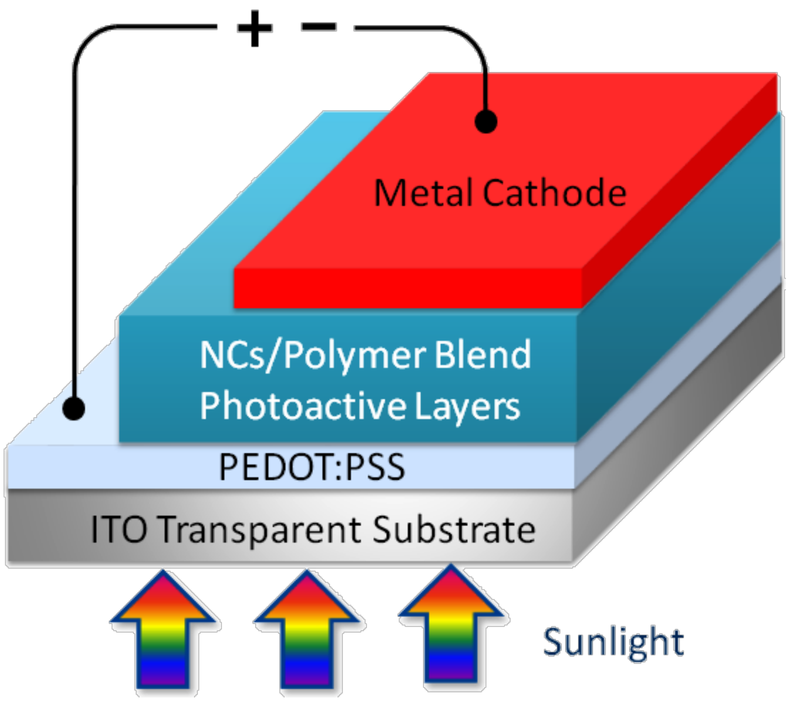
Performance enhancement of hybrid solar cells by postsynthetic surface treatment of quantum dots

Michael Krueger

Freiburg Materials Research Centre (FMF), University of Freiburg, Stefan Meier Strasse 21, D-79104 Freiburg, Germany

Inorganic semiconductor nanocrystals (NCs) such as CdSe NCs, with tunable bandgaps and high intrinsic charge carrier mobilities can act as good electron acceptors and be incorporated into conjugated polymers to form bulk-heterojunction hybrid solar cells with a typical device structure shown in Figure 1. Nevertheless their power conversion efficiencies (PCEs) are still lagging behind the PCEs of fullerene based organic photovoltaic devices.



Scheme 1: Typical device structure of a bulk-heterojunction hybrid solar cell.

Crucial factors limiting the device performance of hybrid solar cells will be highlighted. Recent strategies to overcome this limiting barriers are demonstrated. This includes the efficiency enhancement of CdSe NC based devices due to different postsynthetic treatments of the NCs, the use of low-bandgap polymers, the optimization of device structures including active layer thickness and electrode materials, novel NC hybrid structures and approaches to control the nanomorphology of the donor acceptor phases.

Especially post synthetic modification of semiconductor nanocrystals will be addressed. The direct utilization of colloidal semiconductor nanocrystals in hybrid solar cells is usually limited due to long chain insulating organic capping molecules. Postsynthetic surface treatments have to be applied in order to reduce or to replace the insulating capping for improving charge separation between the polymer and the nanocrystals as well as charge transport between individual nanocrystals. The decrease of the insulating ligand sphere around CdSe nanoparticles by various surface treatments was confirmed by TGA-MS. By applying a combination of different postsynthetic surface treatments and by the use of a low bandgap conjugated polymer, improved power conversion efficiencies up to 3.5% have been achieved for bulk heterojunction hybrid solar cells.

With dedicated nanocrystal surface modification the short current density and/or the open circuit voltage can be chemically modulated and adjusted and opens an additional degree of freedom for future performance enhancement.