

Integration of core/shell semiconductor colloidal quantum dots in bulk-heterojunction polymer solar cell

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Semiconducting polymer solar cells are promising devices for harvesting solar energy at low cost. They offer other desirable properties like low weight, flexibility and semi-transparency [1]. Consequently, intensive research is in progress to increase the solar power conversion efficiency of these devices.

Performances around 3% have already been reported in bulk-heterojunction devices [1]. In this type of solar cell, the charge separation is done by an interpenetrating network of hole and electron accepting materials inside the device. This can be achieved by using polymer blends [2] or mixtures of C₆₀ derivatives [3]. Nanocrystals of inorganic semiconductor such as CdSe can also be used as hole acceptors from conjugated polymers.

These nanocrystals, also called colloidal quantum dots (cQDs), have interesting properties for optimizing the charge transfer in photovoltaic applications. They have energy levels that can be tuned through the size-dependent quantum confinement effect. Their chemical surface properties can be modified by ligand exchange. Moreover, cQDs are also available in core/shell heterostructures made of two materials with different bandgap (e.g. CdSe/ZnS). Thus, we designed band alignments different configurations: types I and II [4]. In a type I cQD, both electron and hole are confined in the core. In a type II cQD, one carrier is mostly confined in the core, while the other is mostly confined in the shell. These different configurations have a significant influence on the carrier mobility and the efficiency of a polymer solar cell.

In this work, we are interested in charge transfer as well as transport properties between cQDs and conjugated polymers such as P3HT. To study these processes, two techniques were used: measurement of

photoluminescence (PL) quenching of single polymer-cQDs thin films and I-V characterisation of polymer-cQDs solar cells.

We observed that adding cQDs in a photoluminescing polymer film decreases its PL intensity by charge transfer. Measurements of this PL quench versus the concentration of dispersed cQDs in the film gave us further evidences of charge separation between the two materials [5].

The polymer-cQDs solar cell is represented on figure 1. The fabrication of our devices followed the procedure described by Blouin et al. [6]: each layer of polymer was spin-coated on a patterned ITO substrate and an aluminum contact was deposited on top by thermal evaporation. We characterised the dependence of series resistance and photocurrent generation with cQD density in the active layer for different core-only (CdSe, CdS, CdTe) and core/shell structures (CdSe/ZnSe, ZnSe/CdSe, CdSe/ZnS). We assess how the different band structure designs of these cQDs affect charge carrier separation and mobilities with the aim of increasing power conversion efficiencies in polymer photovoltaic cells.

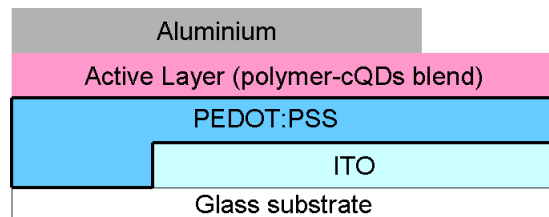


Figure 1: Structure of the organic polymer-cQDs photovoltaic cell.

References

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