

Third Generation Solar Photon Conversion to Electricity and Fuel: *Multiple Exciton Generation in Colloidal Quantum Dots; Quantum Dot Arrays and Solar Cells*

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Abstract:

One potential, long-term approach to more efficient future generation solar cells is to utilize the unique properties of quantum dot (QD) nanostructures to control the relaxation pathways of excited QD states to produce enhanced conversion efficiency through efficient multiple exciton generation (MEG) in QDs.

We have observed very efficient multiple exciton generation (MEG) in PbSe, PbS, PbTe, and Si QDs at threshold photon energies of 2-3 times the HOMO-LUMO transition. We have studied MEG in close-packed QD arrays where the QDs are electronically coupled in the films and thus exhibit good carrier mobility. We have developed a simple, all-inorganic metal/QD/metal sandwich solar cell that produces a large short-circuit photocurrent (~25-35 mA/cm² - equivalent to crystalline Si) via a Schottky junction at the negative electrode, without the need for QD sintering, superlattice order or separate phases for electron and hole transport. We have demonstrated that the MEG efficiency in conductive Pb chalcogenide QD films after certain chemical treatments can be comparable to isolated QDs in colloids, but the QY varies greatly depending upon the specific chemical treatment. and subsequent QD surface chemistry.

Selected aspects of this work will be summarized and recent advances will be discussed. Various possible configurations for novel QD solar cells that could produce high conversion efficiencies for the production of electricity and solar fuels. like H₂ via water splitting, will be presented, along with progress in developing such new types of solar cells. Recent controversy about MEG will also be addressed.