



OPTICAL AND ELECTRICAL CHARACTERIZATION OF MEH-PPV ORGANIC HETEROSTRUCTURE

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ABSTRACT

MEH-PPV thin layer is grown onto silicon substrate by ultrasonic spray pyrolysis process to achieve Ag/MEH-PPV/Si/Al heterostructure. Optical transmittance is measured using UV-Vis spectrophotometer and I-V characteristics under dark and light conditions are measured and electrical parameters are extracted. Based on optical measurement, 140 nm thick film exhibits high transmittance within a visible band recording an optical band gap of 2 eV. The ideality factor, series resistance and barrier height of the organic heterostructure are extracted in dark and illumination conditions. It is observed that the current is space-charge limited (SCLC) and that the exponential distribution of trapping levels has the most influence on how traps affect the conduction current. Such organic heterostructures can meet photodiode and solar cell applications.

Keywords. MEH-PPV; Optical measurement; I-V characteristics; heterostructure; Conduction mechanism.

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1. INTRODUCTION

Due to the potential for inexpensive electronic device manufacture and simplicity of synthesis with desired forms, organic materials have stimulated extensive research to examine electrical and optical properties in the field of electronics [1]. Organic electronics refers to the device design of a hybrid structure with semiconductor layers based on organic material, such as solar cells, sensors, photodetectors, and LEDs [2-4]. The phenylenevinylene (MEH-PPV), one

of the most significant derivatives of PPV with a -conjugation system in their main chain is one of the most important organic heterojunctions due to both their unique optoelectronic properties and their processability from solution, which allows facile integration with the existing technologies. MEH-PPV, one of the most significant derivatives of PPV with a -conjugation system in their main chain is one of the most important organic heterojunctions due to both their unique optoelectronic properties and their processability from solution, which allows facile integration with the existing technologies. A cryptic amorphous polymer is MEH-PPV. As a result, MEH-PPV can be diluted in both aromatic and non-aromatic solvents due to the polymer chains' alkoxy on the phenyl position. Using a homemade ultrasonic spray pyrolysis system, an ultrasonic sprayed MEH-PPV has been created for the deposition of organic material on p-type silicone, and silver is physically evaporated for metallic connections. The ultrasonic spray pyrolysis route (USSP) is used to create thin, dense, and smooth layers with fewer flaws because it is an easy method for creating high-quality thin films for high-performance organic devices. In this study, we demonstrate the successful fabrication of a MEH-PPV and p-type silicon-based MSP organic heterojunction assembly. In order to identify various heterojunction device parameters, this work's primary objective is to conduct optical, structural, and electrical investigations with I-V and C-V measurements in the dark and at ambient temperature. This research is interesting since it uses a low-cost USSP method to create a device from an organic MEH-PPV molecule.

2. EXPERIMENTAL PROCEDURE

To obtain as-grown film and related device, the following protocol is accomplished. To fabricate Ag/MEH-PPV/Si/Al heterostructure, a thermal evaporation is used at lower pressure as portrayed in Fig.2.

