Effect of Boundary Conditions and Crystallographic Orientation on the Cylindrical Void Growth in FCC Single Crystals Using CPFEM

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The crystal plasticity finite element method was used to investigate cylindrical void growth and coalescence in face-centered cubic single crystals. In the finite element model, a rate-dependent crystal plasticity constitutive theory has been implemented [1].Twelve potentially active slip systems $\{111\}\langle 110\rangle$ are used to characterize plastic deformation in fcc single crystals. A 2D plane strain model with one void has been used. The effects of lattice orientation and boundary conditions on void growth are investigated. Boundary constraints were enforced in two different ways. The first is based on enforcing constant in plane stress biaxiality via a particular truss element for many defined values of the stress biaxiality ratio η [3], while the second is based on displacement controlled by imposing load biaxiality factor β. Three crystallographic orientations were examined, with the major loading direction along [100], [110], and [111].

Two loading scenarios were explored in the current study for displacement-controlled boundary conditions. One is a uniaxial loading case, while the other is a biaxial loading scenario, with varying load biaxiality factor β to investigate its impact on void evolution. When compared to biaxial loading, void evolution under uniaxial loading is greatly influenced by crystal orientation. Under biaxial loading, the influence of lattice orientation diminishes. The void expansion and coalescence are dictated by stress triaxiality and accumulated strain in such circumstances. The void growth is accelerated with larger load biaxiality factor β due to higher in plane mean stress, and the void shape is a polygon with rounded corners, as shown in [2]. The response of void evolution differs for the same β and η values. However, the response is the same for uniaxial loading and $\eta = 0$ case.

References

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