POSTER

PROCESSING AND MECHANICAL PROPERTIES OF OXIDE-CARBON COMPOSITES.

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Introduction

Many researchers have been trying to increase the toughness of ceramics[1-3]. They have used various methods such as incorporating fibres or whiskers which have been successful in many cases.

However, the fibres and whiskers currently used are extremely expensive and whiskers are toxic . An attractive approach is to introduce weak interfaces into a material which act to deflect propagating cracks. This approach is adapted in the development of ceramic laminates [4] . Here we examine a related but cheap approach to improving the reliability of alumina ceramics by incorporating natural graphite platelets to provide weak interfaces.

Experimental

Five different materials were prepared using Alcoa A-16 powder to form the matrix, silicon powder as an additive and fine natural graphite platelet as a reinforcement. Powders were mixed together by wet ball milling, then dried and passed through a 500 μm sieve (BS.) to produce free flowing powder . Some physical properties of the powders are shown in table 1. The sieved powders with 5-25 %vol. graphite platelets were pressed in a steel die. The green, pressed, disc-shaped, composites were sintered under an inert atmosphere up to 1500°C. A similar ceramic composition was also prepared by tape casting as shown in fig. 1.

X-ray pole figures have been obtained from polished, sintered samples to identify the orientation of the graphite platelets. Flexural strength and modulus were measured at room temperature in three-point bending with a 20 mm span. Apparent work of fracture is calculated from the cross sectional area of the bar and the area under the load deflection curve.

Results

Incorporation of natural graphite platelets in the alumina matrix composites has caused a change in fracture behaviour from brittle to non-catastrophic for composites containing medium and large size graphite platelets. A typical load-deflection curve together with that of the pure alumina sample curve has been shown in fig. 2.

The strength of the composites was, however, lower than the matrix material (fig. 3). By increasing the volume and size of the graphite platelets the flexural modulus and bending strength of the composites both decreased . With fine size graphite platelet, the fracture behaviour remained of brittle character except where samples were hot pressed .

A Weibull analysis was carried out on strength results from 20 fracture measurements to determine the Weibull modulus, m. This is increased from 5 for matrix to 19 as the graphite content increases.

Table 2 shows some information about properties and processing conditions of the fabricated composites.

Discussion

Incorporation of graphite platelets into the alumina could lead to the fabrication of a new kind of ceramic matrix composite (CMC) with a level of damage tolerance. The bending strength of these CMCs is lower than the matrix alone. This is thought to be because of flaws at the surface of the composites from exposure of platelets. Preferred orientation of the platelets is evident from the pole figures confirmed by microstructural analysis. Multiple fracture and higher work of fracture could be obtained depending on the size, volume content and orientation of the graphite platelets. The increase in the toughness of some of the composites is because of energy dissipation mechanisms such as crack deflection, pull out , shearing of the platelet planes, directional induced cracks, all caused by the presence of graphite platelets in composites. The reliability of the composites in terms of Weibull modulus has been increased effectively because of the defect population being controlled by the platelets rather than fabrication induced inhomogenities as in the alumina ceramic. Tape casting caused a marked increase in the strength of the composites in comparison to those produced by uniaxial pressing, due to a decrease in the pore size. Hot pressing increases the strength further.

Conclusion

It has been shown that a measure of damage tolerance can be introduced into brittle ceramics by the incorporation of graphite platelets. The increase in toughness is offset by a decrease in strength and elastic modulus but is nevertheless worthwhile for applications such as those including thermal shock.

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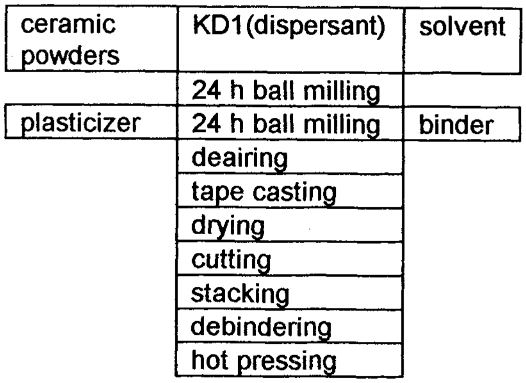

Fig. 1. Flow diagram of composite preparation through tape casting.

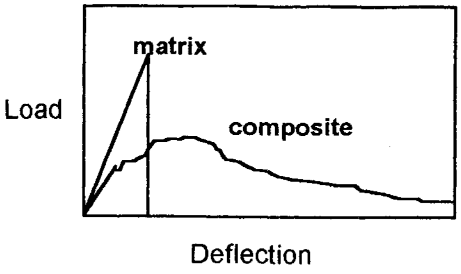

Fig. 2. Schematic representation of load-deflection curves of the composite and matrix.

Table 2 - A comparison of some properties of the fabricated samples.

	UP	TC	TC & HP		HP
PS (d90) / µm	53	53	53	53	504
alumina (% vol.)	70	70	70	70	75
graphite (")	25	25	25	25	25
Silicon...(")	5	5	5	5	0
S T / °C	1500	1500	1500	1600	1500
St/ h	4	4	1/2	1/4	1/2
pressure MPa	10	0	10	10	10
bulk density g/cm^3	2.10	2.04	2.90	3.23	3.43
total porosity %	39	40	16	8	4.5
w.o.f J/m^2				520	600
MOR (MPa)	27	81	129	251	101

UP=uniaxially pressed, TC=tape cast, HP=hot pressed, ST=sintering temperature, St=sintering time, PS= platelet size

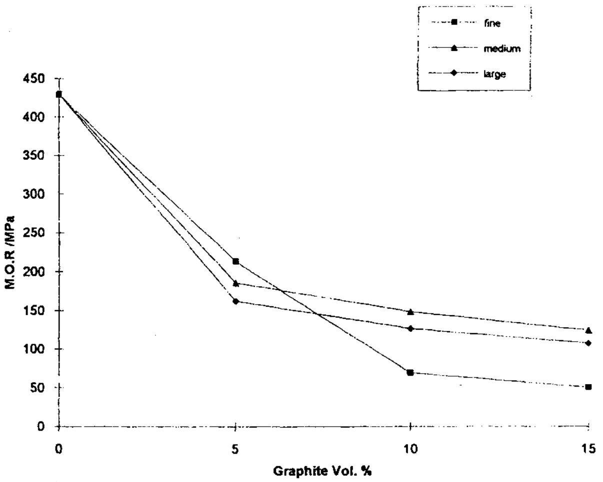

Fig.3 The effect of graphite size and content on flexural strength.

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