有機太陽電池電子輸送中間層用亜鉛ドープ酸化スズの作製

Preparation of Zinc Doped Tin Oxide as an Electron Transport Interlayer for Organic Solar Cells

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[Introduction]

Organic solar cells have attracted broad attention due to their advantages of being light in weight, low in cost and solution process-able in large area.[1] Zinc doped tin oxide (ZTO) is a ternary metal oxide possessing a high electron mobility,[2] long term stability,[2] good optical properties[3] and high response speed,[3] which makes it suitable for wide range of potential applications for solar cells. In this context, we focus on the preparation and characterization of crystalline ZTO and the application and optimization of this material as an electron transport interlayer for an organic solar cell with the inverted structure of ITO/ZnO/ZTO/P3HT:$PC_{61}BM/MoO_3$/Ag.

[Experimental]

Zinc chloride and tin chloride were dissolved in acetonitrile. Prior to the evaporation of the samples, the solution was kept in the ultrasonic bath for 30 min and stirred magnetically at 50 ^oC for 2 h.–Obtained powder was calcined at 100 ^oC for 15 min and 950 ^oC for 3 h. A mixed solvent of ultrapure water and isopropyl alcohol (4:1) was poured to form a suspension with a density of 1 mg/mL. Prior to the deposition, the samples were centrifuged at 6000 rpm for 5 min followed by the filtration with 0.2 μm PTFE filters. ZTO layers were prepared by spin coating at 2000 rpm for 40 s followed by calcination at 200 ^oC for 10 min.

[Results and discussion]

XRD results revealed that the obtained ZTO was crystalline and had the cubic spinal phase. The dominant peak was observed to be in the (220) orientation and the average size of the particles were calculated along with the lattice parameter, which were found to be 39.50 nm and 0.953 nm, respectively. From the SEM images, the surfaces of the spin coated ZTO layers were observed to be smooth without any crack formations. Furthermore, the optical properties of the ZTO samples were investigated by the uv-vis characterization, from which the energy gap of the material was found to be 3.93 eV, through drawing a Tauc's plot. Additionally, the valence band of the material was estimated to be -8.0 eV from the work function that was obtained through photoelectron spectroscopy.

On the other hand, the devices on which ZTO was coated twice at 2000 rpm for 40 s and annealed at 200 ^oC for 10 min showed a power to conversion efficiency (*PCE*) of 1.83 %, which is 8.6% higher than the device without the ZTO interlayer. The increase in *PCE* was mainly reflected by the increases in current density (J_{sc}) and open circuit voltage (V_{oc}). The increase in J_{sc} might be ascribed to the high charge carrier mobility of ZTO, whereas the increase in V_{oc} probably dues to longer electron lifetimes and improved contact of the interfaces between the ZnO and ZTO and/or ZTO/P3HT:PCBM.[4]

[References]

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