FIBER CREEP RATE AND HIGH-TEMPERATURE PROPERTIES OF SiC/SiC COMPOSITES -- C. A. Lewinsohn, R. H. Jones, G. E. Youngblood, and C. H. Henager, Jr., (Pacific Northwest National Laboratory)*

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EXTENDED ABSTRACT

Results of studies aimed at relating the fiber creep rate to the subcritical crack growth rate and fracture properties of SiC/SiC composites have demonstrated that the crack growth rate in a bulk composite is controlled by the fiber creep rate. This result was demonstrated for Nicalon-CG and Hi-Nicalon fiber reinforced material where a 50-75°C shift in the creep strength of the fiber resulted in a similar shift in the crack growth rate of the composite. Irradiation enhanced creep of SiC fibers and matrix must also be considered in the performance assessment of SiC/SiC composites.

The shape of the displacement versus time curve for composites containing Hi-Nicalon fibers were similar to those of the previously tested materials, containing Ceramic-grade fibers, that exhibited subcritical crack growth controlled by time-dependent relaxation of the fiber-bridging stresses due to fiber creep. The crack velocity in the CG-C composites at 1100°C in argon was very close to that of the Hi-C materials at 1150-1175°C, this roughly corresponds to the temperature differential shown by DiCarlo et al. to obtain the same relaxation in 1 hour bend stress relaxation(BSR) tests in the two fibers. This supports the hypothesis that subcritical crack growth in SiC/SiC composites is controlled by fiber creep.

The effective crack velocity of a material containing Ceramic-grade Nicalon fibers and a 150 nm carbon coating was also measured at 1373 K in argon. The crack velocity of this material was faster than the materials containing Ceramic-grade Nicalon fibers with a 1 μm -thick interphase. This is probably due to the stronger clamping stresses, hence higher fiber stresses, that promote fiber creep.

The steady state creep rate, $d\varepsilon_c/dt$, was assumed to be linearly proportional to the product of stress, σ, and flux, ϕ,

$$d\varepsilon_c/dt = K \sigma \phi$$

For a hypothetical stress of 100 MPa and a fluence of 5 dpa, the maximum steady state creep rate, $d\varepsilon_c/dt$, would be 3.98×10^{-12} s^{-1} at 900°C (E>0.18 MeV). The equivalent steady state creep rate of CVD silicon carbide due to thermal effects at the same stress and temperature would be 1.05×10^{-13} s^{-1} according to data published by Carter et al.. Therefore, irradiation may enhance the thermal creep of CVD silicon carbide by an order of magnitude. If irradiation enhanced the creep rate of Nicalon™ fibers by a similar order of magnitude a similar increase in the subcritical crack growth rate in SiC/SiC composites would occur.

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