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The Fatigue Behavior at High Temperatures of a SiC/SiC Composite with a Multilayered Matrix

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Ceramic matrix composites (CMCs) are potential candidates for use in severe conditions of temperature and environment (for instance in aerospace or aeronautical industry). SiC/SiC composites present some interesting advantages including high mechanical and oxgen resistances. It has been established that the non-brittle behavior of CMCs depends on the matrix/fiber interphase. Pyrocarbon is a most efficient interphase in SiC/SiC composites, but it is sensitive to oxidation at temperatures >500°C. So oxidation resistant multilayered interphases [1] or matrices [2] have been devised. Multilayered matrices contain phases that produce a glass at high temperature which heals the cracks and prevents oxygen from reaching the interphase and the fiber.

The paper investigates the damage and failure of SiC/SiC composites during fatigue at high temperatures with respect to the crack healing.

Material and Experimental Procedure

The SiC/SiC composite with a multilayered matrix was produced via Chemical Vapor Infiltration by SNECMA. It consists of a woven preform of tows of Nicalon SiC fibers coated with a thin layer of pyrocarbon interphase and the multilayered matrix which contains phases from the Si-B-C ternary system.

The specimens were tested at 600°C and 1100°C in air, under static and cyclic loading conditions (Table 1). Deformations were measured using an extensometer (25 mm gauge length). Acoustic emission was recorded during the tests. After failure, specimens were inspected using a scanning electronic microscope.

Table 1 Fatigue conditions at 600°C and 1100°C

Applied load (MPa)	Initial damage	Fatigue conditions
150	No	Cyclic (0,25 Hz)
150	No	Static
220	No	Cyclic (0,25 Hz)
150	Strain 0,25%	Cyclic (0,25 Hz)

Results and Discussion

Various data including elastic modulus, deformations, residual strain at zero load, area of the hysteresis loops, and acoustic emission (amplitude and cumulative count) were measured during the tests. Two specific behaviors, depending on the temperature, have been observed (Fig.s 1 and 2).

At 600°C, the elastic modulus decreases significantly whereas the deformation increases. The area of hysteresis loops follows the same trend as the elastic modulus. As the interphase is degraded tow debonding proceeds. The applied load becomes carried by the tows. The failure of tows is brittle and the fibers appear to be strongly bonded within the tows.

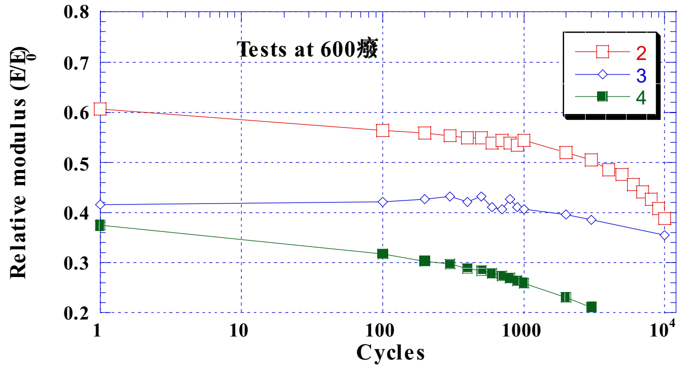

Fig. 1 Evolution of relative elastic modulus during cyclic fatigue tests at 600°C in air

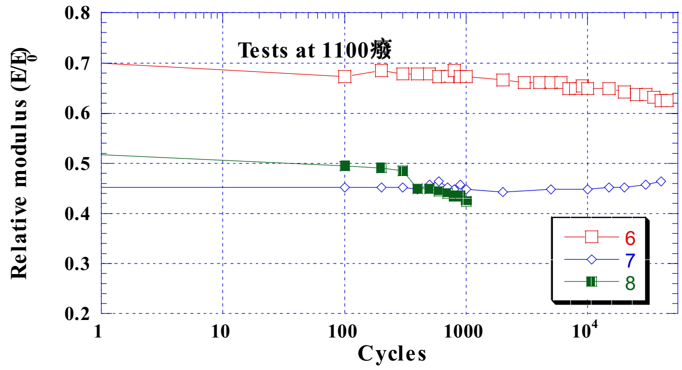

Fig. 2 Evolution of relative elastic modulus during cyclic fatigue tests at 1100°C in air

At 1100°C, the composites exhibit no damage growth, no hysteresis loops area evolution, but the deformation increases during the tests. A glass is produced and heals the cracks. The interphase is protected and no damage occurs.

Relative modulus versus deformations plots were constructed to evidence specific behaviors at high temperature and they provide master curves which permit comparison of the respective influences of damage induced by environment and by loading conditions.

Acknowledgements

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References

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