MECHANICAL PROPERTIES OF CARBON FIBER REINFORCED CERAMICS COMPOSITES BY CVI

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INSTRUCTION

Fiber-reinforced ceramic-matrix composites have recently attracted attention for use in high temperature structural applications [1]. The primary reason for this interest lies in the assumption that strong fibers can prevent catastropic brittle failure in ceramics by providing various energy-dissipation process during crack advance [2]. However,overcome is that some ceramic fabrication process tend to mechanically and chemically damage the fibers when they are consolidated whthin a ceramic matrix. The most common processing method in preparation of carbon fiber reinforced ceramic composites is chemical vapor infiltration (CVI) which process is good for overcoming damaging the carbon fiber. In a previously study, the authors reported fabrication of non-circular carbon fiber to increase mechanical properties [3,4] and to be coated carbon fiber to improve oxidation resistance by CVD/CVI [5-7].

The purpose of this study is to investigate the effect of SiC coating and the shape of carbon fiber on the mechanical properties of carbon fiber reinforced ceramics for improving fiber-matrix bonding in reinforced composites.

EXPERIMENTAL

Carbon fibers which are circular, C-shape and SiC deposited C-shape are added respectively to Si_3N_4 manufacture ceramics composites for investigation of CVI process and chracteristics of carbon fiber reinforced ceramics composites. The properties of their carbon fibers manufactured on laboratory scale for this study are listed in table 1. The thickness of the surface coating of SiC-coated carbon fiber was about 300nm. The composition of slurry use for impregnation of carbon fibers are listed in table 2. The composite are fabricated using powder lay-up techniques. The powder lay-up preform was densified using hot pressing at 1750℃ under pressure of $300kg/cm^2$ for 2hrs in N_2 atmosphere. The strengths of the composite were measured utilizing three-point flexure and tensile testing.
Specimens were mounted in a three-point bending fixture with a span length of 20mm and were loaded to failure on an instron machine at a crosshead speed of 0.5㎜/min. Scanning electron microscopy were used to characterize the microstructure. X-ray diffraction analysis was used to study the phases present in the materials.

RESULTS AND DISCUSSION

Fig.1 shows comparision of flexural strength of ceramics composites with various carbon fibers. The flexural strength of carbon-fiber reinforced Si_3N_4 composites is found to be lowered with the addition of carbon fibers. The flexural strengths of circular and C-type carbon fibers reinfoced compositles are similar to each other, and the flexural strength of SiC-deposited C-type carbon fibers reinforced composite is higher by 15% than the previous ones. It is believed that circular and C-type carbon fiber reinforced composites have a lot of defects, whereas SiC-deposited carbon fiber reinforced composite have relatively a few defects due to the dense bonding with the Si_3N_4 matrix.
Fig.2 shows comparision of fracture toughness of ceramics composites with various carbon fibers. The fracture toughness of carbon fiber reinforced composites is increased with the addition of carbon fiber. The fracture toughness of SiC-deposited C-type carbon fiber reinforced composite is increased by 50%. It is found through microstructure observation that the cracke are deflected due to the residual compressive carbon fibers by producing fiber pull-out for 3-types of composites, the circial cleavage for C-type carbon fibers reinfoced composites, and the difference in the thermal expansion of Si_3N_4 and SiC for SiC-deposited

C-type carbon fiber reinforced composite.

CONCLUSIONS

The flexural strengths of circular and C-type carbon fibers reinfoced composities are similar to each other, and the flexural strength of SiC-deposited C-type carbon fibers reinforced composite is higher by 15% than the previous ones. The fracture toughness of carbon fiber reinforced composites is increased with the addition of carbon fiber. The fracture toughness of SiC-deposited C-type carbon fiber reinforced composite is increased by 50%.

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Table 1. Properties of carbon fibers for ceramics composites

	Round type	C type	SiC coated C type
Tensile strength [kg_f/mm^2]	130	162	122
Tensile modulus [ton/mm^2]	17	20	17.7
Torsional Rigidity [Gn/m^2]	6.2	12.3	11.6
Density [g/cm^3]	1.80	1.80	1.81
Diameter [μm] (D_o/D_i)	12	24/13	-

Table 2. The composition of slurry for the impregnation of carbon fibers

	Material	Wt(%)
Powder	Si_3N_4 Polysilazane	33.0 20.0
Solution	Toluene IPA MEK	24.0 16.0 4.0
Binder	PVB 98 DBP	2.0 1.0

NOTE) IPA : Isopropyl alcohol
MEK : Methylethyl ketone
PVB 98 : Polyvinyl buthyl 98
DBP : Dibuthyl phthalate

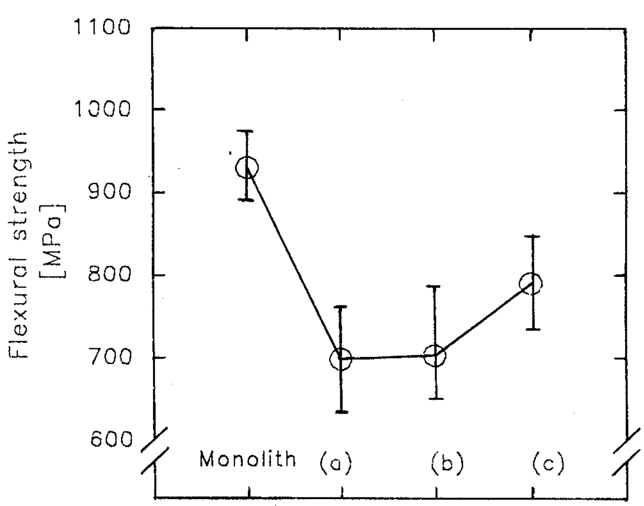

Fig. 1. Comparision of flexural strength of ceramics composites with carbon fibers.
(a) R type (b) C type
(c) SiC coated Ctype

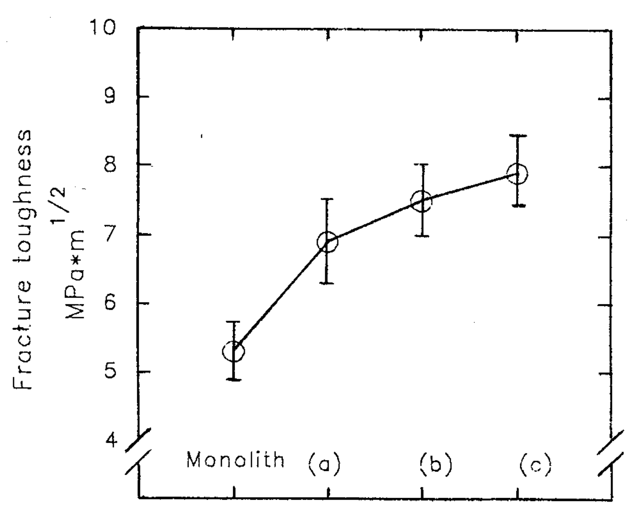

Fig. 2. Comparision of fracture toughness of ceramics composites various carbon fibers.
(a) R type (b) C type
(c) SiC coated C type