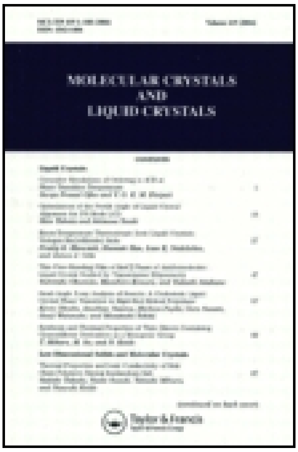

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Photovoltaic Properties of Multilayer Heterojunction Organic Solar Cells

Y. J. Ahn [a], G. W. Kang [a] & C. H. Lee [a]

[a] Department of Physics, Inha University, Incheon, 402-751, Korea

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Photovoltaic Properties of Multilayer Heterojunction Organic Solar Cells

Y. J. AHN, G. W. KANG and C. H. LEE

Department of Physics, Inha University, Incheon 402-751, Korea

We report the photovoltaic properties of the multilayer organic solar cells fabricated with the vacuum deposition of copper phthalocyanine (Cu-PC) as a p-type layer and fullerene (C_{60}) as an n-type layer. The insertion of the bathocuproine (BCP) layer as an exciton-blocking layer and a thin (0.5 nm) LiF film between BCP and Al significantly enhances the efficiency of the cells. The power conversion efficiency is calculated as about 0.8 % for the ITO/Cu-PC/C_{60}/BCP/LiF/Al cell upon illumination of about 30 mW/cm^2.

KEYWORDS: organic solar cells, photovoltaic properties, exciton-blocking layer, LiF

INTRODUCTION

Organic photovoltaic (PV) cells have attracted a great deal of interest due to their potential cheapness and ease of fabrication.[1-4] Recently, P. Peumans *et al*[5,6] reported an enhancement of the power conversion efficiency by inserting an exciton-blocking layer (EBL) between the organic donor-acceptor (D-A) heterojunction and the metal cathode.[2,3] The EBL confines excitons near the D-A interface where the effective generation of charge carriers occurs.[5] In this work, we have investigated the effect of a thin (5 Å) LiF buffer layer between the EBL and the Al electrode in the organic solar cells containing a heterojunction of the donor-like Cu-PC and the acceptor-like C_{60}.

EXPERIMENTAL

We fabricated four types of organic solar cells by using vacuum-deposition under a base pressure of about 2×10^{-6} Torr; ITO/Cu-PC/C_{60}/BCP/LiF/Al (type A), ITO/Cu-PC/C_{60}/BCP/Al (type B), ITO/Cu-PC/C_{60}/Al (type C), and ITO/Cu-PC/C_{60}/LiF/Al (type D). The thickness of both Cu-PC and C_{60} is 500 Å and that of BCP is 100 Å. The photovoltaic properties were investigated in the temperature range between 200 and 315 K under vacuum. The current-voltage (I-V) characteristics were measured with a Keithley 236 source-measure unit in the dark and under illumination with a 300 W Xe lamp, dispersed by an ARC 150 monochromator. The intensity of illumination was measured using a calibrated broadband optical power meter (Spectra Physics model 404) and was varied using neutral density filters.

RESULTS AND DISCUSSION

Fig. 1 shows the I-V characteristics of four types of organic solar cells in the dark and under illumination of about 30 mW/cm^2 at room temperature. The PV parameters of each cell are summarized in Table 1

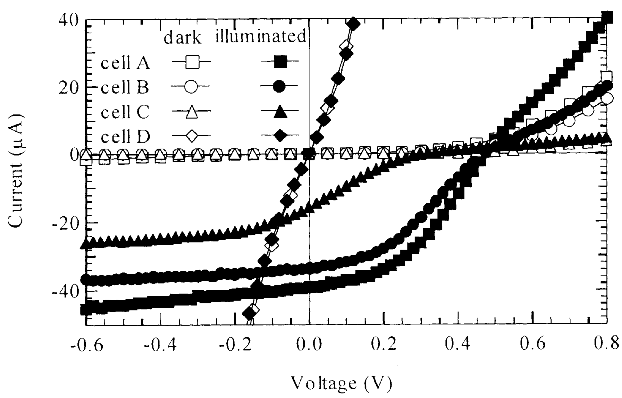

FIGURE 1. The I-V characteristics of the cells measured in the dark and under illumination of ~30 mW/cm^2 at room temperature.

