Role of optically injected carriers in high harmonic generation in silicon

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High harmonic generation (HHG) in solids can be understood as a three-step process, in which a non-resonant oscillating electric field generates electron-hole wavepackets via quantum tunneling and then accelerates them. The electron-hole wavepackets then recombine to produce coherent radiation with high photon energies. Along with the recombination, the intraband currents originating from the anharmonic motion of electrons and holes in non-parabolic bands also contribute to the high harmonic radiation [1] [2].

Here we use a pump-probe like setup to study the influence of incoherent optical carriers injected in the conduction band on HHG in crystalline silicon. Pump pulse with energy 3.6 eV or 1.8 eV excites the carriers via direct or indirect transition leading to different energy distribution of carriers. The mid-infrared pulse (0.6 eV) acting as the probe arrives at a certain time delay to produce the harmonics. The yield of HHG is measured as a function of the time delay between the pump and strong-field mid-infrared pulses. We identify two competing mechanisms that influence the HHG yield - a decrease of the yield due to ultrafast dephasing induced by carrier-carrier scattering [3], and an increase in the intraband HHG contribution caused by the excess carriers. Using experiments along with numerical calculations we show that the intraband HHG contribution is strongly influenced by the carrier energy distribution and effective temperature. The results allow us to clarify the role of the band structure, carrier relaxation, and carrier-carrier scattering in the HHG process and further advance the control of high harmonic spectroscopy in solids.

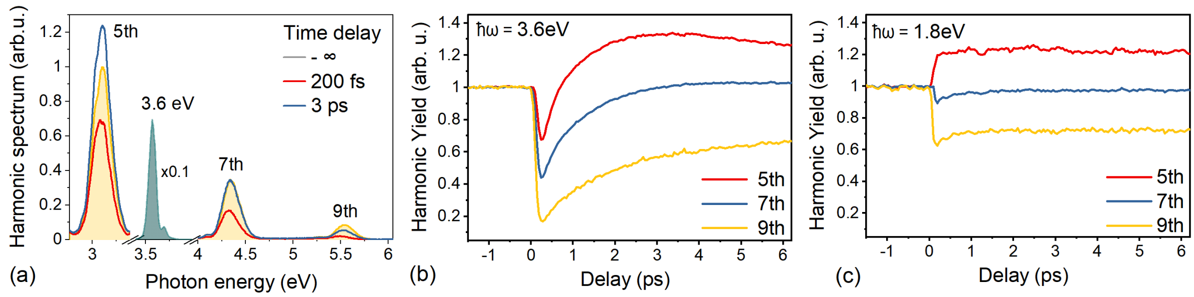

Figure 1: (a) Spectra of the harmonics at different time delays between the two pulses for 3.8 eV excitation. HHG yield change of different harmonics as a function of the delay between the two pulses using excitation wavelengths of (b) 3.8 eV and (c) 1.9 eV.

References

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