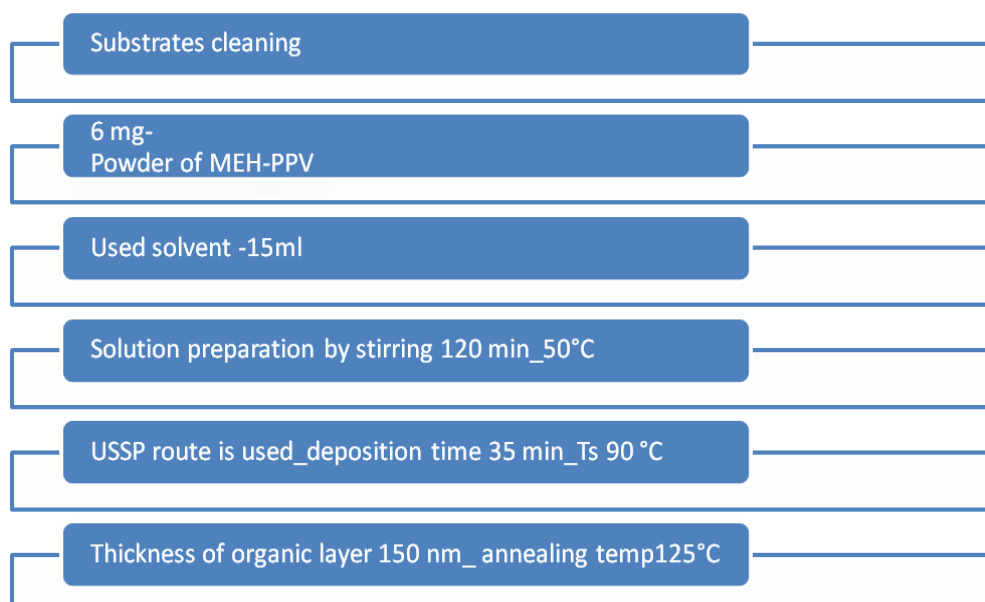


Fig.1. Experimental Protocole of organic layer and device.

2. RESULTS AND DISCUSSION

Fig.2 describes the I-V characteristics of Ag/MEH-PPV/Si/Al heterostructure in dark-light conditions. I-V plot shows several curves within reverse and forward -1V, 1V voltage range. Current sweeps from 0 to 200 μ A as a result of 0-200 mW/cm² illumination intensity.

Based on the thermionic emission model, the current can be expressed as[5-7];

$$I = I_0 \left[\exp \left(\frac{V - IR_s}{nkT} \right) \right] \quad (1)$$

As indicated in Table 1, N_d , V_d and ϕ_b of our organic device based on MEH-PPV organic molecule values are frequency dependent. Similar trends are prior described for another polymer [1].

Table 1. Extracted parameters of MEH-PPV based diode from C-V characteristics under several applied frequencies (not shown here)

Frequency (Hz)	N_d (10^{18}cm^{-3})	V_d	V_{bi}	ϕ_b (V)
100k	1.18	1.28	0.10	0.77
500k	1.15	1.51	0.22	0.90
1000k	0.66	1.50	0.13	0.82

Where I and V are the experimental current and applied biasing voltage of the MEH-PPV device, respectively, and I_0 is the reverse saturation current can be written as[7];

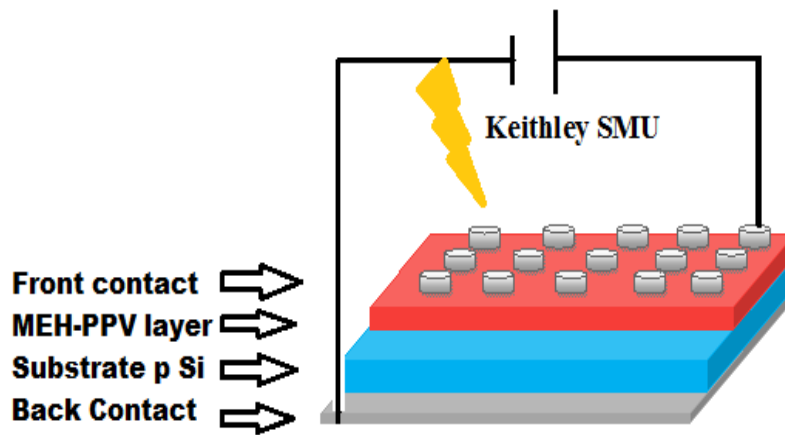


Fig.2. Design of Ag/MEH-PPV/Si/Al heterostructure.

$$I_0 = AA^* T^2 \exp \left(- \frac{q\Phi_b}{kT} \right) \quad (2)$$

Where the effective device area of contact is noted A (0.071 cm^2), the effective Richardson constant for the p-type silicon is A^* of $32 \text{ A/cm}^2 \text{K}^2$, q is the electron charge, T is the absolute temperature expressed in Kelvin, n is the ideality factor, Φ_b is the zero-bias barrier height. The determination of the Φ_b value is calculated after extraction and injection of I_0 in equation 3, and the barrier height is then calculated using [7];

$$\Phi_b = \frac{kT}{q} \ln \left(\frac{AA^* T^2}{I_0} \right) \quad (3)$$

Table 2. Extracted electrical parameters of Ag/MEH-PPV/Si/Al heterostructure under light.

