FINITE-STRAIN HOMOGENIZATION MODELS FOR POROUS VISCOPLASTIC SINGLE CRYSTALS AND POLYCRYSTALS

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Abstract
This talk is concerned with the development of constitutive models for the finite-strain, macroscopic response of porous viscoplastic polycrystals. For this purpose, use is made of the recently developed iterated second-order homogenization method for porous polycrystals consisting of large pores randomly distributed in a fine-grained polycrystalline matrix. The porous polycrystal is modeled as a two-scale composite, where the grains are described by single-crystal viscoplasticity and the pores are assumed to be large compared to the grain size. The method makes use of a linear comparison composite (LCC) with the same sub-structure as the actual nonlinear composite, but whose local properties are chosen optimally via a suitably designed variational statement. In turn, the effective properties of the resulting two-scale LCC are determined by means of a sequential homogenization procedure, utilizing the self-consistent estimates for the effective behavior of the polycrystalline matrix, and the Willis estimates for the effective behavior of the porous composite. The iterated homogenization procedure allows for a more accurate characterization of the properties of the matrix by means of a finer “discretization” of the properties of the LCC to obtain improved estimates, especially at low porosities, high nonlinearities and high triaxialities. In addition, consistent homogenization estimates for the average strain rate and spin fields in the pores and grains are used to develop evolution laws for the sub-structural variables, including the porosity, pore shape and orientation, as well as the “crystallographic” and “morphological” textures of the underlying matrix. The model can also be applied for porous single crystals by considering the limiting case of a perfectly textured polycrystalline matrix (containing only one grain orientation). Finally, the model will be used to generate estimates for both the instantaneous effective response and the evolution of the microstructure for porous FCC and HCP polycrystals and single crystals under various loading conditions.

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