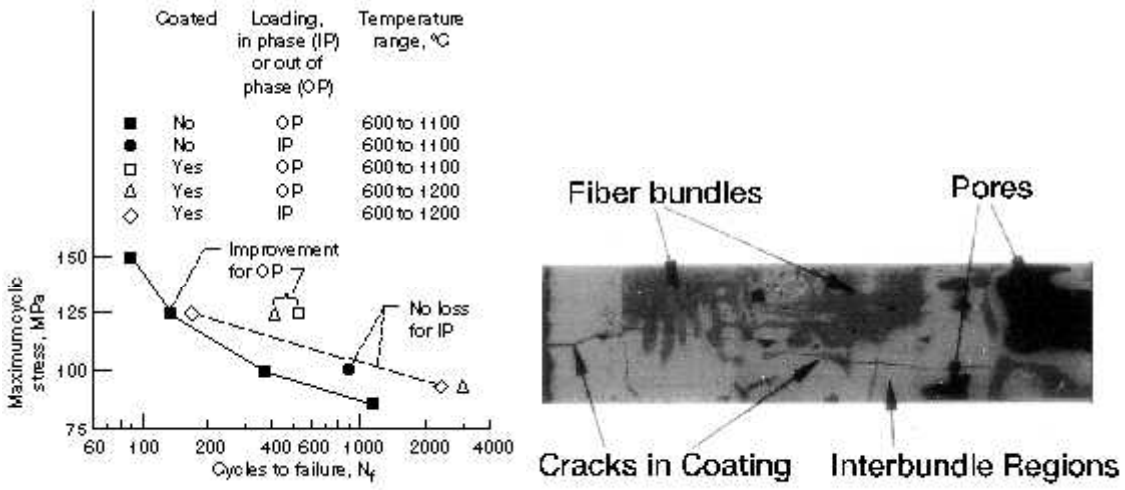
# Thermomechanical Fatigue Behavior of Coated and Uncoated Enhanced SiC/SiC Studied

Thermomechanical fatigue (TMF) testing provides a method of evaluating candidate continuous- fiber-reinforced ceramic composites under thermal and mechanical loading conditions. Although these tests are complicated, they provide a reasonable approximation of the combined thermal and mechanical loads that will be experienced by the material in service. The resulting data will be used to develop life-prediction models as well as to aid materials development.

Previous TMF testing of the SiC/SiC composite at the NASA Lewis Research Center demonstrated that enhancing the oxidation resistance of the matrix by a proprietary process increased the TMF lives (ref. 1). The improvement allowed the continued application of maximum cyclic stresses at or above the level where microcracking occurs (ref. 2)--in contrast to the unenhanced composite where the development of microcracks led to rapid failure. This indicates that the enhanced composite has improved damage tolerance. Further improvements in TMF life were realized with the use of an oxidation-resistant coating, which also permitted an increase in the maximum temperature by at least 100 °C (ref. 3).

Cracks developed in the composite with the enhanced matrix (both coated and uncoated) through the formation of periodic microcracks. These cracks initiated on the edge of the sample at interbundle regions where only matrix material (which also contained uninfiltrated regions) existed. The interbundle regions are weak, unreinforced areas and are very susceptible to crack formation. The cracking subsequently allowed oxygen to penetrate into the interior of the composite, leading to the formation of a glasslike phase, which was intended to seal the cracks. However, this phase also formed at the fiber/matrix interface and is suspected of degrading fiber strength.




*Left: Maximum cyclic stress versus cycles to failure. Right: Optical micrograph showing the composite microstructure and the propagation of cracks from the edge of the sample.*

These results indicate that the TMF behavior of SiC/SiC composites can be improved by an improvement in the oxidation resistance of the matrix and an application of an oxidation-resistant coating. However, these improvements may only be marginal, because the material still suffered from the weak interbundle regions. These regions are manifestations of the woven character of the material. Also, the matrix enhancements and the oxidation-resistant coating may be chemically incompatible with the fibers, leading to strength degradation during long-term tests.

# References


1. Worthem, D.W.: Thermomechanical Fatigue of Three Ceramic-Matrix Composites. HITEMP Review 1993, NASA CP-19117, Vol. III, 1993, pp. 79-1 to 79-11. (Available to U.S. citizens only. Permission to use this material was granted by Hugh R. Gray, January 1996.)

2. Marshall, D.B.; and Evans, A.G.: Failure Mechanisms in Ceramic-Fiber/Ceramic-Matrix Composites. J. Am. Ceram. Soc., vol. 68, 1985, pp. 225-231.

3. Worthem, D.W. : Thermomechanical Fatigue Behavior of Coated and Uncoated Enhanced SiC/SiC[PW]. HITEMP Review 1994, NASA CP-10146, Vol. III, 1994, pp. 66-1 to 66-12. (Available to U.S. citizens only. Permission to use this material was granted by Hugh R. Gray, January 1996.)