Light intensity (mw/cm^2)	I_{ph} (μA)	Photosensitivity	Max power (μW)	FF	PCE (%)
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100	0.02	38.30	5.13	0.37	5
150	0.04	22.0	4.36	0.49	2.9
200	0.02	43.4	11.6	0.31	5.8

As sketched in Fig.3, current is varying as a result of illumination intensity. Photocurrent values ranging inside 0.02-0.04 μA range while photosensitivity of our device is increasing with light intensity as listed in Table 2. PCE data are varied from 2.9 to 5.8 as listed above.

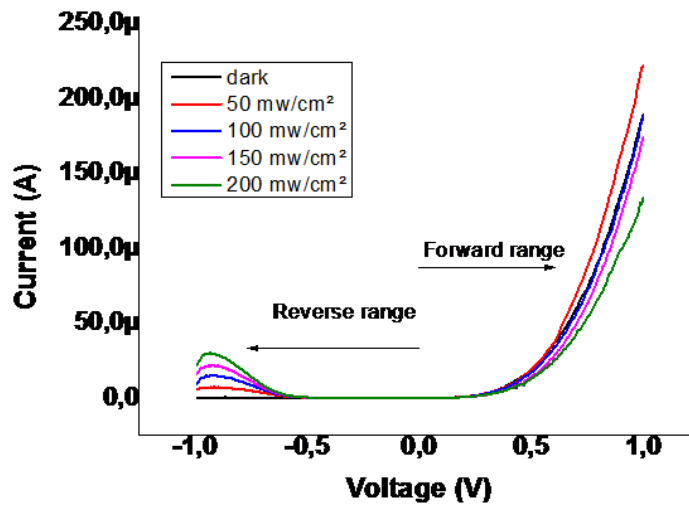


Fig.3. I-V characteristics of Ag/MEH-PPV/Si/Al heterostructure in dark-light conditions.

Rectifying ratio (RR) of Ag/MEH-PPV/Si/Al heterostructure is calculated as shown in Fig.4. RR records a value of 1430 in dark and is lowering as a result of light increases. Lower values are observed 39, 19, 10.9 and 6 for 50, 100, 150 and 200 mw/cm^2 respectively. Similar trends are recorded for ideality factor 1.75, 1.89, 2.1, 1.76 and 2.1 are obtained values for dark and light conditions. Furthermore saturation current I_0 of Ag/MEH-PPV/Si/Al heterostructure is assessed within range 10.4-20.15 μA . By using $\log I$ - $\log V$ plots (not shown here) of Ag/MEH-PPV/Si/Al heterostructure the conduction mechanisms are well defined and studied. It is observed that the current is space-charge limited (SCLC) and that the exponential distribution of trapping levels has the most influence on how traps affect the conduction current. Such organic heterostructures can meet photodiode and solar cell applications. Similar mechanisms are already reported by S.Aydogan et al. for organic Orcein [8].

