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Principles and Challenges of Organic Solar Cells

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Organic solar cells are a relatively new entry into the field of distributed power production and are promising as clean sources of energy. The organic semiconductors used in the devices offer unique opportunities for tailoring of properties by modifying chemical structure, fabricating light-weight and flexible devices because of their strong absorption in thin layers, and new applications such as printed and transparent devices. To realize practical devices, progress in device and material physics, fabrication, and engineering are all necessary. The general principles of devices and studies to improve them will be discussed.

Interface engineering is one important aspect of solar cell design that can greatly impact performance. As one example, photoluminescence measurements show that recombination of absorbed photons occurs at the interface between a common hole-transport layer, PEDOT:PSS, and the donor DBP.[1] Recombination can be reduced and device performance improved by inserting a layer of the semiconductor TPTPA because of its wide band gap and matched energy levels.

The donor can also be blended with the acceptor to form a bulk heterojunction. DBP was used in bulk heterojunctions with C_{70}, and low concentrations of DBP were found to give the highest performance, as shown in Fig. 1. Understanding the molecular interactions and blending that leads to high performance is of interest. In this case, the decreasing efficiency appears to be related to decreasing electron mobility and changes in C_{70} packing at higher concentrations.

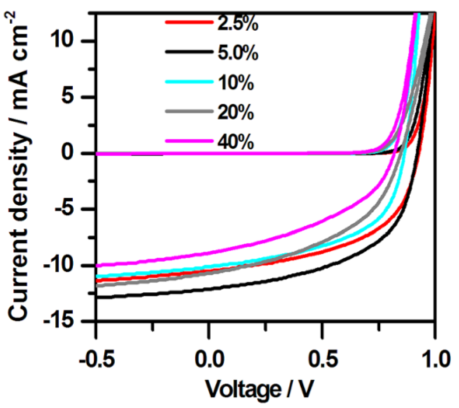

Fig. 1: J-V curves for devices with the structure ITO / MoO_X (5 nm) / DBP:C_{70} (*X*%, 40 nm) / BCP (10 nm) / Ag under simulated AM1.5 G illumination.[2]

Finally, the advantages and use of tandem geometries containing stacked devices will be discussed.[3]

[1] M. Hirade and C. Adachi, Appl. Phys. Lett. **99**, 153302 (2011).
[2] Y.-Q. Zheng *et al.*, Appl. Phys. Lett. **102**, 143304 (2013).
[3] Y. Zho *et al.*, Appl. Phys. Lett. **100**, 243302 (2012).