20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

High temperature mesoscale solid mechanics

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Paper ID: 568
Symposium S10: Coupled problems in material mechanics
Extended Abstract

Abstract

At high homologous temperatures, the deformation of polycrystalline solids is characterized by diffusion within the crystals, as well as lattice growth/disappearance at the boundary and grain boundary sliding. This is further complicated by: formation of new phases, dislocation plasticity and nucleation and evolution of voids. Applications include: creep and creep fracture, sintering and stress-assisted sintering, grain growth and recrystallization. To address these phenomena on the mesoscale, i.e., within crystalline grains and on the grain boundaries, a specialized continuum formulation is needed. A general mathematical formulation for such a mesoscale solid continuum (lattice continuum) has been developed, assuming sharp interfaces between grains and voids . A notable feature of the problems with diffusion and lattice growth at the boundary is that the reference configuration has no physical but only mathematical meaning. Therefore, the deformation gradient is a state variable with evolution defined in the Eulerian sense. The figure illustrates the multiplicative decomposition of deformation gradient for solids with and without diffusion and boundary growth. For problems characterized by complex 3D geometry and moving boundaries, the mesoscale phase field formulation is developed. The mathematical description includes translation and rotation of crystalline grains, diffusion through the crystals and interfaces, lattice growth at the boundary and grain boundary sliding, elastic stresses and compositional eigenstrains. The formulation connects heterologous continua; solids are represented by the lattice continuum, while the voids/gas are the standard mass continuum.

Keywords:

heterologous continua phase field method lattice growth diffusion