NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE
School of Electrical and Electronic Engineering

COEB PHOTONICS
COEB - Centre for OptoElectronics and Biophotonics

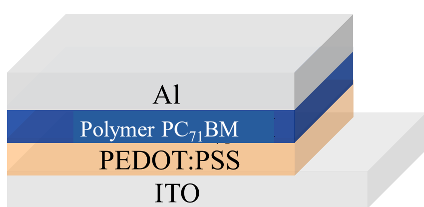
Effects of Molecular Weight of A New Hole Transporting Polymer on The Organic Solar Cells' Performance

Introduction

In this research, organic solar cells (OSCs) based on a new hole transporting polymer were fabricated. The highest power conversion efficiency of the device was received of 6.7% with the optimized molecular weight of the polymer. The charge carrier mobility in the OSCs was measured by using photoinduced charge extraction by linearly increasing voltage (PhotoCELIV) and time-of-flight (TOF) techniques. It is found that the charge carrier mobility is similar in the devices with both high and low molecular weight polymers. Light intensity dependence of the current-voltage characteristics was measured, which indicates strong bimolecular recombination in the low molecular weight polymer devices. Furthermore, the series and bulk resistances of the OSCs were obtained from the impedance measurement of the device. The high molecular device has a lower bulk resistance which corresponds to the weak bimolecular recombination of the device. It is concluded that the different performance of the different molecular weight polymer devices can be attributed to the different bimolecular recombination of the carriers in the devices.

Experiment

Device Structure



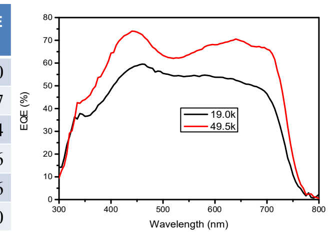
- ➢ Transparent ITO electrode acts as anode while the cathode consists of Al
- ➢ Polymer:$PC_{71}BM$ blend film functions as BHJ photoactive layer
- ➢ PEDOT:PSS layer was inserted as hole-transporting layer (HTL)

Measurement Results

Photovoltaic parameters of OSCs at different weight ratios

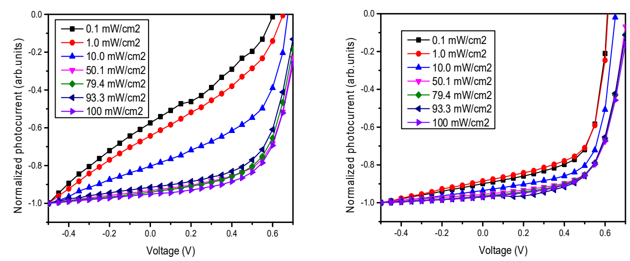
Mn (kDa)	Weight Ratio (D/A)	J_{SC} (mA/cm^2)	V_{OC} (V)	FF (%)	PCE (%)
19.0	1:0.8	9.29	0.65	48.76	3.00
	1:1	11.24	0.72	60.40	4.87
	1:1.2	12.54	0.67	56.40	4.74
49.5	1:1.2	13.63	0.69	61.86	5.86
	1:1.5	15.65	0.7	61.31	6.76
	1:1.8	13.22	0.76	62.68	6.30

External quantum efficiency (EQE) of the best OSCs



- 49.5 kDa device has the highest PCE of 6.76% at weight ratio 1:1.5
- The better performance of 49.5 kDa device comes from a higher J_{sc} as a result of higher EQE

Light Intensity Dependence of J-V Characteristics



P_c-V characteristics of 19.0 kDa (left) and 49.5 kDa (right) under different illumination intensity

- Recombination mechanism evolves from monomolecular recombination to bimolecular recombination with increasing voltage
- For 19.0 kDa OSC, a large spread of P_c curves can be observed even at a small negative reverse bias
- The small spread of P_c curves of 49.5 kDa OSCs indicates that the bimolecular recombination is weak22

Conclusions

1. Similar charge carrier transport was observed in both high and low M_n OSCs
2. The severe bimolecular recombination in the low M_n OSC limits its J_{sc} thus it has poor device performance.
3. Low M_n OSCs have higher bulk resistance which contributes to the poor performance

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