Modeling of electron and lattice thermodynamics in semiconductors interacting with swift ions

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The evolution of the strong electronic excitation induced by swift heavy ion irradiation in semiconductors is studied by a formalism based on Boltzmann's scattering equation that describes the relative scattering motion of electrons in a doped GaAs semiconductor interacting with a swift heavy ion by including impurity- and phonon-assisted absorption as well as Coulomb scattering between electrons. Ion projectiles with intermediate non-relativitic velocities are considered. Charge transfer and ionization across the band-gap are not taken into account at this stage. An alternative method is considered to describe electron excitation in bulk GaAs during ion irradiation. It is based on a semi- equivalent process of interaction of the bulk semiconductor with two orthogonal electromagnetic radiation pulses. The envelopes of the radiation pulses are chosen to simulate the electric field produced by the incoming ion during the ion interaction process.

Our approaches provide quantitative information on the electron distribution. Upon irradiation we observe a high-energy tail in the Fermi-Dirac distribution. The thermodynamics of hot electrons is studied by calculating the transient average electron kinetic energy as a function the impact parameter of the ion projectile, its velocity and charge number. The time evolution of the lattice-temperature is determined by a thermal diffusion equation for phonons. A comparison of the results with results from the thermal spike model are presented.