Effect of Co-evaporated Liq:Alq_3 Layer for Power-conversion-efficiency Enhancement of Polymer Photovoltaic Cells

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Recently, many researchers have studied to improve power-conversion-efficiency (PCE) of organic photovoltaic (OPV) cells because of low cost, easy process, simple structure, and available for fabricating flexible device. However, polymer PV cells have not enough PCE for replacing other types of PV cells. There are many approaches about enhancing PCE, developing a wide energy band gap and high mobility materials, tandem structure, and buffer layer. In this study, we investigated the effect of Liq:Alq_3 layer for power-conversion-efficiency enhancement of polymer PV cells, because Liq has been used as an electron injection layer (EIL) in polymer PV cells, and Alq_3 has been used as electron transfer layer (ETL) in organic light emitting diodes (OLEDs) [1−3].

In our experiment, polymer PV cells were fabricated, as shown in Fig. 1(a). The device structures are indium tin oxide (ITO)/PEDOT:PSS/P3HT:PCBM/Liq:Alq_3/Al. On ITO glass substrate, PEDOT:PSS and P3HT:PCBM (2wt%) were spin-coated and annealed at 140°C during 10 min for PEDOT:PSS and at 125°C for 10 min for P3HT:PCBM. Then, Liq:Alq_3 layer was co-deposited (1:1 ratio) as ETL and variation from 0.5 to 5 nm. Finally, 80 nm of Al was evaporated as cathode electrode.

Figure 2 shows the current density-voltage (J-V) characteristics and the performance of polymer PV cells with Liq:Alq_3 layer. The J-V characteristics were analyzed under AM 1.5G solar illumination at 100 mW/cm^2 (1 Sun). The highest PCE is 3.593% at 2 nm of Liq:Alq_3 layer. But the PCE without Liq:Alq_3 layer is 1.605%. Other parameters of polymer PV cells with 2 nm of Liq:Alq_3 layer are short-circuit current (J_{SC}) of 8.53 mA/cm^2, open-circuit voltage (V_{OC}) of 0.655 V, and fill factor (FF) of 64.3%. The J_{SC} and FF at 2 nm of Liq:Alq_3 layer indicated ~5.81 and ~21.35%, respectively, and increased comparing with the reference (without Liq:Alq_3 layer). In addition, the V_{OC} increased ~39.69% compared to the reference, and saturated as Liq:Alq_3 layer thickness increased.As a result, the PCE peaked at 2 nm of Liq:Alq_3 layer, representing ~55.32% compared to the reference.

In our presentation, we will review the mechanism why the insertion of Liq:Alq_3 layer as ETL enhances the PCE of polymer PV cells by analyzing energy band gap of Liq and Alq_3 through XPS and UPS measurement.

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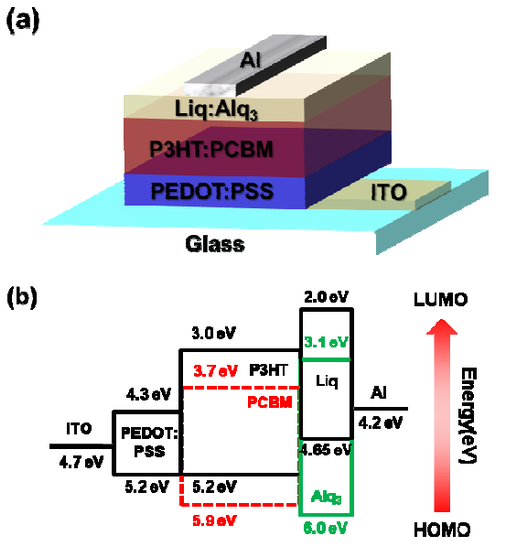

Figure 1. (a) Device structure and (b) energy band diagram of the polymer PV cells with Liq:Alq_3 layer.

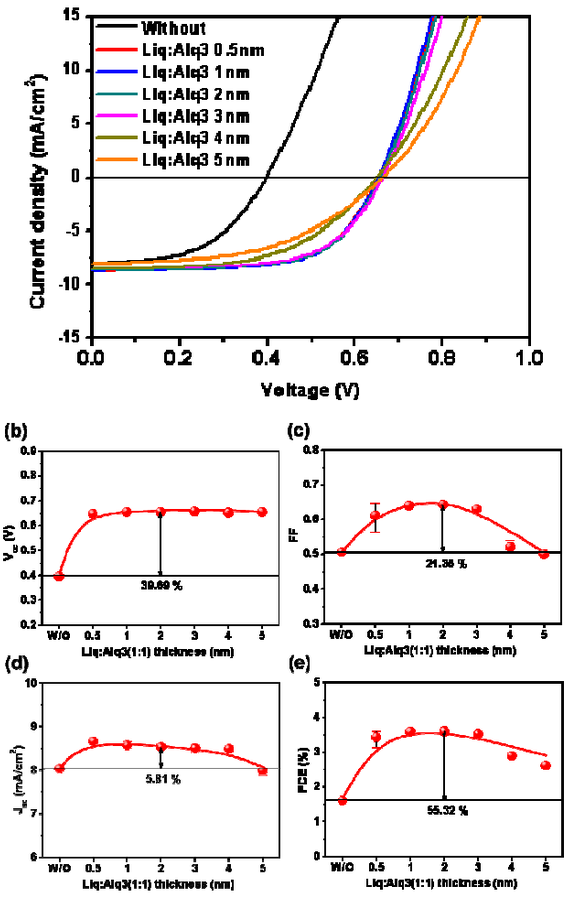

Figure 2. Polymer PV cells (a) J-V characteristics, (b) open-circuit voltage (V_{OC}), (c) fill factor (FF), (d) short-circuit current density (J_{SC}), (e) power-conversion-efficiency (PCE).