Nanoscale physics

Accounting of nanoscale defects in the description of plastic deformation in amorphous materials

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Deformation and fracture of materials under the influence of the applied forces is the main phenomenon that determines the mechanism of the behavior of materials. The plasticity has been studied from the various viewpoints based on mechanics, physics, statistics, etc. [1]. Thus the science of deformation and flow of continuous media got great development in recent times [2].

Usually the plastic deformation is considered as the emergence and movement of the dislocations within the grains. In our approach we propose a phenomenological scheme, when the transition from a solid state to a plastic flow is presented as a self-organization process of the ensemble of nanoscale defects (vacancies and interstitial atoms) within the external influence.

The basic equations of plastic flow are determined by the hydrodynamic theory, where the auxiliary variable (parameter m) was introduced. For the amorphous materials parameter m can be interpreted as the concentration of vacancies. It is convenient to choose m as an order parameter, distinguishing the solid state and the plastic flow state. The conjugated field and the control parameter of the system are played by the velocity of shear displacement and stress respectively.

As a result within the framework of the phenomenological scheme a self-consistent description of the transition from the solid state to the plastic flow was presented taking into account the nanoscale defects such as interstitials and vacancies. On the basis of the system of synergistic equations the dependencies of the internal stresses and curvature of the velocity profile of the shear displacement on the order parameter, and the stationary distribution of the concentration of vacancies were found.

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