Area: Perovskite Solar Cells, Invited talk

18.3% RECORD-EFFICIENCY FLEXIBLE PEROVSKITE SOLAR CELLS

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Metallic oxides used as electron transport material in perovskite solar cells normally undergo high temperature process to attain their desired structural characteristics. However, the recent incorporation of friendly, low-temperature electron transport material also faces positive demanding situations due to the high cost of production and resultant low electron mobility. In order to improve this technology, new research must be conducted in view of producing high electron mobility electron transport material, well-suited to a low-temperature process technology coupled with a low-cost production approach.

We have investigated low temperature processed TiO_2 thin film, ionic-liquid modified TiO_2 film, as well as a solid-state ionic-liquid film as an electron transport material with the use of low-temperature processing to attain high efficiency flexible perovskite solar cells with good reproducibility. We discovered a reduction in work function of indium-tin-oxide cathode whilst coated with 1-benzyl-3-methylimidazolium chloride solid-state ionic-liquid, enabling electron collection as a result of decreased interface barrier between the cathode and the perovskite absorber. The addition of the solid-state ionic-liquid also led to enhanced short-circuit current density and fill factor in the perovskite solar cells due to their wider bandgap.

The solid-state ionic-liquid coated with flexible poly(ethylene terephthalate)/indium-tin-oxide PET/ITO had a higher transparency and average transmittance approximately 88% in region of 400-450 nm and 400-800nm respectively compared to the bare samples thereby showing its anti-reflective properties. We were able to provide an appropriate solid-state ionic-liquid layer thickness of flexible perovskite solar cells. It is found that the layer thickness of 10 nm is the best for the solid-state ionic-liquid layer to achieve the best solar cell performance.

Results from current density-voltage curves also showed a higher power conversion efficiency PCE of value 16.09% for perovskite solar cells based on $(HC(NH_2)_2PbI_3)_{0.85}(CH_3NH_3PbBr_3)_{0.15}$ with the solid-state ionic-liquid as an electron transport material compared with the absent electron transport material[1]. Incident photon-to-current conversion efficiency, short-circuit current density, fill factor and energy levels were also confirmed with higher values.

We also discovered a heavily suppressed hysteresis in the current density-voltage measurement. This was attributed to the increase in higher electron mobility as a result of the solid-state ionic-liquid as an electron transport material. Results from dark current-voltage analysis showed a significant decrease of electron trap density in perovskite films deposited on substrates of the solid-state ionic-liquid coated with indium-tin-oxide which results in a large short-circuit current density. With these attributes, the solid-state ionic-liquid used in this study as an electron transport material meets the requirement of a low-temperature processing and low-cost manufacturing process favors the technology involved in high efficiency flexible perovskite solar cells.

Reference

[1]Yang, D., Yang, R., Ren, X., Zhu, X., Yang, Z., Li, C., Liu, S. Hysteresis-Suppressed High-Efficiency Flexible Perovskite Solar Cells Using Solid-State Ionic-Liquids for Effective Electron Transport, Advanced Material 28 (2016) 5206-5213