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MASS TRANSFER IN IRRADIATED MATERIALS

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Dissipation of the kinetic energy of accelerated charged particles during their motion in the material causes its response to the external radiation effect, which, in turn, can significantly affect the kinetics of mass transfer. The effect of the electron flow and non-equilibrium phonons formed in the gradient field of temperature on the defect migration is considered for the first time. The heating temperature is calculated nearby the ion track as well as gradients of temperature and forces affecting the interstitial atoms and their migration.

Keywords: mass transfer process, non-diffusion defect propagation, radiation heating

INTRODUCTION

In our previous research [1] we showed that the elastic and thermoelastic responses from the crystal lattice to the radiation effect led to the formation of the force factors which affected the evolution of the impurity-point defect complexes especially in nanoscale objects. However, similar effects driven by strong temperature gradients which apparently occur in such processes have not been yet investigated. Turning to the matter of the material heating nearby the electronic energy loss of ions, it is worth noting that the pressure rate within the ion track is substantially higher than the limit of the dynamic fracture of the material. In this case, the respective atomic ensemble transfers to gaseous state rather than to molten state [2]. There are a number of approaches to the temperature calculation nearby the ion track which include, in particular, the interaction between the electron and ion subsystems of the material (see the cited literature from [2]). Taking the unimportant number of atoms in the system of interest into account (the classical definition of temperature is inapplicable here), we consider the whole ion track as a heating zone absorbing the ion energy by the mechanisms of elastic and inelastic energy loss without compromising the accuracy of estimation. In this case, the temperature $T(r, t)$ can be derived from the traditional heat conduction equation:

$$T(r,t) = T_0 + \frac{N(S_i + S_e)}{4\pi\mu}\frac{e^{-\frac{r^2}{4Dt}}}{t}, \tag{1}$$

where r is the distance to the ion track surface, t is the time, T_0 is the ambient temperature, N is the atomic density in the target, S_e and S_i are the cross-sections of elastic and inelastic energy loss, respectively, μ is the heat conductivity, D – is the thermal diffusion factor. Eq. (1) is rather convenient for further calculations.

For the medium ion energy E ($E \leq 1$ MeV) the following simple equations can be used to obtain S_i and S_e values:

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