A DISCRETE DISLOCATION PLASTICITY STUDY OF THE MICRO VOID SIZE EFFECT

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Micro voids have a significant effect on the macroscopic plastic behaviour of crystalline materials. Studies have shown that when the void size approaches that of the intrinsic material length scale, the rate of void growth diminishes and the level of strain hardening increases [1]. An understanding of the deformation and failure mechanisms at these length scales necessitates the use of a plasticity theory or technique that accounts for size effects.

This study presents a discrete dislocation plasticity analysis of voided microstructures with varying volume fractions and void size. Plastic deformation is modelled through the motion of edge dislocations in an elastic solid medium. The lattice resistance due to the motion, nucleation and annihilation of dislocations, as well as their interactions with obstacles, are incorporated through a set of constitutive rules [2]. For simplicity, a two-dimensional plain strain model of a face-centered cubic (fcc) crystal with a periodic array of square voids is considered. Focusing on pure shear loading, results are presented for the dependence of the shear yield strength upon void volume fraction and upon void size for a fixed void volume fraction. The calculations clearly demonstrate that the strength of the voided material increases with decreasing void sizes. The implications of this are discussed in the context of nano-porous materials.

References

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