Abstract

Organic-inorganic hybrid solar cells (HSCs) have the potential to be economical and portable energy source. Semiconducting nanocrystals are attractive for solar cells as they have tune-able bandgaps and can improve charge separation when blended with the conjugated polymers. This dissertation advances the field of HSCs by documenting device fabrication and physics employing cobalt oxide (Co_3O_4), chromium oxide (Cr_2O_3) for the first time in bulk heterojunction active layer.

Two main device structures, bulk heterojunction HSCs and perovskite solar cells (PrSCs) were investigated in this research. In both cases the effect of metal oxide nanoparticles (NPs) on morphology, opto-electronic properties and lifetimes was systematically studied.

The NPs were synthesized using co-precipitation technique and the average particle size of 29.3-36.7 nm and 10-13 nm was obtained for Co_3O_4 and Cr_2O_3 respectively. The active layer of HSCs primarily composed of 3-hexylthiophene (P3HT), [6,6]-phenyle-C60-butyric acid methyl ester ($PC_{60}BM$) and poly[[4,8-bis[(2-ethylhexyl)oxy]benzo[1,2-b:4,5-b']dithiophene-2,6-diyl][3-fluoro-2-[(2-ethylhexyl)carbonyl]thieno[3,4-b] thiophenediyl]][6,6]) (PTB7), [6,6]-phenyle-C70-butyric acid methyl ester ($PC_{70}BM$) blended with Co_3O_4 and Cr_2O_3 separately. An orderly incorporation of NPs in both blends was found to increase the open circuit voltage, short circuit current density, fill factor and conclusively power conversion efficiency (PCE).

In PrSCs, methylammonium lead iodide ($CH_3NH_3PbI_3$) was used as main absorber and ZnO and Al:ZnO NPs were used as electron transport layer in addition with PCBM. The NPs interlayer between PCBM and metal electrode increased the overall device performance i.e. PCE and stability.

Various characterizations techniques such as short circuit current density vs voltage, field emission scanning electron microscopy (FESEM), atomic force microscopy (AFM), UV-Vis spectrophotometry, external quantum efficiency (EQE) and x-ray diffraction (XRD) have been utilized to fully understand the effect of NPs.

A substantial increase in absorption and EQE was observed for the devices with metal oxide NPs. The inclusion of NPs also increased the film roughness and was found to form percolation network with in the active layer in case of HSCs that facilitates charge transport.