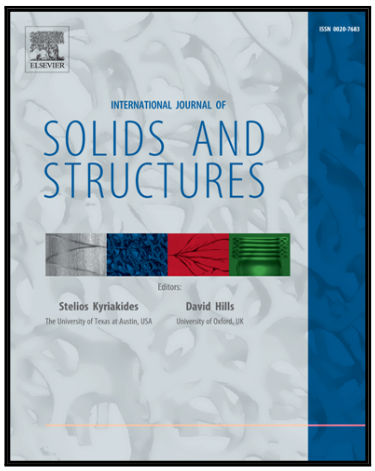

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Viscoplasticity of voided cubic crystals under hydrostatic loading

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Abstract

A micromechanical study of the viscoplasticity of voided cubic crystals is presented. The microscopic void distribution is isotropic and the macroscopic loading is hydrostatic. Three different approaches are considered. The first approach consists in idealizing the voided crystal as a hollow sphere assemblage and bounding from above the corresponding dissipation potential *à la* Gurson. The second approach consists in idealizing the voided crystal as a sequential laminate of infinite rank and computing the corresponding dissipation potential exactly. Finally, the third approach consists in idealizing the voided crystal as a periodic medium with a complex unit cell and computing the mechanical fields numerically via a Fast Fourier Transform (FFT) algorithm. Predictions are reported for a wide range of crystals deforming by power-law creep and rate-independent plasticity. When the plastic anisotropy is weak, a fairly good agreement between all three approaches is observed. When the plastic anisotropy is strong, by contrast, discrepancies arise. In the extreme case of plastically deficient crystals, the various predictions can exhibit different asymptotics. While estimates based on hollow-sphere assemblages predict that any deficient voided crystal is rigid under hydrostatic loading, FFT simulations and sequential laminates suggest that some deficient voided crystals with more than two linearly independent systems may dilate. Overall, estimates based on sequential laminates are found to be superior to Gurson-type estimates based on hollow sphere assemblages and to predict the hydrostatic response of cubic voided crystals with reasonable accuracy, even for relatively strong plastic anisotropies.

Keywords: crystalline solids, porosity, viscoplasticity, micromechanics, homogenization

1. Introduction

Some engineering alloys employed in nuclear reactors can nucleate intragranular voids when exposed to prolonged neutronic irradiation (e.g., Garner (2012)). In the concomitant presence

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