Coherent optical phonons on semiconductor surfaces studied with transient reflectivity

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Coherent optical phonons are the lattice atoms vibrating in phase to each other over a macroscopic spatial region. They are excited either by electric field of the optical pulses through non-linear susceptibility (*impulsive stimulated Raman scattering*) or as a result of photoexcitation into the excited electronic states (*transient depletion field screening* and *displacive excitation of coherent phonons*). Pulse-trains and pulse-shaping techniques have enabled mode-selective excitation of the coherent phonons and have achieved vibrational states far from thermal equilibrium. Our experiments with shaped pulses have revealed that, for a given photon energy, the amplitude of the coherent phonons is determined by the spectral component at the phonon frequency. Pump-probe reflectivity/transmissivity measurements, second harmonic generation (SHG), and X-ray diffraction (XRD) are the three major detection techniques of the coherent phonons. While SHG and XRD monitor atomic layers and bulk crystals, respectively, the reflectivity measurements on opaque semiconductors can tune the probing depth by tuning the wavelength of the probe light. We demonstrate that near-UV pulses monitor exclusively the depletion layer of doped GaAs, in which ultrafast dynamics of coherent phonons and plasmon-coupled modes are in striking contrast with their counterpart in the bulk.