LMS Seminar

Stored energy vs dissipation in gradient crystal plasticity: Application to cyclic plasticity and recrystallization

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Abstract

The dislocation density tensor is treated as a new constitutive variable of crystal plasticity in addition to the usual scalar dislocation densities and kinematic hardening internal variables, within the framework of strain gradient plasticity. It is an argument of the Helmholtz free energy density function since the accumulation of geometrically necessary dislocations leads to the storage of energy which can be released under suitable thermomechanical loading conditions. Comparison with dislocation dynamics simulations of cyclic plasticity on small scales shows that dissipative contributions to the evolution of the dislocation density tensor must also be included. Previous contributions were based on an additive decomposition of the higher order stress tensor into reversible and dissipative parts. An alternative is presented here that splits the dislocation density tensor itself into reversible and dissipative contributions. The energy stored by geometrically necessary dislocations and statistically stored dislocations is the driving force for grain boundary migration phenomena and grain nucleation in recrystallization processes. The gradient plasticity framework is specialized to a Cosserat crystal plasticity theory and coupled with a phase field approach to simulate microstructure evolution in polycrystals. A striking example is the simulation of grain nucleation events during the torsion of a copper single crystal wire.

About the speaker

Samuel Forest is research director at CNRS and professor of continuum mechanics at Mines Paris. He obtained his PhD in Materials Science and Engineering in 1996 at Mines Paris and his Habilitation to direct research in Mechanics in 2004 at Sorbonne University. His work aims at introducing the physical aspects of deformation and fracture of materials into the framework of continuum mechanics, especially for aeronautical industrial applications. He has participated in the recent developments of the mechanics of generalized continua. He received the bronze (1998) and silver (2012) medals from the CNRS, the Jean Mandel Prize (2001) and the Huy Duong Bui Prize (2022) from the French Academy of Sciences. He recently became a Fellow of the Euromech Society for his contributions in computational mechanical metallurgy. He is Editor in Chief of Comptes Rendus Mécanique , Associate Editor for Journal of the Mechanics and Physics of Solids, and member of the editorial board of three other international journals. He has been elected as a membre of the French Academy of Sciences in 2022.

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