MULTIPLE EXCITON GENERATION, CHARGE CARRIER DYNAMICS, AND SOLAR ENERGY CONVERSION IN ELECTRONICALLY COUPLED FILMS OF PBSE NANOCRYSTALS

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Multiple exciton generation (MEG) is a process that occurs in semiconductor nanocrystals where one highly energetic photon produces multiple charge carriers and can significantly enhance solar energy conversion efficiencies. Recently, we have developed a simple, ITO/PbSe-NC/metal cell via a Schottky junction at the back electrode that routinely produces a large short-circuit photocurrent and solar conversion efficiencies of ~ 2%. In this cell, the PbSe NC films are chemically treated using 1,2-ethandithiol (EDT) to produce highly photoconductive films that yield EQEs of 65% across the visible and up to 25% in the infrared region of the solar spectrum, with IQEs approaching 90%. A layer-by-layer technique is used to deposit the films and produces smooth, high quality, reproducible films. We have measured the *n* and *k* of our layer-by-layer PbSe nanocrystal films and constructed an optical model in order to understand the optical generation rate in our devices. We report preliminary results, utilizing this model, in order to determine whether MEG-produced carriers contribute to the high photocurrents observed in our devices. We discuss limitations of our device structure in observing MEG photocurrents and report progress towards overcoming those limitations. These encouraging results provide incentive to study and understand the carrier dynamics in these films.

We recently reported that in hydrazine treated PbSe nanocrystal films, the MEG efficiency remains about the same as in untreated NCs. However, with these treatments, the inter-NC coupling increases. The biexciton lifetime (Auger recombination time) increased by a factor of ~3 for the coupled NCs and the mobility, measured using time-resolved THz spectroscopy (TRTS), greatly increases. Using transient absorption measurements, we have studied carrier-dynamics in films of PbSe NCs chemically treated using EDT and find that the biexciton lifetime increases by a factor of 10 relative to isolated NCs. We also have found evidence for a reduced MEG QY in these treated films. We report carrier dynamics and MEG QYs for a series of chemical treatments. The NC surfaces in each case have also been characterized.