Finite Element Simulations of Void Growth and Coalescence in Magnesium Single Crystals

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ABSTRACT

In this work, plane strain unit cell simulations of cylindrical void growth and coalescence in Mg single crystals corresponding to different biaxial stress ratios λ are conducted using a crystal plasticity based finite element procedure. Further, ductile fracture initiation is analyzed by considering Single Edge Notch Tension (SENT) specimens with shallow and deep notches as well as Four Point Bend (FPB) specimen which have different biaxiality parameters β. A fracture process zone (FPZ) containing a rectangular array of voids ahead of the notch tip is also modeled. Two lattice orientations with c-axis along the thickness direction (A) and normal to the flat surfaces of the notch (B) are considered.

It is found that prismatic slip contributes predominantly to plastic deformation for orientation A and void coalescence occurs by internal ligament necking [1]. In all fracture specimens, moderate to high mean stress prevails in the FPZ causing the voids to grow and coalesce directly ahead of the tip. The fracture resistance shows a marked increase with reduction in β akin to isotropic plastic solids. By contrast, for orientation B, profuse tensile twinning occurs along with basal slip as seen in experiments [2]. Following lattice reorientation in the voided cells, pyramidal <c+a>, basal and prismatic slip become strongly active causing coalescence by ligament necking for high λ and shear localization for low λ. The level of λ in the FPZ is very low following reorientation for all specimens and hence shear localization is favored. The *J* at first void coalescence in the FPZ is much higher than in orientation A and reflects the retarded plastic slip and porosity development caused primarily by tensile twinning. The above *J* value is lower for the shallow cracked SENT specimen as compared to the other two and is attributed to several intersecting shear bands that form in the FPZ.

REFERENCES

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