International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VIII Month of publication: Aug 2023

DOI: https://doi.org/10.22214/ijraset.2023.55140

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VIII Aug 2023- Available at www.ijraset.com

Hybrid Solar Cells using Screen Printing Method

Dr. Dileep. P.
Head of Department (Electronics), Maharaja's Technological Institute, Thrissur

Abstract: Hybrid bulk heterojunction (BHJ) organic solar cells with a poly (3-hexylthiophene-2,5-diyl)(P3HT):(6,6)-phenyl C61-butyric acid methyl ester (PC61BM) active layer, a poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate)(PEDOT:PSS) buffer layer, and an electrochemically deposited zinc oxide (ZnO) n-type inorganic layer were produced. The PET/ITO/ZnO/PEDOT:PSS/P3HT:PC61 BM/Al device was manufactured and tested under solar illumination (AM1.5G, 100 mW/cm^2

Keywords: BHJ Solar cells, photovoltaic, P3HT/PCBM, Screen Printing, ZnO

I. INTRODUCTION

The main attraction of organic solar cells that are based on BHJ architecture due to the potential of low-cost and large-area manufacturing compared to conventional photovoltaics (Brabec et al., 2005). By simple methods these Organic solar cells can be manufactured in large areas on flexible substrates (Krebs, 2007; Krebs, 2009a) from solution by printing and coating techniques (Krebs, 2008; Krebs et al., 2009), at low temperatures and with no need for vacuum coating steps (Krebs, 2009b). The efficiency, η = 4.8%, was obtained in one of these basic organic solar cell structures, ITO/PEDOT:PSS/P3HT:PCBM/Al (Yoon et al., 2008), but for use in commercial applications, this efficiency value is still not enough. By the Industrial Screen printing, the production of polymer-based photovoltaics has established the possibility of producing more numbers in a single day. The production based on silicon, the production plant typically takes 1 year (Krebs, 2007).

In this, we produced a hybrid bulk heterojunction (BHJ) flexible organic solar cells with a P3HT:PCBM active layer, PEDOT:PSS buffer layer, and n-type zinc oxide (ZnO) inorganic layer (Figure 1). For the deposition of inorganic ZnO we used the electrochemical deposition (ECD) method. One of the most promising semiconductor materials for manufacturing optoelectronic devices is ZnO because of its characteristics like, nontoxic, cheap, and wide bandgap semiconductor. In addition, ZnO is a natural n-type semiconductor (Lare et al., 2009).

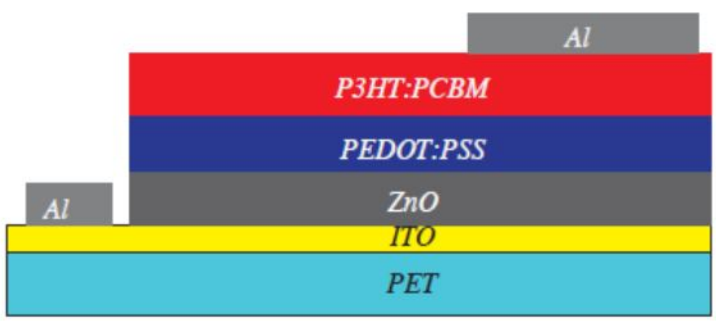

Figure 1. Schematic representation of the hybrid solar cell

In this device, between the top electrode, Al, and the ITO electrode (Park et al., 2009), ZnO layer was deposited to prevent short paths, which causes to reduce device efficiency. The ZnO layer also acts as an n-type semiconductor layer to enhance open-circuit voltage. The organic layer was coated by the screen printing method on a PET/ITO substrate.

II. EXPERIMENTAL DETAILS

In this the ITO-coated poly(ethylene terephthalate) (PET) substrates were sonicated in detergent, acetone, ethanol, and distilled water for 15 min at each step, and then the PET substrates were dried with argon. The ZnO coating was achieved in a 0.1 M aqueous zinc nitrate tetrahydrate (Zn(NO3)2 .4H2O) solution (Yoshida et al., 2004) with a Ag/AgCl reference electrode, ITO/PET as the working electrode, and a pure zinc metal sheet as the counter electrode under the previously obtained deposition potential of -0.850 V, and at 80 oC (Hames et al., 2010).

PEDOT:PSS that had been preheated to 70 oC was coated onto the previously obtained ZnO/ITO/PET substrate by spin coating at 1200 rpm for 1 min. Samples were then annealed at 120 oC for 1 h. A polymer blend of P3HT:PCBM (1:1, wt/wt) was prepared in the chlorobenzene solution and the obtained solution was stirred at 1200 rpm, 70 oC, for 24 h. An evaporation system was designed for precision control of the evaporation process and also to reduce the evaporation time, which is demonstrated in Figure 2. In this system, chlorobenzene was evaporated at 110 oC for 100 min to obtain feasible viscosity.

