ID 1644

First Matrix Cracking Behavior of Fiber Reinforced Ceramic Composites at Elevated Temperatures

Raj N. Singh
Department of Materials Science and Engineering
University of Cincinnati, P.O. Box 210012
Cincinnati, OH 45221-0012, USA

Keywords: ceramic, composites, mechanical properties

A knowledge of the first-matrix cracking stress and its dependence on composite parameters in fiber-reinforced ceramic composite is important because of the irreversible damage to mechanical properties of composites stressed beyond the first-matrix cracking stress. The primary objective of the current research has been to study the roles of interfacial properties and preexisting matrix flaw size on the steady state (long crack) and non-steady state (short crack) first-matrix cracking behaviors in ceramic matrix composites (CMCs) over a range of temperatures. This objective is achieved via (1) developing processing techniques to fabricate composites with a range of fiber-matrix interfacial properties and flaw sizes, (2) characterizing interfacial properties using fiber pushout and other techniques, (3) finding ways to introduce internal and external flaws of controlled-size into the matrix, and then (4) studying the influence of interfacial properties and flaw sizes on the matrix cracking behavior at elevated temperatures.

Experimental

Four types of zircon-SiC composites were especially fabricated with a variety of reinforcing SiC fibers and fiber coatings (C and/or BN) in order to create composites with different interfacial properties, surface roughness, and in different state of residual stress to demonstrate their role on interfacial properties and first-matrix cracking behavior. Fiber pushout and other tests were performed on these composites to extract important interfacial properties, residual stresses, and surface roughness. The nature and magnitude of residual stresses in composites were independently characterized by measuring the coefficient of thermal expansion of the fiber, matrix, and composite for comparison with similar values measured using fiber pushout tests.

Results

The first matrix-cracking behavior of a silicon carbide fiber (SCS-6^{TM})-reinforced zircon matrix composite is studied as a function of flaw size and temperature. Flaws of controlled size are created in the monolithic zircon and silicon carbide fiber-reinforced zircon matrix composite by means of a Vicker's indentation technique. The first matrix cracking stress is measured at three different temperatures of 25°C, 500°C and 1200°C as a function of the crack length (Fig. 1). The results on ceramic composites demonstrated both steady state and non steady state matrix cracking behaviors and an increase in the steady state matrix cracking stress with an increase in temperature as predicted by the theoretical models. These results are compared with the predictions of the theoretical models of matrix cracking based on fracture mechanics analysis (Fig. 1) .

These results on the influence of the flaw size and interfacial properties on the first matrix cracking behavior and analytical modeling results in fiber-reinforced ceramic composites will be presented.

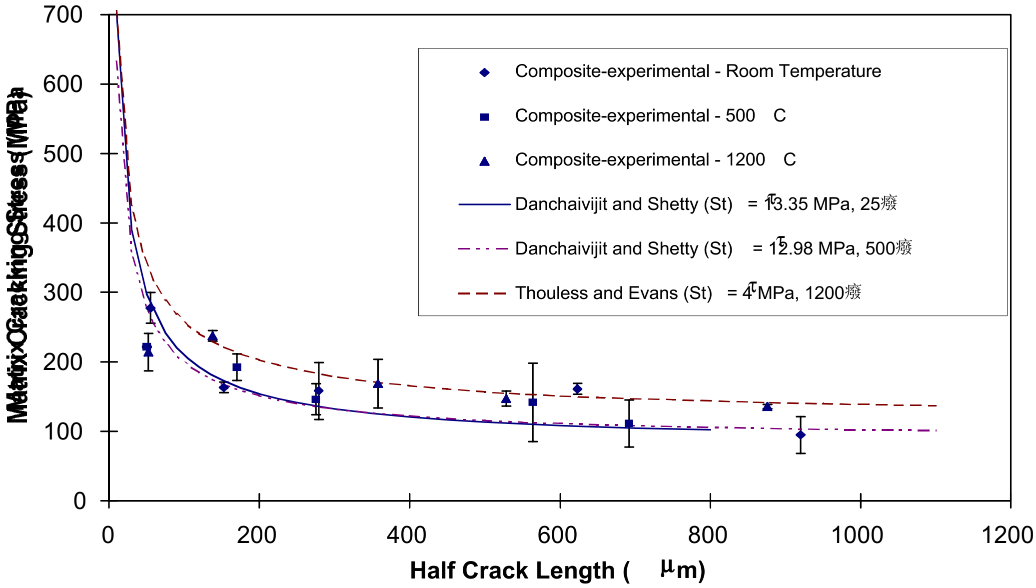

Fig.1 Variation of matrix cracking stress in zircon silicon carbide composites as a function of crack length and temperature. The figure also shows the theoretical model which best describes the first matrix cracking behavior at these temperatures

References

1. S. Kumaria, S. Kumar, and R. N. Singh, " The First Matrix Cracking Behavior of Fiber Reinforced Ceramic Matrix Composites," Acta Mater. 45[12], 5177-5185 (1997)
2. U. Anandakumar, S. Kumar, R. N. Singh, " The First Matrix Cracking Behavior of Ceramic Composites at Elevated Temperatures," Acta Mater. 47[12], 3339-3352 (1999)