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P3HT-wrapped Carbon Nanotubes in Bulk-heterojunction Organic Photovoltaic Cells

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With the ongoing progress in the field of organic photovoltaic cells, the power conversion efficiencies have improved to almost 10%. Yet before these devices can become practically useful, the maximum power conversion efficiencies must go beyond 15% [1]. Several works have studied the incorporation of carbon nanotubes to organic photovoltaic cells in order to improve the device performance. The carbon nanotubes are used as transparent anodes or are blended into the photoactive layer. Carbon nanotubes as dopants in the photoactive layer are known to increase the I_{sc} [2]. They act as interpenetrating nanochannels for charge carriers to be easily transported to the electrodes. Carbon nanotubes, however, are insoluble and intrinsically form bundles thereby making it difficult to form a homogeneous film.

We used a mechanochemical high-speed vibration milling (HSVM) technique [3] to solubilize the single-walled carbon nanotubes (SWNTs) in a P3HT/PCBM (2:1) blend. The strong π-π interactions between the polymer and carbon nanotube encourages the helical self-organization of the P3HT chains onto the nanotube surface. After the HSVM process, the SWNT-P3HT complex becomes soluble in chlorobenzene together with PCBM. This solution is spin-coated as the active layer onto a PEDOT:PSS-coated ITO substrate to fabricate the photovoltaic cells.

Figure 1 shows the J-V characteristics of the photovoltaic cells at different SWNT concentrations. Compared to the control cell made with P3HT/PCBM (2:1), the performance of the cells with added SWNTs is reduced. This is attributed to formation of filamentary short circuits due to SWNTs extending across the photoactive layer [2]. The HSVM process parameters are optimized to produce SWNTs with shorter lengths to reduce the occurrence of filamentary short circuits.

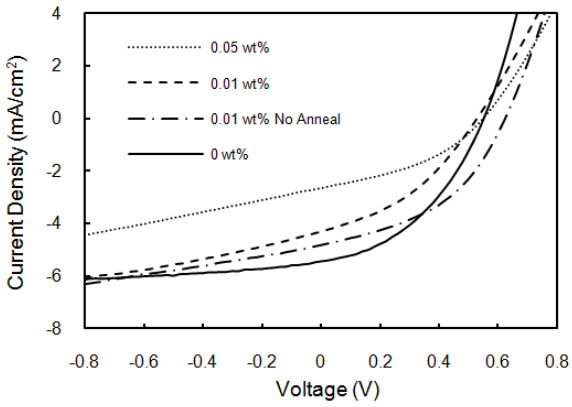

Figure 1. J-V curves of the P3HT/SWNT/PCBM photovoltaic cells with different SWNT concentrations under illumination.

Figure 1 shows an improvement in the J-V characteristic for the 0.01 wt% concentration if it is not annealed. The effect of annealing to the performance of the device is also explored in this study.

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