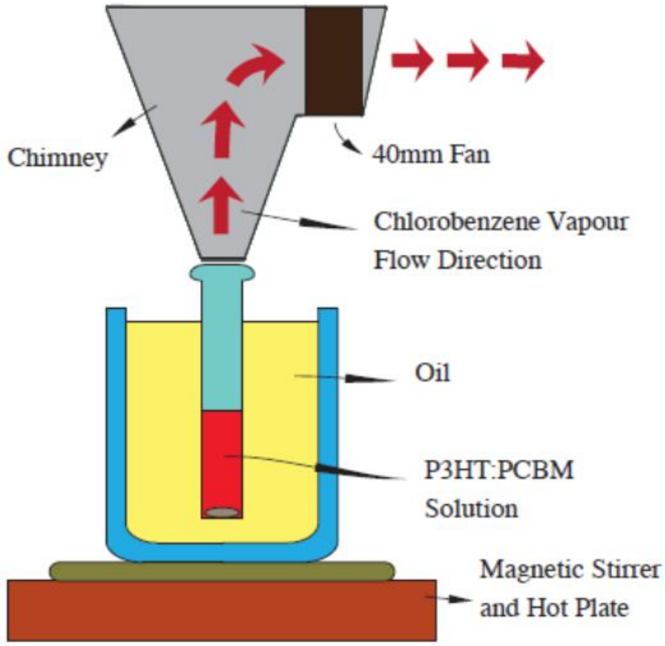

Figure 2. Schematic of the solvent evaporation system

After evaporation, the printing process of the P3HT:PCBM blend was achieved with a 200-µm mask on the PET/ITO/ZnO/PEDOT:PSS substrate. Figure 1 reveals the schematic representation of the device's architecture. After the printing process, the device was annealed at 110 oC for 30 min. n easy way to comply with IJRASET paper formatting requirements is to use this document as a template and simply type your text into it.

III. RESULTS AND DISCUSSION

Investigated the effects of two printing parameters, like, viscosity of solution and screen resolution on power conversion efficiency of devices inorder to obtain optimum conditions for highly efficient inorganic-organic hybrid solar cell production by the screen printing method. The ZnO coating normally increases the roughness of the surface, as shown in Figure 3a. However, the PEDOT:PSS coating on the ZnO layer reduces that roughness (Garganourakis et al., 2009). Optimum evaporation time for printing proper film with the designed evaporation system (Figure 2) was obtained as 100 min from repeated experiments. For each mesh type, smooth surface morphology could not be obtained, so, like evaporation time, the mesh type was optimized as 200 µm, as shown by the SEM image of the device in Figure 3b

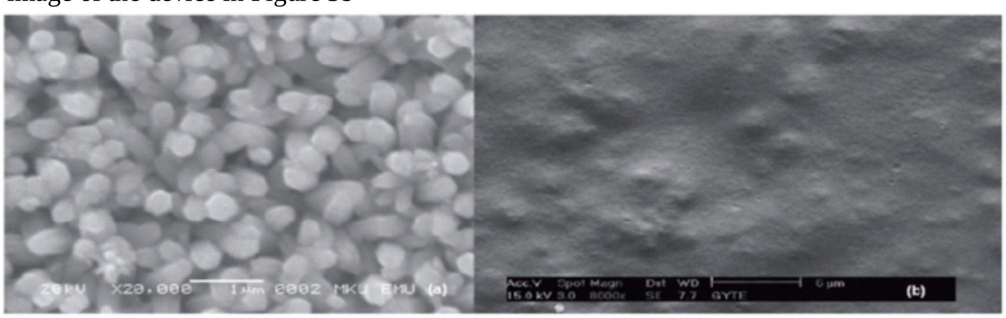

Figure 3. (a) SEM image of ZnO film, (b) SEM image of PET/ITO/ZnO/PEDOT:PSS/P3HT:PCBM device.

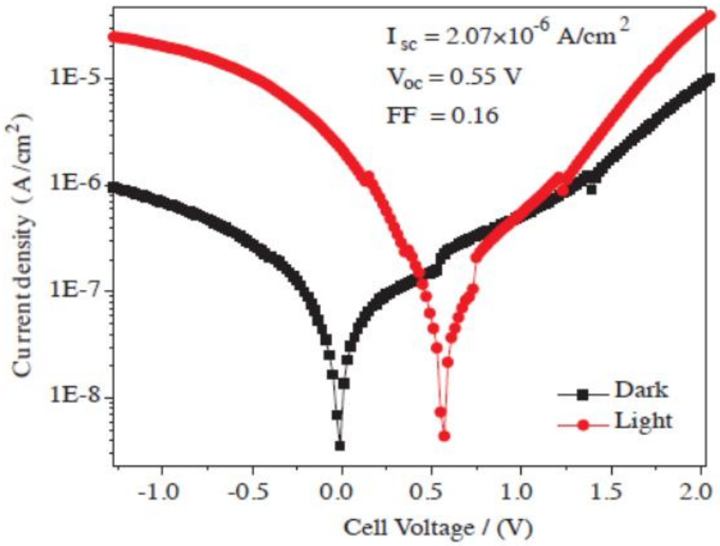

Figure 4. I-V characteristic of manufactured flexible solar cell by screen printing method

