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MODELING AND EXPERIMENTAL CHARACTERIZATION OF MICROSTRUCTURES AND MATERIAL INSTABILITIES

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ABSTRACT

The relation between microstructure evolution and macroscopic constitutive response is crucial in the design and modeling of metallic materials. To interpret and model the material behavior enabling us to design challenging structural properties it is essential to better analyze and understand the interactions of different, even competing strain hardening and defect pattering mechanisms at different length scales. Therefore, the modeling of material instabilities related to different microstructural mechanisms has received significant attention from the scientific community. However, the development of various microstructures at different scales depending on the material, loading path, loading rate and the boundary conditions, makes it a difficult task to develop comprehensive constitutive models. The clustering of dislocations to form cell structures is typical example which is observed in metals. Another microstructure example is the evolution of mechanical twins which proceed by a shear mechanism reorienting the twinned portion into mirror orientation relative to its host component. Phase transformation is another example, where the formation of martensite can be seen analogous to twinning. The Portevin-Le Chatelier (PLC) effect is another striking case, where bursts of plastic strain or stress drops in the stress vs. strain curve and (continuous) propagation and nucleation of PLC bands are the main characteristics. The interaction between the dislocations and grain boundaries such as transmission and accumulation is another phenomenon to be interpreted by constitutive models. Also, shear banding that proceeds as a giant shear localization across multiple internal interfaces is an instability that is not well understood from a microstructural viewpoint. An extended understanding of these mechanisms can only be obtained in a multidisciplinary context, where the experimental observations and model concepts are linked strongly. The experimental findings (through e.g., TEM, EBSD, ECCI) have to be used as input to validate the proposed model formulation, which in turns provide a further physical understanding of the material behavior. The minisymposium aims to bring scientists from material characterization and constitutive modeling together. Therefore we invite experimental and modeling contributions concerned with material instabilities and evolving microstructures in metallic solids due to plasticity, phase transformation, twinning or further mechanisms.