Optimization of ZnO Electron-Selective Buffer Layers in Flexible Organic Photovoltaic Devices

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Organic Photovoltaic (OPV) cells are important in the field of materials science due to their light weight, simple fabrication, and flexibility. Bulk-Heterojunction OPV devices contain photoactive blends of electron donor and acceptor materials between electrodes, but Electron-Selective (ES) and Hole-Selective (HS) buffer layers can be incorporated to facilitate charge-transport and increase Power Conversion Efficiencies (PCE). In this novel research, ES buffer layers and photoactive blends were optimized in Bulk-Heterojunction OPV cells fabricated onto flexible Polyethylene Terephthalate substrates. ITO was the transparent cathode, ZnO was the ES layer, P3HT:PCBM blends were the photoactive layers, MoO3 was the HS layer, and Silver was the anode. First, ZnO was optimized by introducing Al and Al nanoparticle (Al-NP) dopants. Cells utilizing ZnO:Al-NP ES layers performed better in terms of PCE (2.25%) than ZnO:Al (1.95%) and intrinsic ZnO (1.90%). Second, the thickness of ZnO:Al-NP layers was optimized, and the optimal thickness was found to be safely within the range of 7nm-45nm. Third, three photoactive blend materials (P3HT:PCBM, PBDTTT-C-T:PC70BM, and PTB7:PC70BM) were compared in cells utilizing ZnO:Al-NP layers, and PTB7:PC70BM cells demonstrated better PCEs (6.12%) than PBDTTT-C-T:PC70BM (4.10%) and P3HT:PCBM (2.25%). These findings suggest that Al-NP dopants in ZnO ES buffer layers significantly increase PCEs. Also, further modification of ZnO:Al-NP layer thicknesses was shown to be feasible in the range of 7nm-45nm. Finally, the use of PTB7:PC70BM photoactive blends was shown to greatly improve PCEs. This research highlights the potential of flexible OPV devices to provide clean, durable, low-cost, and lightweight energy sources for portable electronics.