C60을 이용한 광기전 소자의 전기적 특성 연구

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Electrical Properties of Photovoltaic Cell Using C60

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Abstract : We have fabricated solar cell devices based on zinc-phthalocyanine(ZnPc) as donor(D) and fullerene(C60) as electron acceptor(A) with doped charge transport layers, and BCP and Alq_3 as an exciton blocking layer(EBL). We have measured the photovoltaic characteristics of the solar cell devices using the Xe lamp as a light source. We were use of Alq_3 layer leads to external power conversion efficiency was 2.65% at illumination intensity 100mW/cm^2. Also we confirmed the optimum thickness ratio of the DA hetero-junction is about 1:2.

Key Words : C60, Photovoltaic Cell, EBL

1. Introduction

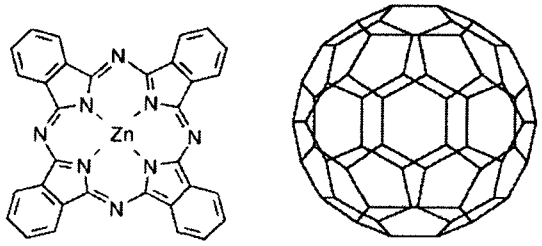
In recent years, the power conversion efficiencies of thin-film organic photovoltaic(PV) cells has increased steadily and rapidly[1,2]. These improvements have come from the introduction of device concepts such as the donor - acceptor(DA)heterojunction blended and laminated DA heterojunctions, the exciton-blocking layer(EBL), and highly doped crystalline materials. A photovoltaic effect is a way of converting solar radiation into electricity, which was first discovered by Becquerel. Most of the small molecules used in organic photovoltaic cells are deposited using thermal evaporation to obtain a desired film thickness. These photovoltaic cells have been intensively studied for the last ten years. In 1986, Tang developed a photovoltaic cell using CuPc/PV organic materials and obtained a solar power efficiency of about 1 % with corresponding external quantum efficiency of about 30 %. Thus, we have studied the photovoltaic effects depending on the photo-active organic layer thickness.

2. Experiment

The indium-tin-oxide(ITO) glass, having a sheet resistance of 15 /□ was received from Samsung Corning Co. The line patterned ITO glass was cleaned by sonicating it in chloroform for 20 minutes at 50 ℃. And then the ITO glass was heated at 80 ℃ for 1 hour in solution made with second distilled deionized water, ammonia water and hydrogen peroxide with a volume ratio of 5:1:1. We sonicated the substrate again with a chloroform for 20 minutes at 50 ℃ and in deionized water for 20 minutes at 50 ℃. After sonicating the substrate, it was dried with N_2 gas stream and stored it under vacuum.

Fig. 1 shows a schematic of a molecular structure and fig 1(a) is, Zinc Phthalocyaine(ZnPc), as an electron acceptor and (b) is C60 as an electron donor.

Fig. 2 shows a schematic structure of photovoltaic cells and energy band diagram of the materials used in our experiment. Double-layered organic photovoltaic cells of ITO/ZnPc/C60/EBL/Al were fabricated to see a correlation between a photovoltaic performance and a ZnPc layer thickness varied from 10 nm to 50 nm made with thermal-vapor deposition at 10^{-6} torr. To compare a performance with exciton blocking layer photovoltaic cells, a device structure of ITO/ZnPc/C60/BCP(or Alq_3)/Al was also fabricated. The C60, BCP and Alq_3 layer were also made using thermal evaporation. And Al cathode(150 nm) was deposited at 1.0 10^{-6} torr using thermal evaporation as well. An active cell area of device was made using a shadow mask to be 3 mm × 5 mm.



(a) ZnPc (b) C60

Fig. 1. Schematic of molecular structure.

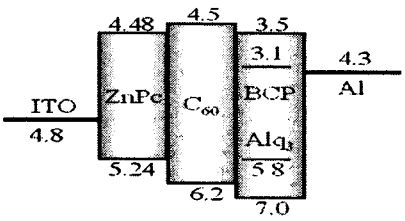


Fig. 2. Schematic the energy band diagram of the PV cell.

3. Results and discussion

Fig. 3 shows the current density-voltage characteristics of ITO/ZnPc/C60/Alq_3/Al and ITO/ZnPc/C60/BCP/Al devices when the light is illuminated to the device(Light illumination intensity @ 100mW/cm^2).

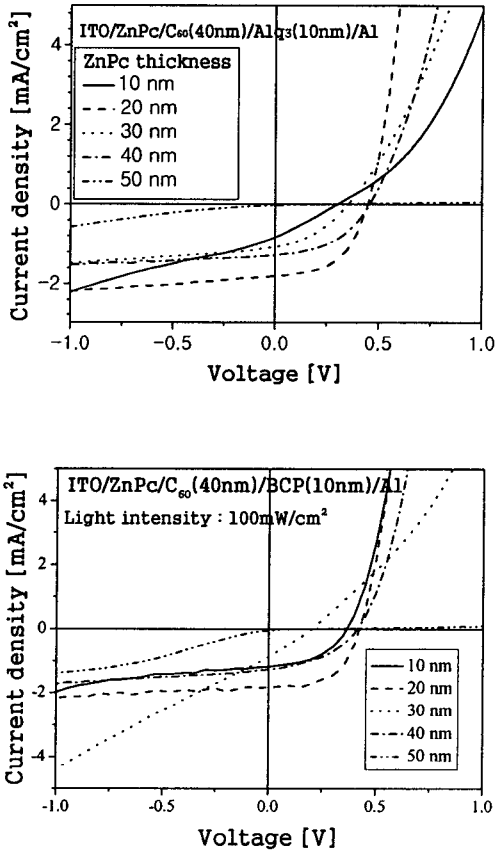


Fig. 3. Current density-voltage characteristics of the ITO/ZnPc/C60/Alq_3/Al and ITO/ZnPc/C60/BCP/Al devices(Light intensity @ 100mW/cm^2).

From the current density-voltage characteristics under the illumination of light, we can obtain two important parameters, which are x- and y-intercept of the curve. One is open-circuit voltage VOC(x-intercept) and the other is short-circuit current density JSC(y-intercept). So we observed that the optimum thickness ratio of the ZnPc : C60 layer was 1:2.

Fig. 4 shows the shot-circuit current of the two PV cell. The Jsc(shot-circuit current density) is almost the same in two PV cells with BCP and the Alq_3 layer.

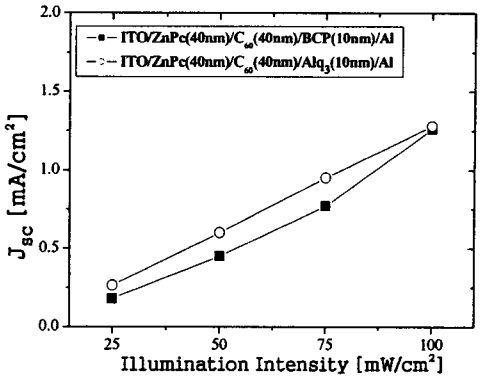


Fig. 4. Short-circuit current density-illumination intensity characteristics of the two PV cells.

4. Conclusion

We have seen the electrical properties and photovoltaic properties of the organic solar cells employing an EBL layer. The use of Alq_3 layer leads to external power conversion efficiency(2.65% at illumination intensity 100mW/cm^2). Also, we confirmed the optimum thickness ratio of the DA hetero-junction with ZnPc/C60 layer is about 1:2. We are going to further works to introduce the buffer layer between ITO and ZnPc for improvement of efficiency.

Acknowledgment

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