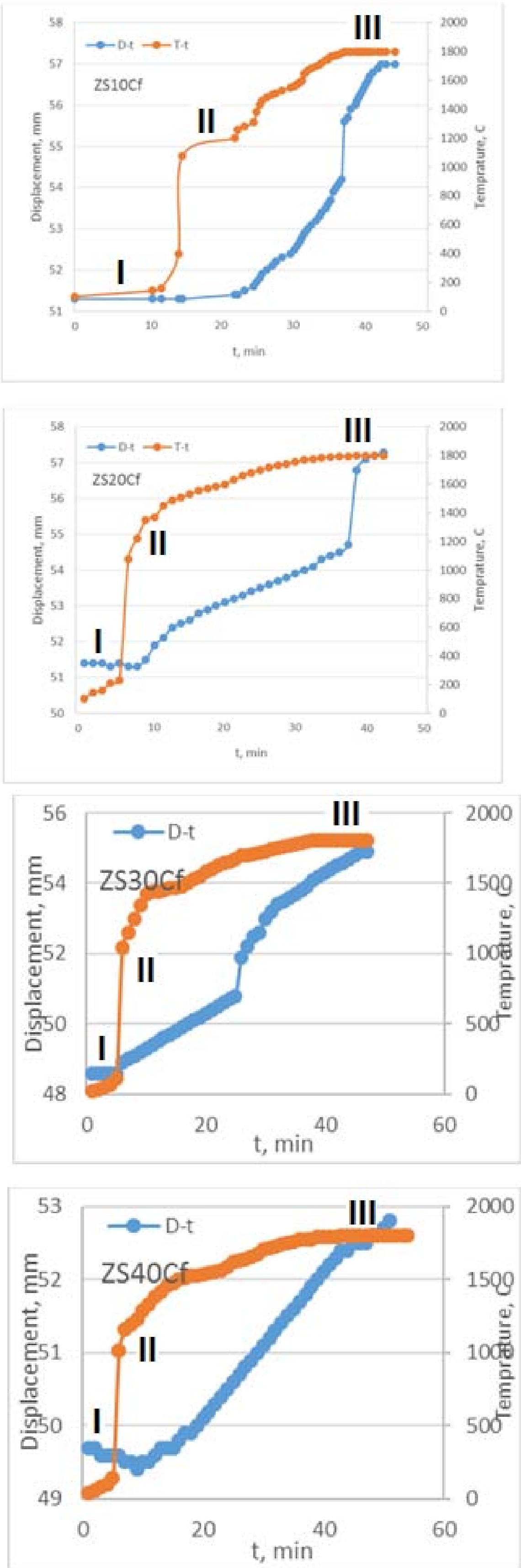

Fig. 2 Time-Temperature-displacement curves of composites.

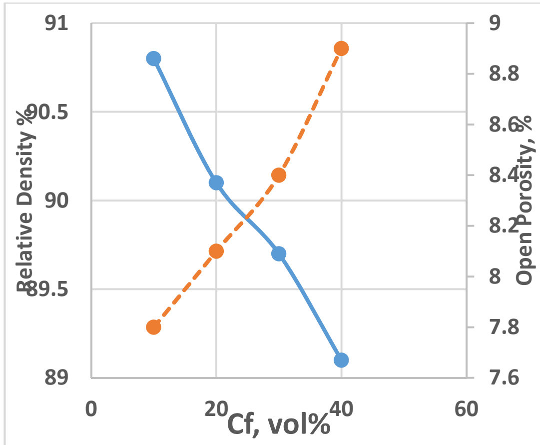

Fig. 3 Effect of C_f on relative density and open porosity

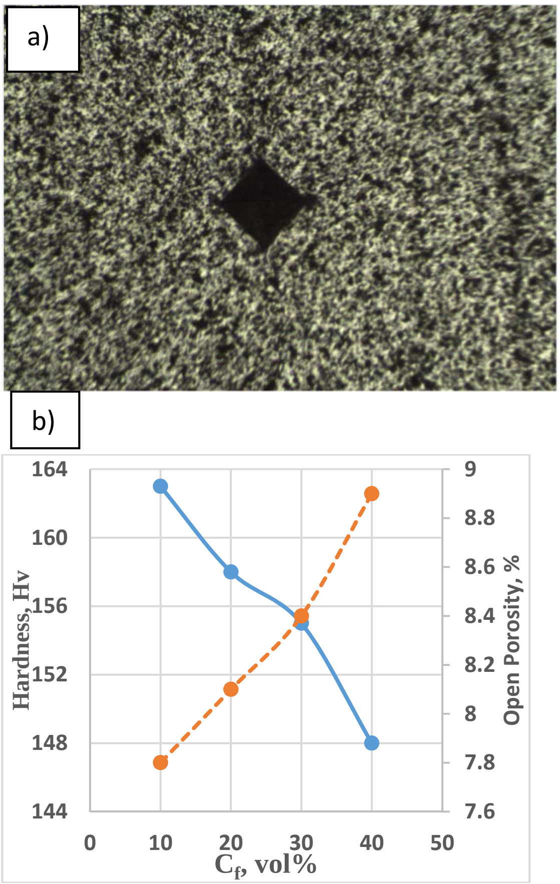

Fig. 4 Effect of C_f on hardness

4- Conclusions

By increasing the carbon fiber amount, the relative density decreases and the open porosity increases. Carbon fiber addition improved fracture toughness due to activation of toughening mechanism such as crack deflection.

Addition of C_f in this range has no significant effect on hardness.