SHOCK09-2009-020009

Abstract for an Invited Paper
for the SHOCK09 Meeting of
the American Physical Society

Mesoscopic studies of shock compression involving structural phase transformations and plasticity

TURAB LOOKMAN, Academy of Sciences of the Czech Republic, Institute of Physics of Materials and Los Alamos National Laboratory, Theoretical Division

An outstanding issue in shock compression is to understand the interplay between a moving shock front, evolution of plasticity and strain-induced phase transformations. At low strain rates, the occurrence of yielding can be identified using a suitable yield criterion that has to be a function of both temperature and plastic strain rate. At high strain rates, the plasticity is overdriven by the rapidly advancing shock front and phenomenological rules are typically utilized to describe this regime. The conditions under which the moving shock front can induce structural phase transformations and the distribution of the individual variants of the product phase have been little studied. In this talk we introduce a mean-field Landau model of structural phase transformations, mediated by elastic strains, that also includes phenomenological models of yielding (von Mises-Prandtl-Reuss) and strain hardening that are dependent on temperature and strain rate. Due to high strain rates, the system is not in equilibrium and a Rayleigh dissipative functional is utilized to include the transfer of energy into heat. The resulting heat conduction equation is coupled with both local strains and strain rates and solved concomitantly with the evolution of the microstructure. The complex phase changes are thus driven by strain, strain rate and temperature. The main features of this model are demonstrated on a two-dimensional model system by examining the dynamic propagation of shock induced by a flying impact plate. For a given initial temperature at which the high-symmetry cubic phase is stable, we study the propagation of heat throughout the sample and evolution of the microstructure as a function of the velocity of the impact plate. This simplified model represents a starting point for the development of a mesoscopic framework that will be useful to study complex phase changes induced by inhomogeneously distributed strain, strain rate and temperature.