Abstract No: PS-16

Effects of ZnO on inverted P3HT:PCBM bulk heterojunction solar cells

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Low cost, low environmental impact, ease of mass production and many more promising attributes of Organic Solar Cells (OSCs) have inspired researchers to investigate OCSs for increasing their performance and stability in a constant phase. Moreover, in the recent years, OSCs with inverted structures have gained more attention compared to the conventional configuration of the device.

In this study, Indium Tin Oxide (ITO) -free inverted OSC devices were fabricated on polished Stainless Steel (SS) substrates with top illumination in order to have the device structure of SS/ZnO/P3HT:PCBM/PEDOT:PSS/Au. A thin film of Zinc Oxide (ZnO) layer was deposited on SS substrates from a solution of Zinc Acetate Dihydrate ($ZnC_4H_6O_4 \cdot 2H_2O$) using spin coating technique. The active layer was spin-coated from a bulk heterojunction polymer blend of regioregular Poly(3-hexylthiophene) (P3HT) and Phenyl-C61-butyric acid methyl ester (PCBM) on the prepared ZnO layer. On the top of the active layer, Ethylene glycol doped poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) was blade coated as the hole transport layer. Then the stack was annealed before Gold (Au) was sputter coated to make the top contact.

The device performance was optimized by varying a number of parameters including the concentration of $ZnC_4H_6O_4 \cdot 2H_2O$ solution, thickness of the ZnO layer, annealing temperature, annealing time, composition of the polymer blend and dopant material of PEDOT:PSS dispersion. Open circuit voltage (V_{oc}) and short circuit current (J_{sc}) of the devices increased after applying ZnO layer. The thermal annealing improved the fill factor (FF) of the devices. Spectral response measurements reveal that photon energies higher than 1.77 eV are absorbed by the device and photogenerated electron-hole pairs are produced. The best OSC device exhibited V_{oc} of 440 mV with the J_{sc} of 6.2 mA/cm^2, fill factor (FF) of 30% and maximum power conversion efficiency of 0.05%.

Keywords: Inverted structure, Organic solar cells, P3HT:PCBM, Stainless steel substrate, Spin coating

Acknowledgment
This work was supported by the National Science Foundation under the research grant NSF-PSF/ICRP/2017EA&ICT/02