TABLE 1. The characteristics of the photovoltaic cells measured under the photoexcitation of about 30 mW/cm^2.

Device Type	J_{sc} (mA/cm^2)	V_{oc} (V)	FF	η_p (%)
A	1.3	0.47	0.41	0.81
B	1.1	0.47	0.38	0.64
C	0.53	0.31	0.20	0.10
D	0.003	0	0	0

The type A cell shows the best performance with the power conversion efficiency of η_p=0.81%. The insertion of the BCP layer as an exciton-blocking layer and a thin LiF layer significantly enhances the power efficiency η_p and the short circuit current J_{sc} of the cells. However, the type D cells with LiF but without BCP do not show a rectifying behavior. Their I-V characteristics are nearly ohmic with smaller series resistance, indicating that the LiF/Al electrode forms a better contact for the electron transport.

Fig. 2 shows the temperature dependence of the I-V characteristics for the type A cell in the dark and under illumination of about 30 mW/cm^2. As the temperature increases, J_{sc} and the slope of the I-V curve increase since the resistance of the cell decreases.

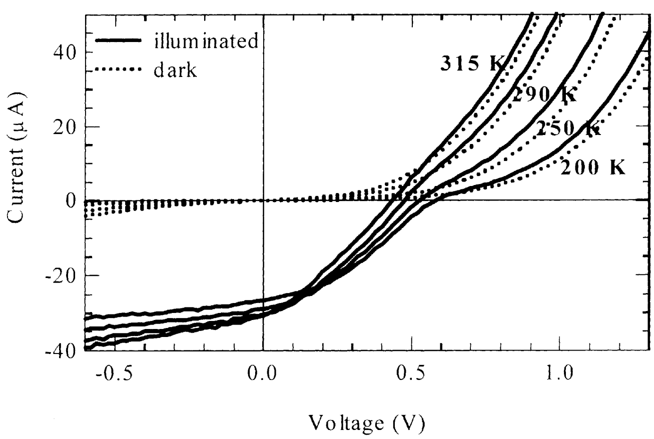

FIGURE 2. Temperature dependence of the I-V characteristics for ITO/Cu-PC/C_{60}/BCP/LiF/Al.

As the temperature increases, V_{oc} decreases slightly. It is also observed that the I-V characteristics under illumination deflect their curvatures near V_{oc} at the low temperture. This behavior seems to arise from severe trapping of charge carriers and the decreased carrier mobility at low electric field since the internal field vanishes near V_{oc}.

CONCLUSION

We have investigated the photovoltaic properties of the multilayer organic solar cells consisting of a donor-like Cu-PC and an acceptor-like C_{60} heterojunction. The insertion of BCP as an exciton-blocking layer significantly enhances the efficiency of the cells. In addition, the power efficiency and the short circuit current can be further increased by inserting a thin (0.5 nm) LiF layer between the BCP and the Al cathode. The power conversion efficiency is calculated as about 0.8 % for the ITO/Cu-PC/C_{60}/BCP/LiF/Al cell upon an illumination of about 30 mW/cm^2.

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References

[1] J. J. M. Halls and R. H. Friend, Organic Photovoltaic Devices, in Clean Electricity from Photovoltaics, ed., M. D. Archer and R. Hill (Imperial College, London, 2001), Chapt. 9, pp. 337-445.
[2] C. W. Tang, Appl. Phys. Lett. **48**, 183 (1986).
[3] S. E. Shaheen, C. J. Brabec, N. S. Sariciftci, F. Padinger, T. Fromherz, J. C. Hummelen, Appl. Phys. Lett. **78** (6) 841 (2001).
[4] J. Y. Park, S. B. Lee, Y. S. Park, Y. W. Park, C. H. Lee, J. I. Lee, and H. K. Shim, Appl. Phys. Lett. **72** (22) 2871 (1998).
[5] P. Peumans and S. R. Forrest, Appl. Phys. Lett. **79**, 126 (2001).
[6] P. Peumans, V. Bulovic, and S. R. Forrest, Appl. Phys. Lett. **76**, 2650 (2000).