Abstract

This thesis investigates the concept of inverting the stacking order of layers in solution-processed organic solar cells. In order to allow the fabrication of these devices, it is necessary to change the work-functions of the electrode materials. In this work, TiO_2 is the material chosen for this purpose.

First, three different types of TiO_2 nanoparticles were investigated to determined which one is the most suitable for film formation by solution-processing on transparent conductive oxide (indium tin oxide: ITO). The nanoparticles yielding the most dense and homogenous films were kept and their film properties analyzed.

Bilayer cells were fabricated with the TiO_2 nanoparticulate film as acceptor layer and an absorbing semiconducting polymer — poly[2-methoxy-5-(3,7-dimethyloctyloxy)-1,4-phenylenevinylene] (MDMO-PPV) and poly-3-hexylthiophene (P3HT) — as donor layer. They were our first tool to demonstrate the proof-of-concept of inverted solar cells, i.e, inversion of the current direction inside the bulk of a photovoltaic device by changing the stacking order of layers.

An optimized inverted bilayer solar cell was produced whose performance equals the performance of our optimized regular bilayer solar cell. Effects on device performance of the nanoparticle type, polymer type, metal electrode material and layer thickness were investigated.

The concept of solution-processing organic inverted solar cells was expanded to the concept of bulk-heterojunction solar cells by the insertion of a thin layer of TiO_2 between the ITO and the organic layer — poly-3-hexylthiophene (P3HT):[6,6]-phenyl C-61 butyric acid methyl ester (PCBM) —.

The optimization of intercorrelated parameters, solvent, layer thickness, annealing temperature, led to an efficiency of 2.5%. Further improvements of the efficiency were achieved by investigating the effect on the current-voltage (I-V) characteristics of the TiO_2 deposition methods, the choice of the metal electrode, the composition of the blended materials P3HT:PCBM, and the insertion of dipole molecules between the oxide layer and the organic layer. A reproducible efficiency of 3.5% could be reached. Other polymers were tested, but with none of them a similar efficiency as with P3HT could be obtained.

Finally, the temperature dependency of the I-V characteristics and the distribution of the materials inside the blend during annealing was analyzed.