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Characteristics of flexible organic solar cells tested with various bending radii

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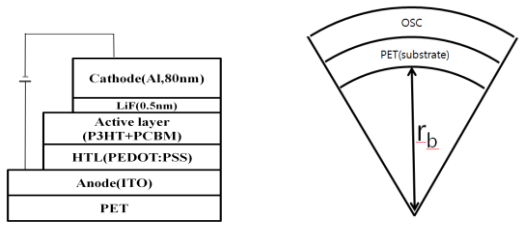
1. Introduction

Renewable and clean sources of energy have generated a great deal of interest because of the depletion of fossil fuels. Among the promising candidates for new energy sources, organic solar cells (OSCs) have been regarded as a promising next generation solar energy harvesting device due to their excellent flexibility, ease of processing, and low cost of fabrication for large area cells [1-2]. In general, the OSCs consist of light absorbing and charge transporting organic semiconducting materials sandwiched between an anode and a cathode [1]. Under illumination, the charges in OSCs are generated in the active layer through photo-excitation and extracted to electrodes. In order to accelerate OSC commercialization, however, devices need to be fabricated on flexible substrates, such as poly(ethylene terephthalate) (PET) and poly(ethylene-2, 6-naphthalate) (PEN). In this work, we fabricated OSCs on the PET substrate, and characterized OSCs subjected to bending with various bending radii.

2 .Experiments

The schematic OSC structure used in this experiment is shown in Fig . 1(a). Fig. 1(b) shows the definition of bending radius. The substrates used in this study were indium tin oxide (ITO)-coated poly(ethylene terephthalate) (PET) with the ITO sheet resistance of 15Ω/sq. Poly(3,4-ethylenedioxythiophene):poly(styrenesulfonic acid) (PEDOT:PSS) mixed with isopropyl alcohol in weight ratio of 1:2 was spin-coated on ITO /PET. Mixture of poly(3-hexylthiophene) (P3HT) and [6,6]-phenyl C_{61} butyric acid methyl ester (PCBM) (P3HT+PCBM) in the optimized weight ratio of 1:1 were prepared with chlorobenzene (4wt.%) and spin-coated on PEDOT:PSS. The spin speed of the polymer film coating was 1000rpm for PEDOT:PSS and P3HT+PCBM.



(a) (b)

Fig. 1 (a) the schematic OSC structure and (b) definition of bending radius r_b

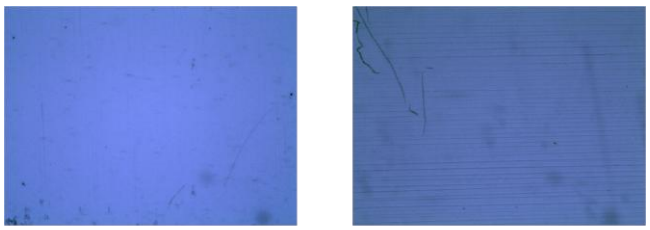
OSCs were bended by being rolled around cylinders with various radii. After being detached from cylinders, OSC characteristics were measured under an illumination condition of 100mW/cm2(AM 1.5). In characterizing OSCs with various bending radii, a solar simulator (LZC-SSR,

Luzchem) was used to measure current density - voltage (J-V).

3. Results and discussion

The OSCs and ITO/PET substrates were subjected to bending test and their characteristics changes were investigated. OSCs with bending radius of 0, 4.0, 3.5, 3.0, 2.5, 2.0, 1.5 and 1.0cm were referred to as control, OSC(4.0), OSC(3.5), OSC(3.0), OSC(2.5), OSC(2.0), OSC(1.5) and OSC(1.0), respectively.

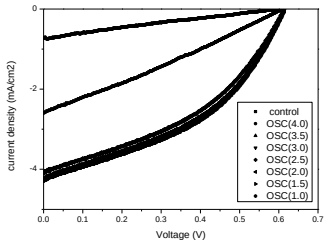
We analyzed the ITO surface on the PET subjected to bending. Fig. 2 shows cracks of ITO, when the bending radius was 1cm [3].



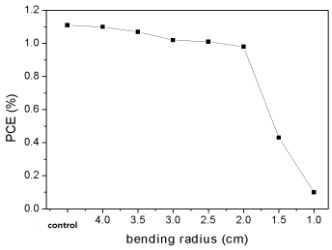
<control> <1cm bending radius>

Fig . 2 ITO crack generation after bending test

The current density-voltage curves and power conversion efficiency (PCE) with various bending radii are shown in Figs. 3(a) and (b), respectively. We compared the OSCs without bending, and the OSC with bending radii of 4cm - 1cm. The current density-voltage characteristic of OSCs deteriorated with a decreased bending radius[4]. The devices with decreased bending radius showed lower J_{sc} compared to the device without bending. But for $r_b \geq 2$cm, there was little change in OSC efficiency. For r_b less than 2cm, efficiency was reduced dramatically.



(a)



(b)

Fig. 3 (a) current density-voltage and (b) PCE of OCSs with various bending radii

4. Conclusion

The OSC devices were fabricated on PET flexible substrates. The current density-voltage and PCE of OSCs were investigated with various bending radii. The current density-voltage characteristic of OSCs deteriorated with a decreased bending radius. J-V characteristics and PCE of OSCs decreased dramatically for bending radius ≤2 cm.

Acknowledgement

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