Ultrafast strong-field excitation of solids

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Strong-field photoinjection of charge carriers can reversibly change optical and electric properties of a solid within a fraction of an optical cycle. Novel measurement techniques enable detailed, time-resolved studies of the nonlinear energy exchange between an intense laser pulse and matter, as well as time-resolved measurements of how electrons move, driven by the electric field of light [1]. This progress motivates theoretical investigations of how dielectrics and semiconductors interact with few-cycle laser pulses in a parameter regime where linear and nonlinear susceptibilities fail to describe light-matter interaction.

When the excitation of a valence electron to conduction bands requires simultaneous absorption of many photons, a complex and highly nonequilibrium distribution of charge carriers forms by the end of the laser pulse. Such distributions define the induced transient changes in optoelectronic properties. Relaxation processes change electron distributions on the time scale of a few tens of femtoseconds, which is why relatively little is known about optical properties of solids immediately after photoexcitation by a laser pulse that has a peak intensity just below the damage threshold. For several representative crystals, we studied photoexcitation dynamics, as well as the response of injected charge carriers to the electric field of a probe pulse. Our findings include a transient optical gain in laser-excited crystalline media, as well as a manifold increase in the average effective mass of charge carriers due to interband tunneling [2]. We also show that photoexcitation dynamics leave characteristic signatures in the dependence of the deposited energy on the carrier–envelope phase (CEP) of a laser pulse.

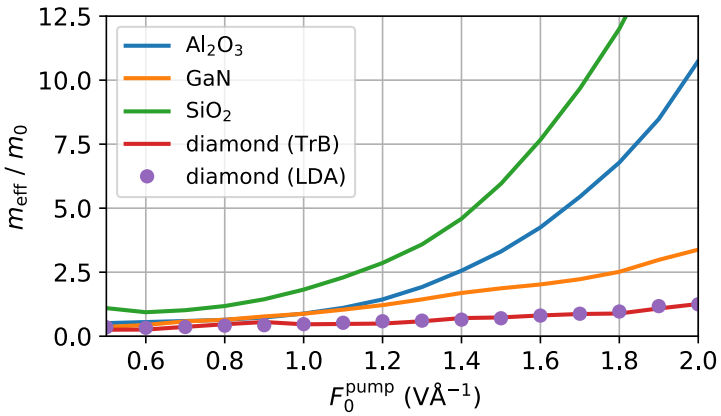

Fig. 1: The average effective mass of photoinjected charge carriers for different peak electric fields of a 4-fs 800-nm laser pulse [2]

References:

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