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Collective properties of mesodefect ensembles and nonlinear aspects of relaxation and failure in shocked materials

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Statistical theory allowed definition of parameters for mesodefects ensemble and formulation of nonequilibrium potential as generalized Ginzburg-Landau expansion. Kinetics of parameters determines relaxation property during plastic slip and damage-failure transition. Generation of mesodefects collective modes (solitary wave of structural-scaling transition and "blow-up" dissipative structures) is consequence of nonlinear properties of solid with defects, leads to steady-state structure of plastic wave front and delay of damage-failure transition (failure wave). Four power law is consequence of self-similar behavior of mesodefects ensemble. Structural scaling properties in shocked copper plate were studied in cross-section of wave propagation direction with interferometer New View and support high correlation in microshear ensemble related to steady-state plastic front. Simulation of strain kinetics showed importance of nonlocality effects as mechanism responsible for group velocity of plastic wave front with feature of "plastic strain diffusion". Shock failure (spall, failure waves) was studied experimentally in linkage with scenario of crack dynamics in preloaded PMMA plate by high-speed camera coupled with photo-elasticity method, correlation analysis of stress recording data with laser system and New View scaling analysis of failure surface. It was shown existence of "blow-up" scenario of damage-failure transition for crack dynamics, spall and failure wave as resonance excitation of "blow-up" damage kinetics in microshear ensemble under compressive shock. Direct observation of failure wave dynamics in modified Taylor test and plate impact experiment for fused quartz and lead-field glass established correlations with theoretical predictions of mechanisms of failure wave generation and propagation.