Flexible PTB7:PC70BM Bulk-Heterojunction Solar Cells with LiF Cathode Buffer Layer

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1. Introduction

Organic thin-film solar cells are of special interest because they are cheap to produce, lightweight, and flexible[1)]. Bulk-heterojunction solar cells are potential low-cost large-area devices because they can be fabricated by solution processes, without using high-vacuum equipment[2)]. Rayes-Rayes *et al.* reported a bulk-heterojunction solar cell based on poly(3-hexylthiophene) (P3HT):[6,6]-phenyl-C_{61}-butyric-acid-methyl-ester (PCBM)[3)]. The solar cell was fabricated on a glass substrate, and it exhibited an efficiency of 4.9%. A bulk-heterojunction solar cell with an efficiency of 7.4%, produced using a p-type semiconductor, poly[[4,8-bis[(2-ethylhexyl)oxy]benzo[1,2-*b*:4,5-*b*′]dithiophene-2,6-diyl][3-fluoro-2-[(2-ethylhexyl)carbonyl]thieno[3,4-*b*]thiophenediyl] (PTB7), and an n-type semiconductor, phenyl-C_{71}-butyric-acid-methyl-ester ($PC_{70}BM$), on an ITO-coated glass substrate has also been reported[3)] (Fig. 1).

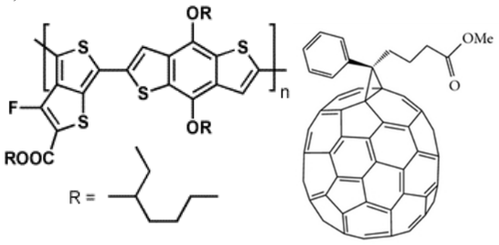

Fig. 1 Molecular structures of PTB7 (left) and $PC_{70}BM$ (right).

It is therefore interesting to fabricate similar solar cells on a flexible substrate such as poly(ethylene terephthalate) (PET)[4)], which will provide solar cells suitable for roll-to-role fabrication. However, organic solar cells fabricated on flexible organic substrates usually exhibit inferior efficiencies.

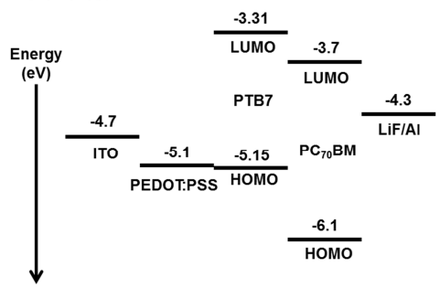

Fig. 2 Energy-level diagram of all materials used in this study.

It is also known that insertion of a cathode buffer layer such as lithium fluoride (LiF) between the active layer and the electrode effectively improves the efficiencies of these organic solar cells[5)]. An energy-level diagram of an Al/LiF/PTB7:PC70BM/ITO solar cell is shown in Fig. 2. In this study, we report the effect of inserting LiF as a cathode buffer layer on the performances of flexible solar cells based on PTB7:$PC_{70}BM$ on a PET substrate.

2. Experimental

Flexible ITO substrates were photolithographically patterned to define an anode electrode. After they were cleaned in de-ionized water, acetone, isopropanol, and UV–ozone, a layer of poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) was spun on the substrates. The active layer was deposited using a solution in which PTB7 and $PC_{70}BM$ were dissolved in dichlorobenzene in a 1:1.5 weight ratio. Then a 2-nm-thick LiF layer was thermally deposited on top of the blend film. Finally, a 90-nm-thick Al cathode pattern was thermally deposited using a hard mask. The active layer area of the device was 0.04 cm^2. The current density versus voltage (*J–V*) characteristics of the devices were recorded in the dark and in air under an intensity of 100 mW/cm^2.

3. Results and discussion

Figure 3 compares the *J–V* characteristics of the devices with and without the LiF buffer layer. Although the levels of the short-circuit current density (J_{sc}) were similar, significant improvements in the open-circuit voltage (V_{oc}) and the fill factor (FF) were observed in the device with LiF. By inserting LiF, the FF and efficiency increased significantly from 0.4 to 0.5, and 2.93% to 4.02%, respectively. This performance improvement may be attributed to differences in the interface between the active semiconductor layer and LiF, which will be investigated in detail.

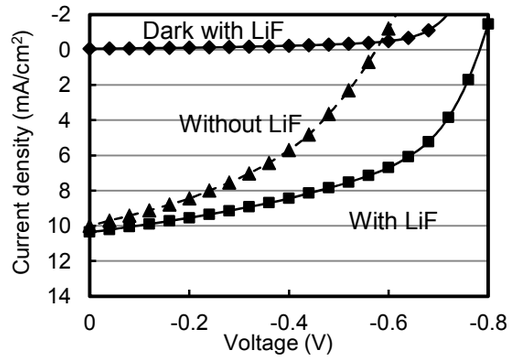

Fig. 3 *J–V* characteristics of devices with and without LiF.

4. Summary

Bulk-heterojunction solar cells were fabricated based on PTB7 and $PC_{70}BM$ on an ITO-coated flexible PET substrate. Performance improvements of the flexible solar cells as a result of inserting LiF as the cathode buffer layer are reported. The efficiency was enhanced from 2.93% to 4.02%.

References

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