

## **Materials design to improve the efficiency of organic photovoltaics: donor/acceptor interfaces and electrodes**

Alberto Salleo<sup>1</sup>, Rodrigo Noriega<sup>2</sup>, Ludwig Goris<sup>1</sup>, Jonathan Rivnay<sup>1</sup>, Tom Holcombe<sup>3</sup>, Claire Woo<sup>3</sup>, Jean Fréchet<sup>3</sup>

<sup>1</sup>*Department of Materials Science and Engineering, Stanford University, Stanford CA 94305*

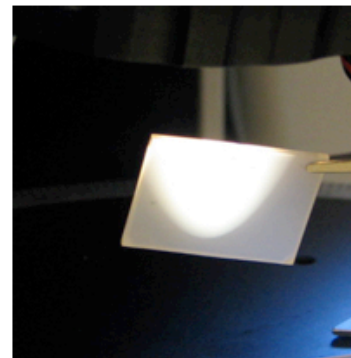
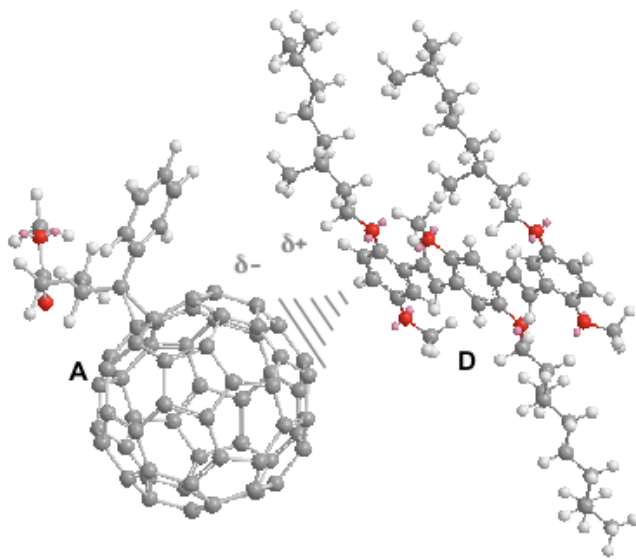
<sup>2</sup>*Department of Applied Physics, Stanford University, Stanford CA 94305*

<sup>3</sup>*Department of Chemistry, UC Berkeley, Berkeley CA 94720*

The efficiency of organic photovoltaics has recently improved substantially, with 2009 being the year of power conversion efficiency records. Currently, the highest efficiency reported reaches 7.9%. While these results are exciting, there still need to be efficiency improvements to propel this technology towards commercialization. I will describe how materials design can improve efficiency by allowing to tailor the energetics of the donor-acceptor interface of bulk heterojunction cells and by improving the incoupling of light into the active layer.

In organic bulk heterojunction solar cells, charge separation occurs at the donor-acceptor interface. While it is understood that this interface is critical for efficient charge separation, many aspects of this fundamentally important process remain unclear. For instance there is an emphasis on the energy difference between the HOMO of the donor and the LUMO of the acceptor, while at the interface these species interact and form a different species during the charge separation process (the charge transfer exciton). I will show that the energy of the ground state of the charge transfer exciton likely plays a role in the charge separation efficiency and that molecular design principles can be used to increase such efficiency, which translates directly into increased photocurrents.

A different strategy to improve photocurrent consists of increasing the effective absorption of the cell by trapping light in the active layer. Many schemes to do so have been proposed however, to be compatible with the low-cost requirements of organic solar cells, such schemes must also be cheap. We have developed a solution synthesis of ZnO nanostructures that can be spray-coated, which exhibit excellent scattering properties. Haze factors of spray-coated ZnO nanostructured layers depend strongly on the shape of the nanostructures (nanowires vs. nanopyramids for instance) and can be as high as 0.4 in the near-infrared. Preliminary results of incorporation of such structures in devices will be shown as well.



Molecular structure of a charge-transfer state at the donor-acceptor interface (left). Highly scattering film of spray-coated ZnO nanowires (right).