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Quantum Confined Semiconductors for High Efficiency Photovoltaics

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Semiconductor nanostructures, where at least one dimension is small enough to produce quantum confinement effects, provide new pathways for controlling energy flow and therefore have the potential to increase the efficiency of the primary photon-to-free energy conversion step. In this discussion, I will present the current status of research efforts towards utilizing the unique properties of colloidal quantum dots (NCs confined in three dimensions) in prototype solar cells and demonstrate that these unique systems have the potential to bypass the Shockley-Queisser single-junction limit for solar photon conversion. The solar cells are constructed using a low temperature solution based deposition of PbS or PbSe QDs as the absorber layer. Different chemical treatments of the QD layer are employed in order to obtain good electrical communication while maintaining the quantum-confined properties of the QDs. We have characterized the transport and carrier dynamics using a transient absorption, time-resolved THz, and temperature-dependent photoluminescence. I will discuss the interplay between carrier generation, recombination, and mobility within the QD layers. A unique aspect of our devices is that the QDs exhibit multiple exciton generation with an efficiency that is $\sim$ 2 to 3 times greater than the parental bulk semiconductor.