Understanding issues related to efficiency and stability in polymer solar cells

Elizabeth von Hauff
[1]*Organic Photovoltaics & Electronics,* Institute of Physics
Albert Ludwigs University of Freiburg, D-79104 Freiburg Germany
[2]Fraunhofer Institute for Solar Energy Systems (ISE)
Heidenhofstr 2, D-79110 Freiburg, Germany

Abstract

The power conversion efficiencies of organic solar cells have been steadily increasing over the last years and the benchmark of 10% was recently reached [1]. Polymer:fullerene bulk heterojunctions (BHJ) are the most commonly investigated type of organic solar cell. BHJ cells are of particular interest as the active layer of the solar cell can be processed from solution, allowing for low cost, low temperature large scale and flexible production.

The physics of organic solar cells is fundamentally different than that of inorganic semiconductor based technologies. Therefore to further develop this technology an understanding of how processes at the molecular and mesoscopic level influence device performance is crucial. Loss mechanisms, such as recombination, must be identified and understood. Additionally material and interface stability has become increasingly important in the field as a result of the rising solar cell efficiencies.

In earlier works we showed how molecular conformation and ordering [2] influences recombination losses over the charge transfer exciton (CTE) at the donor-acceptor interface. In this talk strategies to improve the efficiencies in solar cells based on the low band gap copolymer poly[2,6(4,4-bis-(2-ethylhexyl)-4H-cyclopenta[2,1-b:3,4-b0]-dithiophene)-alt-4,7-(2,1,3-benzothiadiazole)] (PCPDTBT) and PCBM via molecular doping are discussed. It is demonstrated that molecular doping increases charge carrier mobility in the polymer phase and leads to a decrease in CTE recombination [3,4], resulting in higher photocurrents and solar cell efficiencies. These results present a novel method for tuning the electrical properties of non-crystalline organic materials.

In the second part of the talk, factors which influence the stability of BHJ solar cells are explored. Exposure of the active layer to ambient conditions results in the loss of photocurrent. Changes in the optical properties of poly-(3-hexylthiophene) (P3HT):PCBM blends after systematic exposure to light and oxygen are demonstrated [5]. In addition to the active layer, the device interfaces can degrade. It is shown how the composition of the hole transport layer, even in encapsulated devices, can have a significant impact on device lifetime [6].

References

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