INELASTIC THERMAL SPIKE MODEL AS A MECHANISM FOR TRACK FORMATION

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When irradiating materials by swift heavy ions, the input energy is mainly transferred to the electrons of the target and there is no direct atomic displacement like in the case of irradiation in the nuclear collision regime. Making a classification of the materials irradiated by swift heavy ions, it is shown that metals are less sensitive than insulators, suggesting that the main parameter that governs track formation, is the electron mobility. Two models have been proposed in order to explain the appearance of latent tracks induced in matter by the slowing down process of incident ions in the electronic stopping power regime. The first one was the thermal spike proposed by Desauer [1] and reconsidered for metals by Seitz and Koehler [2]. The second one was the ionic spike, proposed by Fleischer et al. [3], explaining that metals are insensitive to the electronic excitation produced by fission fragments. In the ionic spike model the Coulomb repulsion between ionized lattice atoms is dependent on the time of screening by returning electrons. In the thermal spike model the spread of the energy in the electron subsystem depends on the electron mobility. In each case a large mobility is in favor of hindered efficiency of track creation in metals. Now in the course of time, the ionic spike arises within 10^{-14} - 10^{-13} s while the thermal spike occurs at a later stage (10^{-13} - 10^{-12} s). As our experimental observations are at very long time after the ion irradiation (at least 10^{5}s), we have undertaken in a first row, a detail development of the thermal spike model for metals and for insulators.

In the following, we will discuss the thermal spike model for energetic ions which is called inelastic thermal spike (i-TS) [4-8], in order to avoid any confusion with the thermal spike in the nuclear collision regime [9]. In this model the energy is first deposited on the electrons and subsequently transferred to the atomic subsystems via electron-phonon coupling. The heat diffusion in the electron and lattice subsystems is described by two coupled differential equations governing the energy diffusion on the electron and atomic subsystems and their exchange via the electron-phonon coupling. It will be shown that it is possible to explain the defect annealing and defect creation in Fe with the same value of the electron-phonon coupling, indicating that the defect creation results from the quench of a molten phase created along the ion track. The same model was especially extended to insulators. The model will be extended to low energy ions, showing that a lot of phenomena could arise from electronic excitation.

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