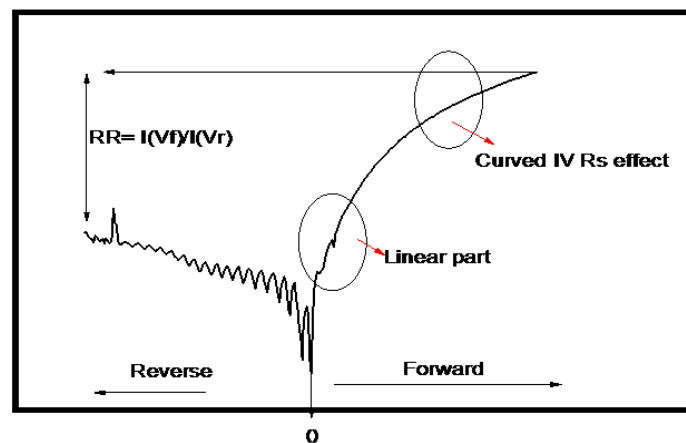


Fig.4. I-V characteristics of Ag/MEH-PPV/Si/Al heterostructure (RR evaluation and R_s effect).

As for any analysis of electronic device involved for photovoltaic application, a measurement of optical parameters is required. Fig.5 and 6 demonstrate the variation of both absorbance and transmittance versus wavelength within 400-700 nm range. An absorbance peak of 12% is indicated at 508 nm and decay is followed within visible range.

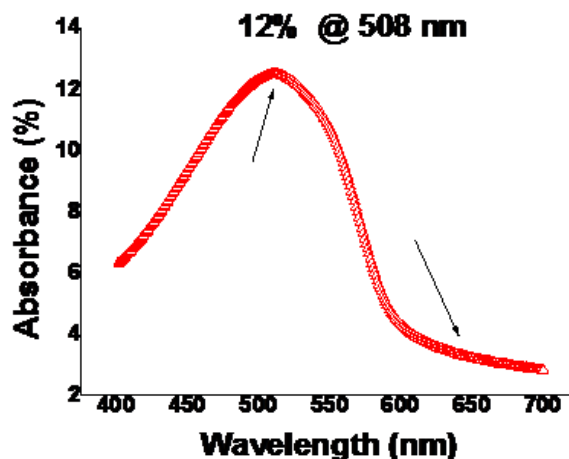


Fig.5. Absorption profile of MEH-PPV layer, a maximum of 12% is recorded at 508 nm.

A high transmittance of 90 % is reached at the end edge of visible as drawn in Fig.6 but a valley is spotted of transmittance inside visible band which confirm optical filter properties of such organic layers. Such findings are already demonstrated for phthalocyanine blue-green pigments layers [9]. Optical characterization of P3HT polymer based thin film has presented similar transmittance inside 400-700 nm wavelength range [1]. Absorbance profile of DPEA-MR-Zn organic crystalline semiconductor exhibited peaks within visible range [10].

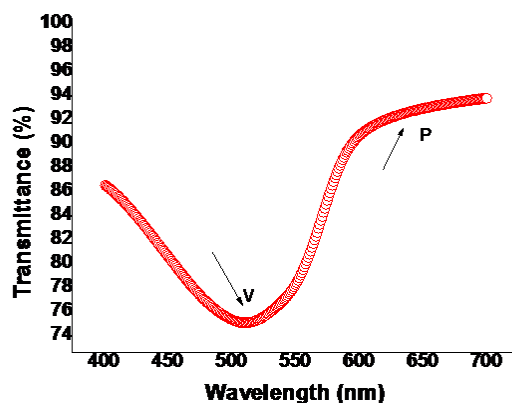


Fig.6. Transmittance plot of MEH-PPV layer onto glass substrate, both a valley V and peak P are recorded.

4. CONCLUSION

Organic molecule-based devices for solar cell and OLED applications have recently been extensively studied and fabricated by several techniques. The NREL table classifies them among the emerging photovoltaic components. Among these molecules we opted for MEH-PPV produced by USSP and PVD techniques. A rather remarkable transparency of the organic film is recorded in the visible and the gap is of the order of 2.02 eV. The effect of light intensity on electrical parameters is evidenced. A non-ideal behavior of organic diode is

observed due to the presence of interface states. Moreover optical filter properties of such organic layers based on MEH-PPV are demonstrated.

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