11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Creep deformation and damage in a polycrystalline Copper-Antimony-Alloy

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Key Words: *Creep damage, grain boundary sliding, cohesive zone, micromechanical model, polycrystal.*

For polycrystalline materials under creep conditions, especially for low external loads and high temperatures, the nucleation and growth of grain boundary pores, driven by the grain boundaries local stress states, cause an accumulation of damage over time. The linkage of several damaged grain boundaries to a macroscopic crack leads finally to failure. Stress redistributions resulting from the interactions of several micromechanical mechanisms on the scale of a polycrystal's microstructure, including grain boundary damage and sliding, usually cause normal stress concentrations on grain boundaries that are oriented perpendicular to the loading direction. To assess the effect of stress redistributions on the development of grain boundary damage, it is necessary to consider a polycrystal's microstructure.
A micromechanical model of creep induced grain boundary damage has been proposed in [1], which allows for the simulation of creep damage in a polycrystal within the framework of finite element analysis. The model considers grain boundary cavitation and sliding according to a micromechanically motivated cohesive zone model, while creep deformations of the grains are described following the slip system theory. The influence of the polycrystalline microstructure is taken into account by a finite element model of an explicit grain structure. The parameters of the model have been calibrated [1] in order to describe the experimentally observed creep damage behaviour of a Copper-Antimony-Alloy.
The calibrated model is applied to artificially generated polycrystalline microstructures (e.g. Voronoi models) in order to analyse the development of creep damage on grain boundaries. The use of three-dimensional periodic microstructures allows to consider deformation constraints from the surrounding material. In particular the contribution of grain boundary sliding to the overall creep rate and the influence of grain boundary orientation on creep cavitation are discussed.

REFERENCES

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