TIME-RESOLVED PHOTOLUMINESCENCE QUENCHING IN QUANTUM WELLS USING A TERAHERTZ FREE-ELECTRON LASER

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We have measured time-resolved photoluminescence (TRPL) quenching in strained $In_{0.2}Ga_{0.8}As$ quantum wells induced by intense free-electron laser-generated (FEL) terahertz (THz) radiation. A picosecond-pulse Ti:Sapphire laser was used to create photoluminescence (PL), which was then collected using a streak camera-monochromator assembly. By changing the temporal separation of the Ti:Sapphire excitation pulse and the THz quenching pulse, we could investigate PL quenching when the system was more plasma-like (unbound correlated electron-hole pairs) and when it was more excitonic (Coulombically bound electron-hole pairs). For all THz wavelengths investigated, we saw more PL quenching when the system was more excitonic. The slow increase of the quenching with increasing excitation pulse-quenching pulse time delay suggests excitonic formation times on the order of a nanosecond. To study excitonic dynamics more fully, we utilized the tunability of the FEL, which is a narrowband THz source, to access photon energies above, at, and below the intra-excitonic 1*s* to 2*p* transition. We observed that when the photon energy was resonant with the 1*s*-2*p* transition, the PL quenching was enhanced. However, when the off-resonant THz photon energy was below the 1*s*-2*p* transition energy, the PL quench was larger than when the THz photon energy was above that energy, a fact we attribute to free-carrier absorption. Thus, both resonant and non-resonant processes are able to produce a quench in PL emission from the 1*s* energy state. In addition to PL quenching, we also observed time-resolved, THz-induced 2*s* excitonic PL. This emission occurs when FEL-created 2*p* excitonic states are Coulombically scattered to energetically degenerate 2*s* states, a process that occurs after ~100 ps. We find that the lifetime of the 2*s* emission is in the hundreds of picoseconds, which is an order of magnitude shorter than the 1*s* emission.