Bulk heterojunction Solar Cells, Perspectives and Limitations

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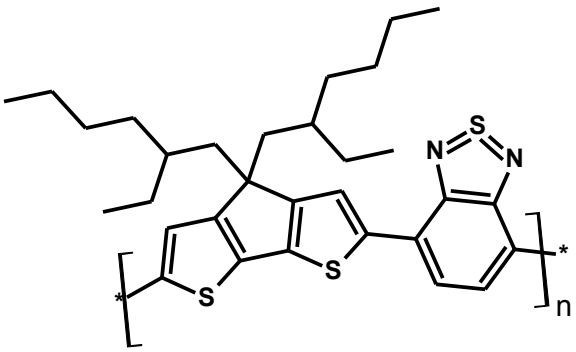
Bulk-heterojunction (BHJ) solar cells have attracted considerable attention over the last years due to their potential as a low cost photovoltaic technology. The possibility of manufacturing modules via a standard printing/coating process in a role-to-role (R2R) fashion in combination with the use of low cost materials will lead to a watt-peak price of less than 1 US$ within the next few years [1].

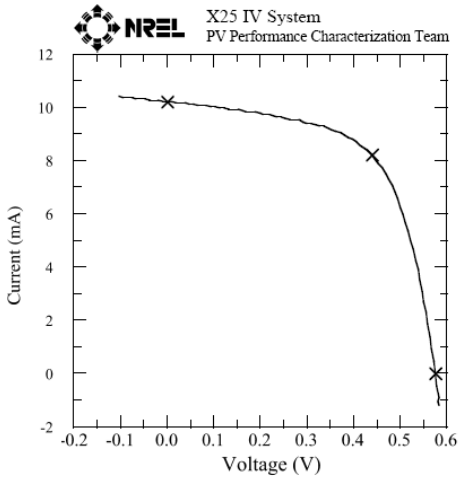
Despite the low cost potential, the power conversion efficiency of BHJ devices is low compared to inorganic solar cells. Efficiencies in the range of 6 to 7 % have been certified at AIST and NREL usually on devices with very small active areas [2].

The current understanding of bulk heterojunction solar cells suggests that the maximum efficiency is in the range of 10-12 % [3]. Several reasons for the power conversion efficiency limitation have been identified [1]. Some of the prerequisites for achieving highest efficiencies are donor and acceptor materials with optimized energy levels (Highest Occupied Molecular Orbital and Lowest Unoccupied Molecular Orbital), efficient charge transport in the donor-acceptor blend, efficient charge generation and limited recombination losses. Power conversion efficiency is strongly dependent on charge generation and transport that is dominated by the phase behavior of the donor and acceptor molecules. Often an unfavourable nano-morphology of this two component blend limits the power conversion efficiency of bulk heterojunction solar cells. Precise control of the nano-morphology is very difficult and has been achieved only for a few systems [4,5]. The relation between the chemical structure of donor and acceptor materials and the nano-morphology that they form when they are blended is not well understood.

In this contribution we will describe the current status and future potential of bulk-heterojunction solar cells. We will discuss the important role of material design and morphology optimization based on our work on an interesting class of low bandgap

polymers (poly[2,6-(4,4-bis-(2-ethylhexyl)-4H-cyclopenta[2,1-b;3,4-b′]-dithiophene)-alt-4,7-(2,1,3-benzothiadiazole)]) and show that minor chemical changes can have a major impact on the photo-physics and power conversions efficiency of donor-acceptor solar cells.





V_{oc} = 0.5756 V	I_{max} = 8.2047 mA
I_{sc} = 10.218 mA	V_{max} = 0.4376 V
J_{sc} = 14.917 mA/cm^2	P_{max} = 3.5908 mW
Fill Factor = 61.05 %	Efficiency = 5.24 %

Chemical Structure of (poly[2,6-(4,4-bis-(2-ethylhexyl)-4H-cyclopenta[2,1-b;3,4-b′]-dithiophene)-alt-4,7-(2,1,3-benzothiadiazole)]) and an NREL certificate received for a low bandgap bulk-heterojunction solar cell prepared by Konarka.

References

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