Studies on carbon fiber reinforced silicon nitride composites prepared using spark plasma sintering

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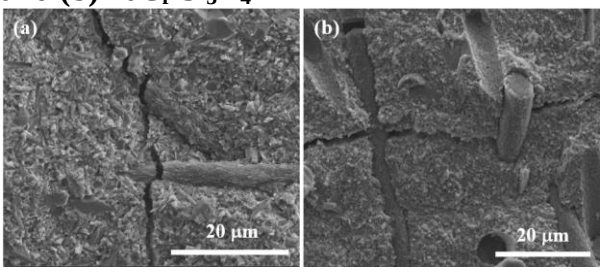
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Abstract

Silicon nitride (Si_3N_4) powder is synthesized using nitridation of silicon powder at 1400°C with N_2-H_2 gas mixture. The laboratory synthesized silicon nitride powder is mixed with various quantities of carbon fibers (5 to 20 vol. %) and sintering additives (6 wt. % Y_2O_3 + 2 wt. % Al_2O_3+ 1 wt. %MgO) through ball milling for 2 h. These mixtures are spark plasma sintered at three different temperatures (1400, 1500 and 1600 °C) at 40 MPa pressure for 10 min. The phase analysis after sintering shows that the composite samples have β-Si_3N_4 phase without any residual α-phase, irrespective of the sintering temperature. The carbon fiber reacted with the Si_3N_4 matrix and resulted in the formation of SiC through the interface reaction. The Rietveld quantification results show that the amount of SiC formation in the composite is less when the fiber content is high. Strong interfacial bonding is observed up to 10 vol. % C_f addition and the interfacial bonding is weak for 15 and 20 vol. % C_f composites. This is reflected in the fracture toughness values, where the highest value (7.1 MPa $m^{1/2}$) is observed for 20 vol. % C_f-Si_3N_4 sintered at 1600 °C. However, the flexural strength values are less for the composites with high C_f content compared to that of composites with low C_f content.

Fractographs of composites: (a) 5C_f-Si_3N_4 and (b) 20C_f-Si_3N_4



References

1. Kelina, I. Yu., Plyasunkova, L. A., Chevykalova, L. A., (2003) Resistance of C_f-Si_3N_4 ceramic-matrix composites to high-temperature oxidation, *Refractories and Industrial Ceramics*, 44, 249-253.

2. Liu, J., Zhu, T., Xie, Z.-P., and Wu, W. (2017). New route to improve the flexural strength of silicon nitride ceramics by introducing tungsten carbide nanoparticles. *International Journal of Applied Ceramic Technology*, 14, 860–865.

Biography

Dr. M. Balasubramanian obtained his Ph.D. degree from the Indian Institute of Technology, Madras in the year 1996 for his work on, "Processing and Characterisation of Alumina-Zirconia Powders and Composites". Currently, he is a Professor in the metallurgical and materials engineering department of the Indian Institute Technology Madras. He is actively involved in teaching and research of ceramics and composites. He has published more than 75 research papers in refereed international journals. He has published a book with CRC Press on, Composite materials and processing.



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