THE TRANSVERSE THERMAL CONDUCTIVITY OF 2D-SiC$_F$/SiC COMPOSITES - G. E. Youngblood, David J. Senor, R. H. Jones (Pacific Northwest National Laboratory)*, and Samuel Graham (Sandia National Laboratories).

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EXTENDED ABSTRACT

A model for predicting the effective transverse thermal conductivity (K_{eff}) of a 2D-SiC$_f$/SiC composite with a fiber-matrix thermal barrier was assessed experimentally and by comparison to numerical finite element model (FEM) predictions.

The Hasselman and Johnson model [1] is described by an expression for K_{eff} based on a composite configuration that consists of dispersed uniaxial fibers in a matrix with thermal barriers (fiber coatings or fiber/matrix debonds) and is given by:

$$K_{eff} = K_m[(K_f/K_m - 1 - K_f/ah)V_f + (1 + K_f/K_m + K_f/ah)] \times [(1 - K_f/K_m + K_f/ah)V_f + (1 + K_f/K_m + K_f/ah)]^{-1} \quad (1)$$

In Eq. (1), "h" is the effective interfacial conductance, K_m and K_f are the thermal conductivity values of the matrix and fiber constituents, and V_f and "a" are the fiber volume fraction and radius, respectively. Examination of Eq. (1) indicates that the value of the non-dimensional parameter, K_f/ah, relative to the ratio K_f/K_m controls the overall effect of interfacial barrier resistances on K_{eff}.

Agreement between predictions of Eq. (1) and the FEM were within 5% for composites with simple unidirectional or cross-ply architectures with fiber volume fractions of 0.5 or less and with ratios K_f/K_m <10. For a woven 2D-SiC$_f$/SiC composite, inhomogeneous fiber packing and numerous direct fiber-fiber contacts would introduce deviations from model predictions. Nevertheless, the analytic model should be very appropriate to examine the degradation in K_{eff} due to neutron irradiation or to other mechanical or environmental treatments [2].

The expected effects of temperature dependence and irradiation on K_{eff} were examined for a hypothetical 2D-SiC$_f$/SiC composite made with a high conductivity fiber (Tyranno™ SA) and a CVI-SiC matrix. In Figs. 1(a-b), the analytical solutions predicted by Eq. (1) are plotted for such a hypothetical composite for a fiber volume fraction of 0.4 and for selected h-values of 5000, 500 and 50 W/cm^{2}K. For example, it is predicted that before irradiation this composite with an optimized interfacial heat transfer coefficient (h ≈5000 W/cm^{2}K) K_{eff} would range from 34 down to 26 W/mK at 200 and 1000°C, respectively. After irradiation to saturation doses at those temperatures, the h-value would likely decrease to 500 W/cm^{2}K or less and the respective K_{eff}-values would decrease to 6 or 10 W/mK (or less) at 200 or 1000°C, respectively.

FUTURE WORK

The theoretical model predictions will be compared to measured thermal conductivity values for unirradiated and irradiated SiC/SiC composites made with advanced SiC fibers and for various matrices and fiber architectures (see the article "KFIB EXPERIMENT" in this volume).

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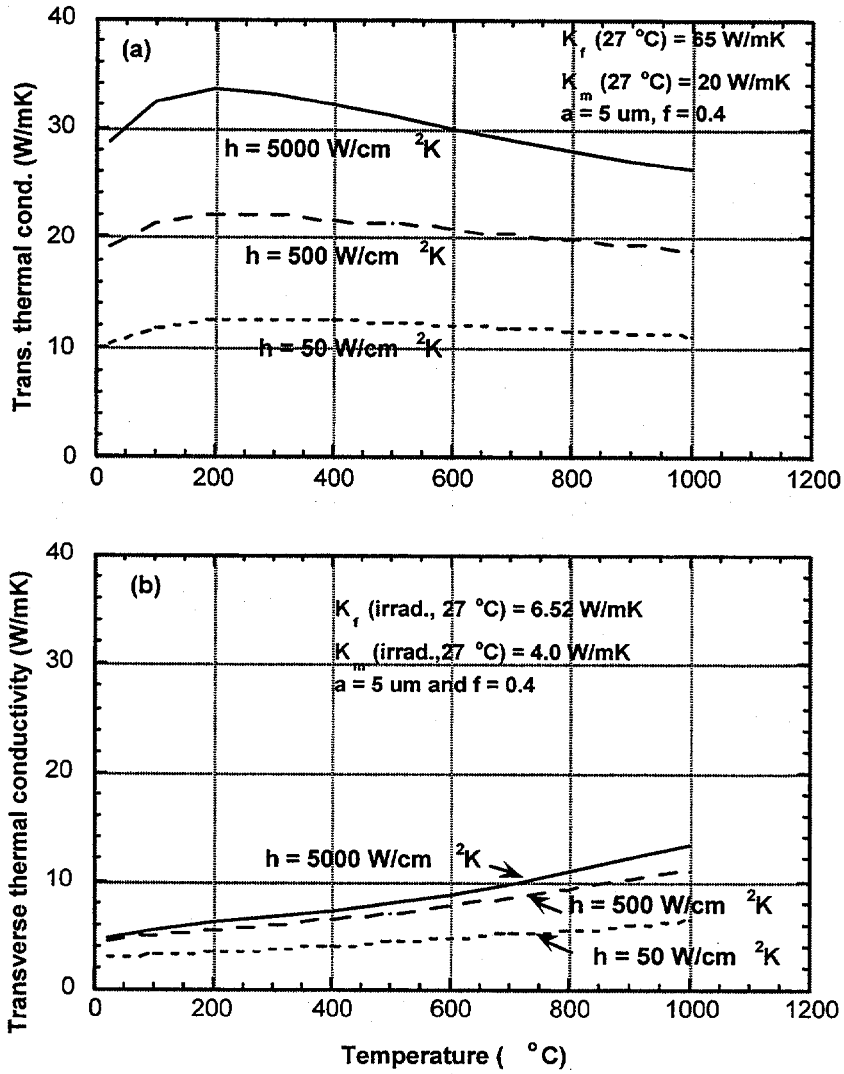

Figures 1(a-b). The transverse thermal conductivity predicted by Eq. (1) for a hypothetical (a) unirradiated and (b) irradiated 2D-Tyranno™ SA/CVI-SiC composite as a function of temperature. The selected values for a, K_f and K_m correspond to expected constituent values at 27°C for a hypothetical composite with V_f = 0.4 and h = 50, 500 and 5000 W/cm^{2}K.

REFERENCES

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