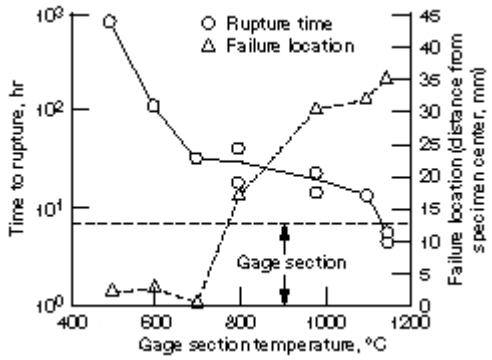
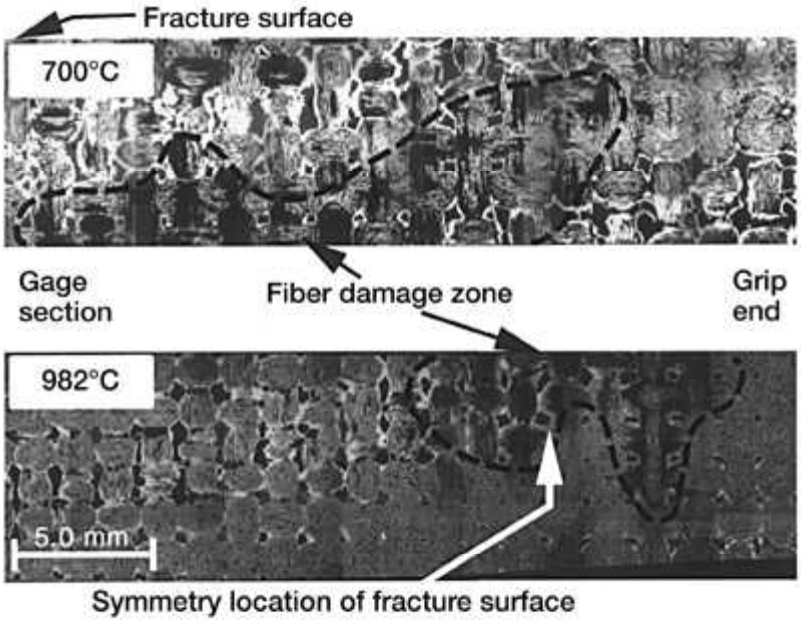
Oxidation Embrittlement Observed in SiC/SiC Composites

As part of a comprehensive materials characterization program at the NASA Lewis Research Center, tensile creep-rupture tests were performed on a SiC-fiber-reinforced SiC-matrix composite. The results of these tests and subsequent analysis revealed an oxidation embrittlement phenomena that occurs readily at a discreet temperature range below the maximum use temperature. The graph shows rupture lives for a creep stress of 83 MPa as a function of temperature. Note that the rupture time is constant at an intermediate temperature range of 700 to 982 °C. This graph also shows the failure location, as measured from the center of the specimen. Whereas for temperatures of 500 to 700 °C, failure occurred in the specimen gage section; at higher temperatures, the failure location migrated toward the cooled grip ends. Although the results initially suggested that the test procedure was influencing the measured creep rupture lives and driving the failure location out of the gage section, subsequent experiments and thermal stress analyses verified the robustness of the test method employed.



Stress rupture data for [0°/90°] DuPont enhanced chemical vapor infiltration SiC/Nicalon SiC composite as a function of gage section temperature at a creep stress of 83 MPa. Also shown is the failure location as a function of gage section temperature.

Metallurgical examination of failed specimens revealed an environmentally assisted material degradation operating in the 700 to 800 °C range. The photomicrographs show the distribution of damage in two specimens tested at the same stress but different gage section temperatures. In the views shown, the sections are polished in the thickness direction, showing the broad specimen face. The loading direction is horizontal. In the 700 °C specimen, creep damage is distributed throughout the uniformly heated test section. However, in the 982 °C specimen, damage is concentrated only at the point outside the gage section where the temperature was found to be 700 to 800 °C; less damage occurred within the hotter gage section. Both specimens failed because of an aggressive environmental attack of the SiC fibers at location where the temperature was in the 700 to 800 °C range.



Creep damage distribution of two [0°/90°] DuPont enhanced chemical vapor infiltration SiC/Nicalon SiC specimens tested at a stress of 83 MPa. The damaged fiber tows were found throughout the gage section of the 700 °C specimen. However, for the 982 °C specimen, the damage was concentrated at the point outside of the gage section where the temperature was 700 to 800 °C.

SiC/SiC composites are candidates for a combustor liner application in the engine of the High Speed Civil Transport vehicle. During its service cycle, the combustor liner will experience a thermal gradient, being cooled near attachment regions and exposed to combustor gases on the inner wall. The existence of a minimum in creep rupture behavior over a discreet temperature range indicates that the kinetics of this process are unconventional. Thus, material properties must be well characterized over the temperature range of expected operation. Also, this behavior must be accounted for in designing and determining the life of components.

Reference

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