BENZODITHIOPHENE AND SELENOPHENE BEARING POLYMER FOR INVERTED ORGANIC SOLAR CELL APPLICATIONS

Gönül Hızalan[1], Mustafa Yaşa[2], Seza Göker[3], Yasemin Arslan Udum[4], Görkem Günbas[1,3], Ali Çırpan[1,3], Levent Toppare[1,3]

1 Center for Solar Energy Research And Applications (GUNAM), Middle East Technical University (METU), Ankara, Turkey
2 Department of Polymer Science and Technology, Middle East Technical University, 06800 Ankara, Turkey
3 Department of Chemistry, Middle East Technical University, 06800 Ankara, Turkey
4 Graduate School of Natural and Applied Sciences, Gazi University, 06500 Ankara, Turkey

Introduction

Organic solar cells (OSC)s have aroused great attention due to their potential for low cost, light-weight and roll-to-roll proocessing on flexible substrates. In general, OSC based on conventional device structure are fabricated by sandwiching an active layer between metal cathode and transparent indium tin oxide (ITO).

Working Principle of Organic Solar Cell

1. Light absorption and exciton creation: the incident light hits the cell, the donor material absorbs sunlight producing excitons
2. Exciton transport: Excitons are transported to the donor/acceptor interface.
3. Exciton separation: Charge separation takes place.
4. Charge extraction: Charge carriers (holes and electrons) that reach the anode and cathode are extracted.

Conventional devices has the device architecture of ITO/ PEDOT:PSS/ active layer/ LiF/ Al. Wheras inverted devices has the architecture of of ITO/ ZnO/ active layer/ MoO_3/ Ag. Conventional devices are suffering from acidity of PEDOT:PSS layer which etches ITO and the requirement of evaporation of top electrodes. However in the case of inverted devices more ambient stable and high work function metals such as gold and silver electrodes are used as the top electrode. Thus, printing technologies can be used instead of thermal deposition.

Results and Discussion

In this study benzodithiophene, quinoxaline and selenophene bearing conjugated polymer was used as donor materials in inverted solar cell applications. Device performances were investigated with the device configuration of ITO/ ZnO/ polymer:$PC_{71}BM$/ MoO_3/ Ag. Dichlorobenzene was used as the solvent. In order to improve device performance, polymer PCBM ratio, active layer thickness, annealing time and temperature optimizations were carried out. J-V characteristics of the constructed devices were investigated under simulated sunlight (AM 1.5G, 100 mW/cm^2). As comparison conventional device with the structure of ITO/PEDOT:PSS /active layer/LiF/Al were also constructed. Photovoltaic paramaters of conventional and inverted devices are summarized in Table 1.

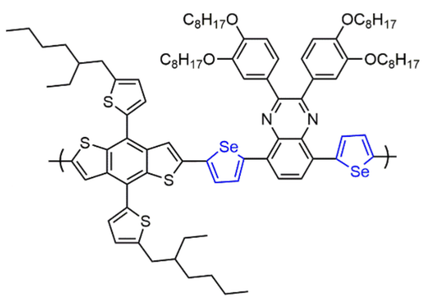

Figure 1 Structure of the polymer (PBDTSeQ)

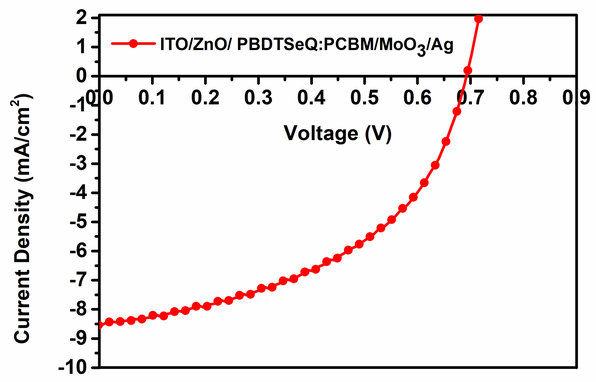

Figure 2 Current density-voltage (J-V) characteristics of the best performance PBDTSeQ:PC71BM based inverted solar cell

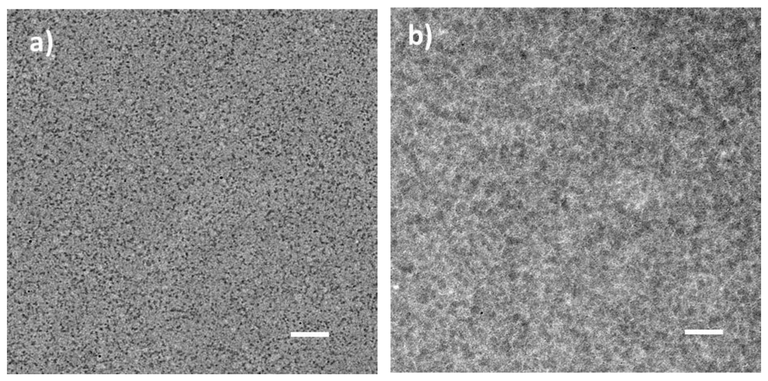

Figure 3 TEM images of a) PBDTSeQ:PC71BM blend processed from dichlorobenzene b) PBDTSeQ:PC71BM blend processed from dichlorobenzene 3%DPE

Table1 Photovoltaic performance of the solar cells based on PBDTSeQ

	P2:PCBM	Solvent	V_{OC} (V)	J_{SC} (mA/cm^2)	FF (%)	PCE (%)
inverted	1:3	dcb	0.690	6.080	46	1.93
inverted	1:3	dcb 3% DPE	0.693	8.525	48	2.84
conventional	1:3	dcb 3% DPE	0.741	8.030	53	3.16

With the addition of processing additive DPE (diphenyl ether) power conversion efficiency of the PBDTSeQ based device was improved through a rise in J_{SC} and FF values. As seen in Figure 3b) with the addition of DPE, fibril-like domains were formed which enhances the donor acceptor interfacial area, resulting in interpenetrated network structure.

Conclusions

Benzodithiophene, quinoxaline and selenophene bearing conjugated polymer was used as donor materials in inverted solar cell applications. Inverted OSC device fabrications of polymers were carried out with a device configuration of ITO/ ZnO /activelayer/ MoO_3/ Ag. Polymers were used as the donor materials and PCBM as the acceptor. Polymer:PCBM weight ratios and active layer thicknesses were optimized. Different processing additives were used and 3% DPE addition showed the highest performance. Best performance device showed Voc of 0.693 V, Jsc of 8.525mA/cm^2, FF of 48% and PCE of 2.84%.