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Grain-boundary sliding and separation in polycrystalline metals: application to nanocrystalline fcc metals. (English) Zbl 1084.74014

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Summary: In order to model the effects of grain boundaries in polycrystalline materials, we have coupled a crystal-plasticity model for the grain interiors with a new elastic-plastic grain-boundary interface model which accounts for both reversible elastic, as well irreversible inelastic sliding-separation deformations at the grain boundaries prior to failure. We have used this new computational capability to study the deformation and fracture response of nanocrystalline nickel. The results from the simulations reflect the macroscopic experimentally observed tensile stress-strain curves, and the dominant microstructural fracture mechanisms in this material. The macroscopically observed nonlinearity in the stress-strain response is mainly due to the inelastic response of the grain boundaries. Plastic deformation in the interior of the grains prior to the formation of grain-boundary cracks was rarely observed. The stress concentrations at the tips of the distributed grain-boundary cracks, and at grain-boundary triple junctions, cause a limited amount of plastic deformation in the high-strength grain interiors. The competition of grain-boundary deformation with that in the grain interiors determines the observed macroscopic stress-strain response, and the overall ductility. In nanocrystalline nickel, the high-yield strength of the grain interiors and relatively weaker grain-boundary interfaces account for the low ductility of this material in tension.

MSC:

74E15 Crystalline structure
82D35 Statistical mechanical studies of metals
74S05 Finite element methods applied to problems in solid mechanics

Keywords:

crystal plasticity model; stress-strain response

Software:

ABAQUS

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