Temporal and thermal properties of surface-trapped plasmon-coupled CdSe quantum dots

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Plasmon-coupling of CdSe quantum dots (QDs) are important to study due to their highly advantageous applications to optoelectronics. The foremost features of typical CdSe QDs includes wide optical tunability, high color purity, and large PL enhancement in the vicinity of plasmonic nanoparticles. The reduced size also allows for straightforward integration with electronic devices. The fluorescence of CdSe QDs originates from exciton carrier recombination, whereas discrete energy states and blue-shift from the bulk bandgap (~712 nm) arises from quantum confinement of these carriers when the QDs are near the bulk exciton Bohr radius (~5.8 nm). In this work, the surface-trapped state transition arises from the crystal irregularity on the surface due to dangling atoms and/or atomic vacancies/defects during the synthesis. PL enhancement and decreased exciton lifetime is observed through plasmon-exciton coupling through the Coulomb interaction between plasmon and excitons at the bandedge and surface-trapped state transitions. Exciton lifetimes were reduced ~2-fold for the dominant bandedge transition while the PL from the surface-trapped transition was slightly enhanced and displayed slow lifetimes at longer wavelengths due to increased non-radiative energy transfer from Au nanoparticles. Temperature-dependent measurements suggested that bandedge transition of plasmon-coupled CdSe were exposed to thermal expansion and possibly plasmon-exciton-phonon coupling while the enhanced PL intensity resulted from the reduction of non-radiative decay. Acknowledgement: This work at HU is supported by ARO W911NF-15-1-0535, NSF HRD-1137747, and NASA NNX15AQ03A.

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