APCOM & ISCM
11-14th December, 2013, Singapore

High Temperature Creep Fracture Mechanisms of ZrB2-SiC Composites

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The high temperature creep fracture of zirconium diboride (ZrB2) silicon carbide (SiC) composites is a complex process resulting from a combination of deformation mechanisms of grain boundary separation, grain boundary sliding and creep of adjacent grains. In this study, a micromechanics model incorporating these mechanisms was developed. For grain boundary separation, nucleation, growth and coalescence of cavities along the grain boundary were considered. A novel constitutive equation of grain boundary sliding has been derived elsewhere by considering accommodation of grain movement and rotation by stick and slip friction along grain boundary from molecular dynamic simulation. Diffusional creep and lattice creep were considered to model creep of grain at low and high temperature regions, respectively. Numerical models of ZrB2 with 20% SiC composites were constructed directly from scanning electron microscope (SEM) images. From experimental observation, the SiC grains were assumed to be relatively rigid. The numerical results exhibited a good agreement with experimental measurements and observations. The results revealed that grain boundary heterogeneity provided a preferred site for cavity nucleation and led to crack propagation through triple junctions. In addition, the change of activation energy with temperature was found to trigger a shift of the controlling creep mechanism.

Keywords: Ultra-high temperature ceramics, creep fracture, micromechanics