CREEP CAVITATION IN SILICON NITRIDE WITH 4 WT% YTTRIA

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Silicon nitride based ceramics are attractive for high temperature and wear resistant applications. However, the major limitation to the use of silicon nitride at high temperature is the tendency of these materials to creep and to fail by creep rupture. One of the main reason for creep damage of silicon nitrides at elevated temperatures is the formation of cavities in the material.

High temperature deformation of Hot Isostatically Pressed (HIPed) silicon nitride with 4 wt% Yttria has been studied. The tests were carried out in four-point bending mode in the temperature range 1200 - 1450 °C. To characterize the materials, Transmission Electron Microscopy (TEM) and X-Ray Diffractometry (XRD) studies were performed on the as-received as well as the deformed samples.

The typical microstructure of the material consists of a major crystalline phase (α- and β- silicon nitride), secondary crystalline phase (yttrium silicate) and a thin intergranular amorphous phase.

Different types of cavities were observed in the deformed materials. The lens-shaped, interfacial cavities were observed primarily in the tensile side of the test bars. It is likely that these cavities were nucleated initially in the amorphous phase between the silicon nitride grains. It was also observed that these cavities were oriented primarily normal to the applied tensile stress and then grow into adjacent silicon nitride grains. In contrast, multi-grain junction cavities were observed in the compressive side of the test bars. No cavities were observed in between Si_3N_4 - $Y_2Si_2O_7$ interfaces.

The study shows that the shear stresses acting on the grains under compressive stress promote the formation and development of these multi-grain junction cavities whereas the tensile stresses acting perpendicular to the grain boundaries promote the formation of lens-shaped cavities. Absence of cavities in between Si_3N_4 - $Y_2Si_2O_7$ interfaces is probably due to the softening of $Y_2Si_2O_7$ phase at high temperature.

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