Time Evolution of Charge Carriers Phonons after Photo-Excitation by an Ultra-Short Light Pulse in Bulk Germanium

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We have calculated the time-evolution of carriers and generated phonons in Ge after ultrafast photo-excitation above the direct band-gap. The relevant electron-phonon and anharmonic phonon scattering rates are obtained from first-principles electronic structure calculations. Measurements of the x-ray diffuse scattering after excitation near the L point in the Brillouin zone find a relatively slow (5 ps, compared to the typical electron-phonon energy relaxation of the Gamma-L phonon) increase of the phonon population. We find this is due to emission caused by the scattering of electrons between the Delta and L valleys, after the initial depopulation of the Gamma valley. The relative slowness of this process is due to a combination of causes: (i) the finite time for the initial depopulation of the conduction Gamma valley; (ii) the associated electron-phonon coupling is relatively weaker (compared to Gamma-L, Gamma-Delta and Delta-Delta couplings); (iii) the TA associated phonon has a long lifetime and (iv) the depopulation of the Delta valley suppresses the phonon emission.

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