Multi-Scale Plasticity Model of Magnesium and Magnesium Alloys for High Velocity Impact Problems

Alexander E. Mayer

Department of General and Applied Physics, Chelyabinsk State University (CSU)
Bratyev Kashirinykh 129, 454001 Chelyabinsk, Russia
e-mail: mayer@csu.ru

ABSTRACT

Structural models of plasticity [1-3], which treat material as having an internal structure and explicitly describe evolution of dislocations or other structural defects, have the most evident advance in comparison with the empirical plasticity models in the case of dynamic problems, such as high velocity impact. Inertness of structural defects significantly influences the plastic behaviour of solids at dynamic loading; this inertness can be naturally addressed within the structural models, while it makes necessary various artificial methods within the empirical models. Disadvantage of the structural models is additional evolution equations for structural defects with relatively large number of parameters. On the other hand, these parameters have explicit physical meaning and can be partially obtained from the molecular dynamic (MD) simulations [4]. In this way, the model becomes a multiscale one and will be referred by this term.

In present work, the structural plasticity model [1,2] is developed to take into account the crystal anisotropy and the finite deformations, and applied for description of magnesium and magnesium alloys. Thermodynamic consistency of the model is discussed. On the atomic level, the MD simulations are used to determine the dislocation motion equation and corresponding parameters in both an ideal crystal of magnesium and a crystal with inclusions, as well as the temperature and pressure dependences of elastic modules. The obtained data are used on the continuum level to close the plasticity model. After construction, the model is verified by comparison with the literature experimental data [5] on the rear surface velocity histories at the high velocity plate impact. Several two-dimensional simulations are also considered as examples of the model application.

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