Journal of Ceramic Processing Research. Vol. 9, No. 6, pp. 649~651 (2008)

J O U R N A L O F
Ceramic Processing Research

A study of SiC/Al composites fabricated by pressureless infiltration

Kezheng Sang[a],* and Chunfeng Wan[a]
[a]*School of Material Science and Engineering, Chang'an University, Xi'an 710064, P.R.China*

SiC/Al composites with a high volume fraction of SiC were prepared at 1,150 °C by pressureless infiltration. The volume fraction of SiC was increased by decreasing the amount of starch in the green body. Both the microstructure and the strength of the composites were investigated. The results showed that the strength decreased with an increase of the particle size and volume fraction of SiC. It is suggested that the interface between the SiC particles, which were not sintered, are the cause of defects in the composites. The defects led to a decrease of the strength with an increase of the volume fraction of SiC.

Key words: SiC/Al composite, Pressureless infiltration, Volume fraction, Strength.

Intrduction

SiC/Al composites have been wildly used due to their high specific strength, high thermal conductivity, high wear resistance and low thermal expansion coefficient. Compared with the traditional composite, composites with a high volume fraction of SiC have received more attention because of further improved properties and have been widely investigated in recent years [1, 2]. This type of SiC/Al composites is hard to fabricate by a traditional casting method because of the high volume fraction of SiC, instead an infiltration technique is preferred [3, 4]. However the microstructure and the mechanical properties of the composites still need to be studied. In the present study, composites with a high volume fraction of SiC were prepared by pressureless infiltration. The microstructure and effects of the volume fraction and particle size of SiC on the bending strength are studied.

Experimental Procedure

The SiC powder and starch (5 %wt, 10 %wt, 15 %wt and 20 %wt respectively) were mixed, and then about 2 %-5 %wt phenol-formaldehyde resin was added into the mixture. The green body was obtained with a forming pressure of about 175 MPa. The dried green body was put into a crucible with industrial grade pure aluminum. Then the crucible was heated up to 1,150 °C and held for 2 hours. To obtain data of the volume fraction of SiC, some green bodies were sintered but not infiltrated (i.e. no aluminum were added into the crucible) with the same temperature and time conditions.

The density and open porosity of the composites were measured by Archimedes' method. The strength of the composites was measured using a 3-point bending test. The microstructure and fracture morphology were analyzed by a scanning electron microscope (SEM).

*Corresponding author:
Tel : +86-29-82336887
Fax: +86-29-82336887
E-mail: sangkz@hotmail.com

Results And Discussion

Composites could be obtained in the present study. Infiltration of the aluminum into the SiC green body seemed complete. The porosity and the density of the composites are shown in table1. The microstructure of sample 3 is shown in Fig. 1.

Table 1. Composites and their properties

Sample	SiC Size (μm)	Starch content (%)	Volume fraction of SiC (%)	Density ($g \cdot cm^{-3}$)	Porosity (%)
1	7	5	64.5	2.88	0.8
2-1	20	5	62.9	2.68	2.9
2-2	20	10	59.9	2.74	3.3
2-3	20	15	55.8	2.82	2.2
2-4	20	20	51.8	2.85	0.9
3	40	5	62.6	2.74	2.2
4	63	5	65.5	2.73	6.2
5	83	5	59.7	2.66	6.7

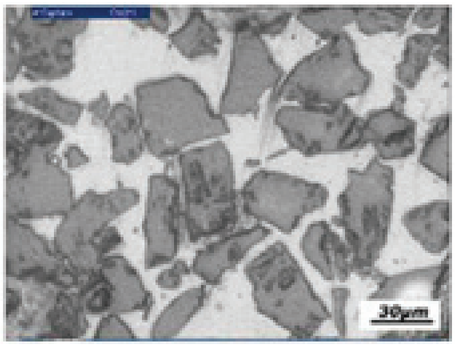


Fig. 1. Microstructure of the SiC/Al composite (sample 3).

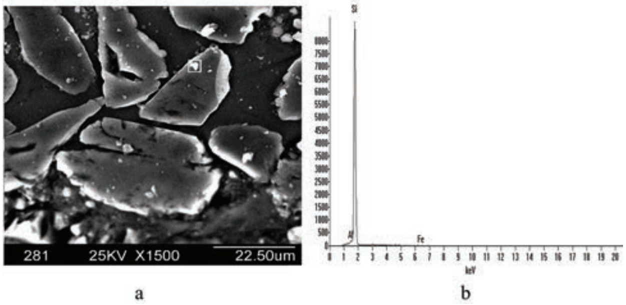


Fig. 2. Small white products (□) on the SiC surface, a) metallographic surface (sample 3); b) chemical composition at ' □ ' by EDX.

The interface between the SiC and aluminum was not investigated thoroughly in the present study. However 'a single Si' was observed on the SiC surface, as shown in Fig. 2 This result agrees with another report [5]. It is suggested that "the single Si" comes from the following reaction [6, 7]:

$$Al+SiC \rightarrow Al_4C_3+Si \quad (1)$$
$$4Al+4SiC \rightarrow Al_4SiC_4+3Si$$

So chemical wetting took place at the interface and the combination between SiC and aluminum should give a better composite.

Both the particle sizes and volume fraction of the SiC had effects on the strength of the composites, as shown in Fig. 3 and Fig. 4 respectively. It can be seen that the strength of the composites decreased with an increase of the particle size and the volume fraction of SiC.

The composites in the present study, which contained more than 50% volume fraction of SiC particles, still belong to the class of metal matrix composites. This is because the sintering between the SiC particles does not basically take place during the preparation of the composites in the present study. Most SiC particles are surrounded by the aluminum matrix; the others come into contact with each other (Fig. 1). The contact interface between the SiC particles is a defect in the composites. The characteristics of the microstructure for the composites in the present study are schematically shown in Fig. 5, where "F" refers to the defects.

