

MODELING THE TRANSVERSE THERMAL CONDUCTIVITY OF 3D-SiC_f/SiC COMPOSITES—G. E. Youngblood and R. H. Jones (Pacific Northwest National Laboratory)* and Reiji Yamada (JAERI, Tokai-mura, JP)

OBJECTIVE

The primary objective of this task is to assess the thermal conductivity of SiC/SiC composites made from SiC fibers (with various SiC-type matrices, fiber coatings and architectures) before and after irradiation and to develop analytic models that describe the transverse and in-plane thermal conductivity of these composites as a function of constituent properties and geometry as well as temperature and dose.

SUMMARY

Our previously developed hierarchical two-layer (H2L) model was modified to describe the effective transverse thermal conductivity (K_{eff}) of a three-dimensional (3D) SiC/SiC composite plate made with cross-layered and Z-stitched X:Y:Z uniaxial fiber tow sub-units. As before, the model describes K_{eff} in terms of constituent, microstructural and architectural properties that include the expected effects of fiber-matrix interfacial conductance, of high fiber packing fractions within individual tow sub-units and of the non-uniform porosity contents, shapes and orientations within these sub-units. Model predictions were obtained for two versions of a 3D-Tyranno SATM/PyC/ICVI-SiC composite that had similar fiber/matrix pyrocarbon (PyC) interfaces, relatively high bulk densities (~2.88 g/cc), and an X:Y configuration with fiber content ratios 1:1. The only major difference between the two versions was their Z-stitch fiber content where the relative fiber ratios were 0.1 and 1.2 in the Z sub-units.

PROGRESS AND STATUS

Introduction

In previous work, the hierarchical two-layer (H2L) model for the effective transverse thermal conductivity (K_{eff}) of 2D-SiC/SiC was used to predict K_{eff} for various composites made with Hi-NicalonTM, Hi-NicalonTM type S or TyrannoTM SA fabric layers and CVI-SiC matrix components [1]. The model included the effects of the interfacial conductance, which in a composite with numerous fiber/matrix (f/m) interfaces can have a profound influence on K_{eff} . In particular, the f/m interface in a 2D-SiC/SiC composite, especially if it is pyrocarbon (PyC), might be vulnerable to radiation degradation. In this case, the fibers could be thermally decoupled from the matrix, and K_{eff} likely would be decreased, perhaps severely. The H2L-model also included the effects of porosity content, shape and orientation, which are not expected to be affected by irradiation.

In this work, the H2L-model was modified to describe $K_{\text{eff}}(T)$ for a 3D-SiC/SiC. A 3D-SiC/SiC is envisioned as having numerous fibers aligned in the direction of the heat conduction, say the Z-direction, which could provide a “heat pipe” effect to increase K_{eff} . Furthermore, K_{eff} for a 3D-composite with a major portion of the heat conduction determined by fiber “heat pipes” might not be so susceptible to radiation degradation.

The Hierarchical Model Approach

In Fig. 1, a schematic diagram depicts the unit cell for a 3D-SiC/SiC composite plate made with cross-layered and Z-stitched X:Y:Z uniaxial fiber tow sub-units used for this study.

*Pacific Northwest National Laboratory (PNNL) is operated for the U.S. Department of Energy by Battelle Memorial Institute under contract DE-AC06-76RLO-1830.

