Development of High-Efficient Organic Solar Cell With TiO$_2$/NiO Hole-Collecting Layers Using Atomic Layer Deposition

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Organic solar cell was fabricated using one-pot deposition of a mixture of NiO nanoparticles, P3HT and PCBM. In the presence of NiO, the photovoltaic performance was slightly increased comparing to that of the device without NiO. When TiO$_2$ thin films with a thickness of 2~3 nm was prepared on NiO nanoparticles using atomic layer deposition, the power conversion efficiency was increased by a factor 2.5 with respect to that with bare NiO. Moreover, breakdown voltage of the film consisting of NiO, P3HT, and PCBM on indium tin oxide was increased by more than 1 V in the presence of TiO$_2$-shell on NiO nanoparticles. It is evidenced that S atoms of P3HT can be oxidized on NiO surfaces, and TiO$_2$-shell on NiO nanoparticles. It is evidenced that S atoms of P3HT can be oxidized on NiO surfaces, and TiO$_2$ shell heavily reduced oxidation of S at oxide/P3HT interfaces. Oxidized S atoms can most likely act as carrier generation sites and recombination centers within the depletion region, decreasing breakdown voltage and performance of organic solar cells. Our result shows that fabrication of various core-shell nanostructures of oxides by atomic layer deposition with controlled film thickness can be of potential importance for fabricating highly efficient organic solar cells.

Keywords: Organic solar cell, Buffer oxide layer, NiO, TiO$_2$, Ultra-thin films, ALD
Fig. 1.