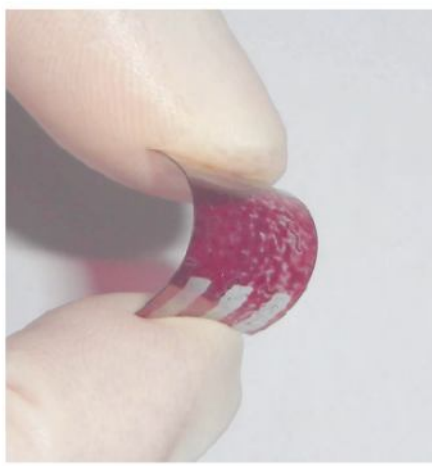

Figure 5. flexible solar cell manufactured by screen printing method

IV. CONCLUSION

In conclusion, the hybrid PET/ITO/ZnO/PEDOT:PSS/P3HT:PC61BM/Al device was manufactured and tested under simulated solar illumination (AM1.5G, 100 mW/cm2). The I-V curve illustrates that the produced device exhibits solar cell characteristics as expected(Figure 4).

REFERENCES

[1] Brabec, C.J., Hauch, J., Schilinsky, P. and Waldauf, C., "Production Aspects of Organic Photovoltaics and Their Impact on the Commercialization of Devices", MRS Bull., 30, 50, 2005.

[2] Garganourakis, M., Logothetidis, S., Pitsalidis, C., Georgiou, D., Kassavetis, S. and Laskarakis, A., "Deposition and Characterization of PEDOT/ZnO Layers onto PET Substrates", Thin Solid Films, 517, 6409-6413, 2009.

[3] Hame，s, Y., Alpaslan, Z., K¨osemen, A., San, S.E. and Yerli, Y., "Electrochemically Grown ZnO Nanorods for Hybrid Solar Cell Applications", Solar Energy, 84, 426-431, 2010.

[4] Krebs, F.C., "Air Stable Polymer Photovoltaics Based on a Process Free from Vacuum Steps and Fullerenes", Sol. Energy Mater. & Sol. Cells, 92, 715-726, 2008.

[5] Krebs, F.C., "Fabrication and Processing of Polymer Solar Cells: A Review of Printing and Coating Techniques", Sol. Energy Mater. & Sol. Cells, 93, 394-412, 2009a.

[6] Krebs, F.C., "Polymer Solar Cell Modules Prepared Using Roll-to-Roll Methods: Knife-Over-Edge Coating, Slot-Die Coating and Screen Printing", Sol. Energy Mater. & Sol. Cells, 93, 465-475, 2009b.

[7] Krebs, F.C., Jorgensen, M., Norrman, K., Hagemann, O., Alstrup, J., Nielsen, T.D., Fyenbo, J., Larsen, K. and Kristensen, J., "A Complete Process for Production of Flexible Large Area Polymer Solar Cells Entirely Using Screen Printing – First Public Demonstration", Sol. Energy Mater. & Sol. Cells, 93, 422-441, 2009.
[8] Krebs, F.C., Spanggaard, H., Kjar, T., Biancardo, M. and Alstrup, J., "Large Area Plastic Solar Cell Modules", Mater. Sci. Eng., 138, 106-111, 2007.
[9] Lare, Y., Godoy, A., Cattin, L., Jondo, K., Abachi, T., Diaz, F.R., Morsli, M., Napo, K., DelValle, M.A. and Berne`ede, J.C., "ZnO Thin Films Fabricated by Chemical Bath Deposition, Used as Buffer Layer in Organic Solar Cells", Applied Surface Science, 255, 6615-6619, 2009.
[10] Park, S., Tark, S.J., Lee, J.S., Lim, H. and Kim, D., "Effects of Intrinsic ZnO Buffer Layer Based on P3HT/PCBM Organic Solar Cells with Al-Doped ZnO Electrode", Sol. Energy Mater. & Sol. Cells, 93, 1020-1023, 2009.
[11] Yoon, W.J. and Berger, P.R., "4.8% Efficient Poly(3-hexylthiophene)-Fullerene Derivative (1:0.8) Bulk Heterojunction Photovoltaic Devices with Plasma Treated AgOx/Indium Tin Oxide Anode Modification", Appl. Phys. Lett., 92, 013306, 2008.
[12] Yoshida, T., Komatsu, D., Shimokawa, N. and Minoura, H., "Mechanism of Cathodic Electrodeposition of Zinc Oxide Thin Films from Aqueous Zinc Nitrate Baths", Thin Solid Films, 451-452, 166-169, 2004.