Charge Transfer Excitons in Low Band gap Polymer based Solar Cell Active Layer and the Role of Processing Additives

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Bulk heterojunction solar cells have attracted considerable attention over the past years due to their potential for being one of the first ultra-low-cost photovoltaic (PV) technologies. The possibility of manufacturing PV modules in a roll-to-roll process in combination with low-cost active materials could lead to a watt-peak price below 0.5 US$ in the near future. Efficiencies of bulk heterojunction solar (BHJ) cells larger 8 % have been reported and certified by the National Renewable Energy Laboratory (NREL). Theoretical and experimental studies suggest that power conversion efficiencies in the range of 10-12 % can be achieved with single junction devices, which is significantly lower compared to maximum efficiency predicted by the Shockley-Queisser-Limit.

Several different factors limiting the performance of BHJ solar cells have been identified including the nano-morphology of the photoactive layer, losses due to charge carrier recombination, inefficient charge transport and the non-optimized offset between the donor and the acceptor level.

Recently, a weak optical transition assigned to a charge transfer state has been observed. A detailed analysis of the ground-state absorption, the photoluminescence of donor-acceptor

blends and also the electroluminescence of BHJ solar cells revealed that a long-lived, low energy transition occurs in various conjugated polymer – fullerene blends. The charge-transfer (CT) state can be populated via a direct transition in the weak CT-band, via the photo-excitation of the donor or acceptor molecule followed by a relaxation into the CT-state or by the recombination of electrons and holes. The role of the CT-state and its effect on the overall efficiency limit of bulk heterojunction devices is also still unclear.

In our presentation the effect of the processing additive octane-dithiole on the charge transfer emission in poly[2,6-(4,4-bis-(2-ethylhexyl)-4H-cyclopenta[2,1-b;3,4-b']-dithiophene)-alt-4,7-(2,1,3-benzothiadiazole)] (PCPDTBT) and [6,6]-phenyl C_{61}-butyric acid methyl ester (PCBM) will be discussed. Despite the fact that blends processed with and without additive show a ground state charge transfer optical absorption only the blend processed without additive shows a corresponding charge transfer emission. The presented experimental data show that the nano-morphology of the bulk-heterojunction blends plays an important role for the formation of emissive charge transfer states, and that it is a loss channel in the studied solar cells.

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I prefer charge transfer exciton-but we should at least be coherent!

References

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