STRUCTURAL DEFECTS AND DYNAMIC PROPERTIES OF METALS

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A computational model of coupled evolution of dislocations, twins and grain boundaries in metals under dynamic load is presented. The model is based on our previous results for the dislocation plasticity [1,2] and the grain boundary sliding [3,4], but generalizes them and accounts twins in addition. It is a self-consistent and allows determining of the mechanical properties in wide range of strain rates and thermodynamic conditions ([2], Fig. 1) as well as investigation of the defect subsystems modification ([5], Fig.2).

The model includes equations of the mechanics of continua for elastic-plastic medium, where the plastic deformation tensor is determined as a result of the structural defects evolution in the material. The next processes are accounted: a) motion, generation and immobilization of dislocations; b) formation, growth and immobilization of twins; c) the grain boundary sliding and recrystallization. Interaction of deferent defect subsystems is also accounted through their barrier stresses. All possible crystallographic orientations of dislocations and twins are considered. Complete equations system and a numerical method for its solution are presented.

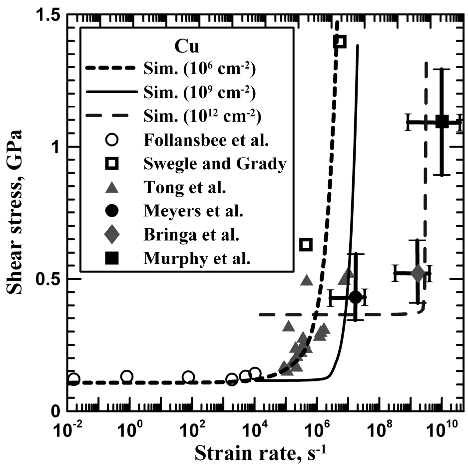

Fig. 1. Strain rate dependences of the maximal shear stress (the dynamical yield strength) for coarse-grained copper. Markers are experimental and calculated (MD) results obtained by different authors and taken from [6]. Lines present our simulation results for various initial dislocation densities. Scattering of experimental points at large strain rates can be explained by difference of the initial dislocation density of samples.

The model contains a number of coefficients. A part of them can be obtained [1,3] from the molecular dynamics simulation (MD). Another part of coefficients can be determined from comparison [2] with the dynamical tests (the high-speed plate impact) and then applied to other problems. For example, the model reveals themselves as a useful tool for investigation of the plastic flow localization ([7], Fig. 2) as well as for investigation of material modification at electron-beam or ion-beam treatment of metals [5].

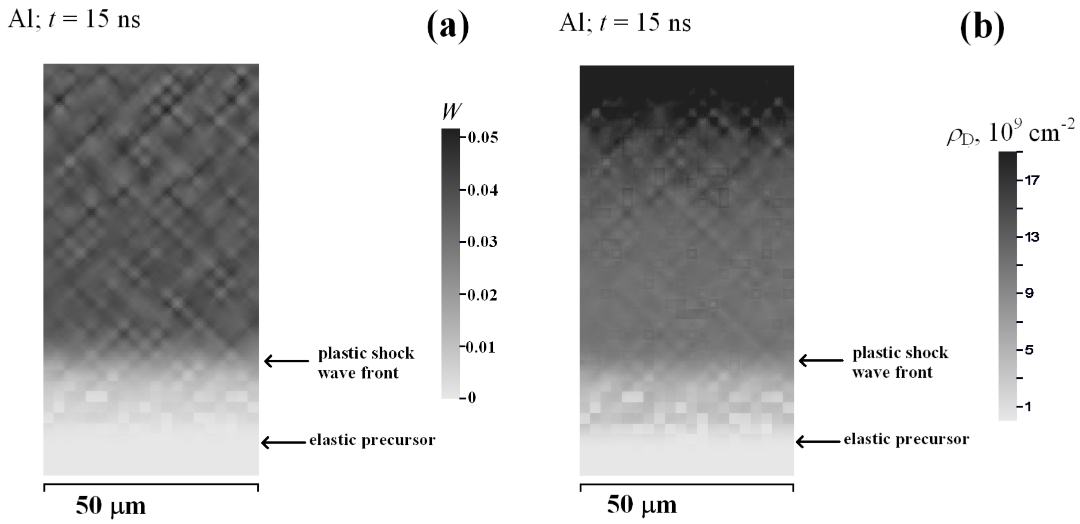

Fig. 2. Localization of plastic flow on the shock wave front: the shock wave propagation in aluminium with the randomly perturbed initial distribution of dislocation density; the plastic strain intensity (a) and the dislocation density (b). Formation of shear bands inclined on 45 degrees to the shock wave front is observed. Velocity jump in the shock wave is 0.3 km/s.

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