Based on the above characteristics of the microstructure, it is easy to understand that the strength of the composites decreases with an increase of the particle size. The smaller SiC particles divide the aluminum matrix into smaller volumes than do the bigger ones. This limits the movement of dislocations in the aluminum matrix during the deformation process. Hence a higher strength of the composites results. However the effect of the volume fraction of SiC on the strength of the composites is different from that of traditional composites which contain less than 40% volume fraction of SiC particles. Here it is suggested that the defects between the contacting SiC particles will increase with an increase of the volume fraction of SiC in the present study which led to a decrease of the strength.

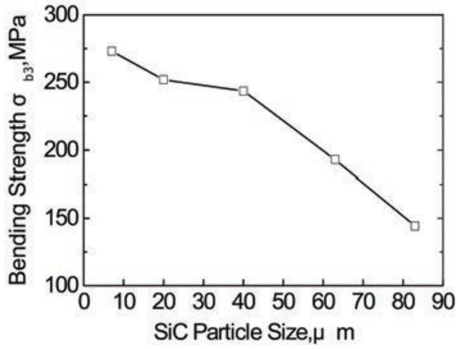


Fig. 3. Influence of particle size on bending strength of SiC/Al.

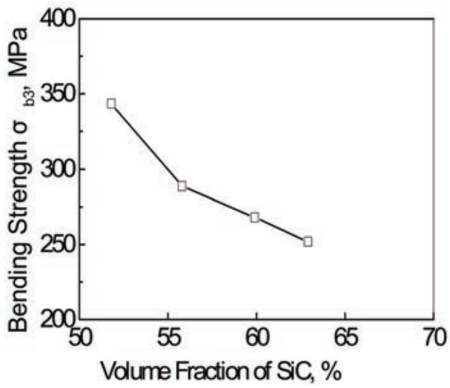


Fig. 4. Influence of volume fraction of SiC on bending strength of SiC/Al.

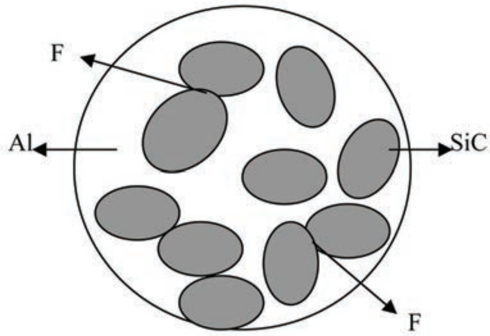
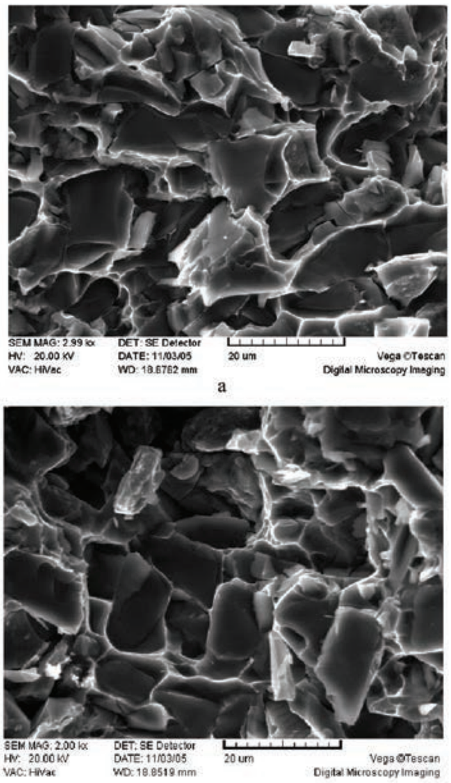


Fig. 5. Schematic showing the microstructural model of SiC/Al composite.

The fracture morphology for the composites is shown in Fig. 6. It can be seen that the features indicating toughness decrease obviously with an increase of the volume fraction of SiC. It is also noticed that defects exist in the left-upper part of Fig. 6b.

Summary

SiC/Al composites with a high volume fraction (50% -70%) of SiC can be fabricated at 1,150 °C by pressureless



b

Fig. 6. Fractograph of the composites: a) sample 2-2; b) sample 2-1.

infiltration. However these composites are still metal matrix composites although they contain more than 50% volume fraction of SiC. The bending strength test showed that the strength decreased with an increase of the particle size and volume fraction of SiC. It is suggested that the interfaces between SiC particles, which were not sintered, act as defects in the composites. The defects increased and led to a decrease of the strength with an increase of the volume fraction of SiC.

References

1. H.S. Lee and S.H. Hong, Mater.Sci. and Tech. 19[8] (2003) 1057-1064.
2. Y. Cui, Key Engineering Materials. 249 (2003) 45-48.
3. N. Altinkok, A. Demir, Y. Karakas, and I. Ozsert, Composites Part A: Applied Science Manufacturing. 34[7] (2003) 577-582.
4. B.S. Murty, S.K. Thakur, and B.K. Dhindaw, Metallurgical and Materials Transactions A: Physical Metallurgy and Materials Science. 31[1] (2000) 319-325.
5. X. Sui, C. Luo, L. Ouyang, and Z. Luo, The Chinese Journal of Nonferrous Metals. 9[1] (1999) 20-24.
6. J.C. Romero and R.J. Arsenault, Acta Metallurgica et Materialia. 43[2] (1995) 849-857.
7. J.C. Viala, P. Fortier and J. Bouix, J. Mater. Sci. 25[3] (1990) 1842-1850.