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Ultrafast modulation of photoluminescence in semiconductors by intense terahertz pulses

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Terahertz (THz) pulse science is a rapidly developing field, and has been applied extensively in the characterization of ultrafast dynamics in semiconductors and nanostructures. The recent development of intense THz pulse sources in lithium niobate (LN), however, allows the dynamics of transient states to be directly manipulated by the large electric field of the THz pulse itself. We have used an ultrafast laser source to generate intense THz pulses in LN with picosecond duration and peak electric fields up to 300 kV/cm. Here we study how these intense THz pulses affect the ultrafast radiative recombination dynamics of photoexcited carriers in semiconductors and semiconductor nanostructures. In GaAs, we observe a sharp transition between THz-pulse-induced quenching and enhancement of photoluminescence (PL) with increasing photoexcited carrier densities. We present spectrally-resolved PL measurements of this transition, which reveal a competition between enhancement at shorter wavelengths versus quenching at longer wavelengths. The dynamics of this interplay between THz pulse enhanced and quenched PL are presented as a function of excitation fluence and time-delay between the excitation and THz pulses. Possible mechanisms that include THz-induced carrier heating and scattering processes are discussed. The effects of intense THz pulses on the PL dynamics in polycrystalline GaAs, and quantum well structures will also be explored. The ability to control material properties with intense THz pulses may lead to novel optoelectronic devices with the ability to modulate light emission on picosecond timescales.

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