2. Experimental

After the initial steps such as patterning of ITO coated glass, etching, cleaning and subsequent processes, the deposition of PEDOT:PSS was carried in first sample by using spin coating technique at the speed of 1200 rpm to form a thin layer of around 50 nm. This sample was dried in a vacuum oven for around 20 minutes. In the second sample the MoO_3 was deposited using vacuum thermal evaporator at the deposition rate of 0.1 Å /sec to form a very thin film of around 5-6 nm. After the deposition of HTL layer the polymer (P3HT:PCBM) was deposited by spin coating technique using a common solvent (chlorobenzene) in both the samples. This layer was also deposited at the speed of 1200 rpm and known as the active layer of thickness around 100-120 nm. Now the last layer also known as cathode was deposited using vacuum thermal evaporation technique at the deposition rate of 10 Å /sec to form a layer of thickness around 100 nm. The pressure of the vacuum chamber should be maintained around 5×10^{-7} torr to ensure good quality deposition. Otherwise without reaching low enough pressure, hot vaporized metal particles react with remaining oxygen molecules and form metal oxide.

3. Results and Discussions

Current - Voltage characteristics

Solar cells are operated between open circuit and short circuit conditions. This is in the fourth quadrant of the current - voltage characteristics, which is shown in Figure 1.2. The current - voltage curve provides a basic for the characterization of the properties of a solar cell. Such a cell is described by several parameters [17]–[19].

Open-Circuit Voltage (Voc): The maximum possible voltage across a photovoltaic cell or the voltage across the cell in sunlight when no current is flowing.

Short-Circuit Current (Isc): This is the current that flows through an illuminated solar cell when there is no external resistance (i.e., when the electrodes are simply connected or short-circuited). The short-circuit current is the maximum current that a device is able to produce.

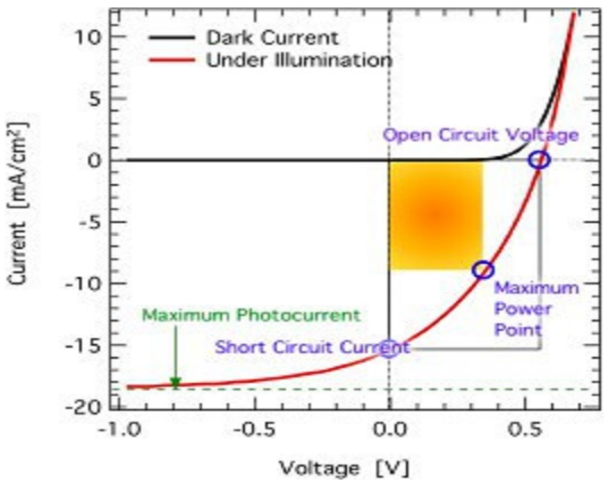

Figure 1.2: Current - Voltage characteristics

Fill Factor (FF): The ratio of a photovoltaic cell's actual maximum power output to its theoretical power output if both current and voltage were at their maxima, Isc and Voc, respectively. This is a key quantity used to measure cell performance. It is a measure of the 'squareness' of the I–V curve. The formula for FF in terms of the above quantities is:

$$FF = \frac{V_{mpp} I_{mpp}}{V_{OC} I_{SC}} \quad (1)$$

Where,
Vmpp = Voltage at Maximum Power Point
Impp = Current at Maximum Power Point

Power Conversion Efficiency (PCE or η): The ratio of power output to power input. In other words, PCE measures the amount of power produced by a solar cell relative to the power available in the incident solar radiation (Pin). Pin here is the sum over all wavelengths and is generally fixed at 100 W/cm2 when solar simulators are used (in lab). This is the most general way to define efficiency. The Formula for PCE, in terms of quantities defined above is:

$$\eta = \frac{V_{mpp} I_{mpp}}{P_{in}} = \frac{V_{oc} I_{SC} FF}{P_{in}} \quad (2)$$

Figure 1.3, shows the J-V characteristics graph of a P3HT:PCBM device (light and dark characteristics) using PEDOT:PSS as HTL and device parameters are shown in Table 1.1. It was found that the Jsc (current density) was found to be 4.91mA/cm2, where Voc was 0.514V, fill factor (FF) and power conversion efficiency (PCE) of a device has reached upto 43.3% and 1.09% respectively. The current density voltage measurements have been used to discuss the performance characteristics of a polymer cell.

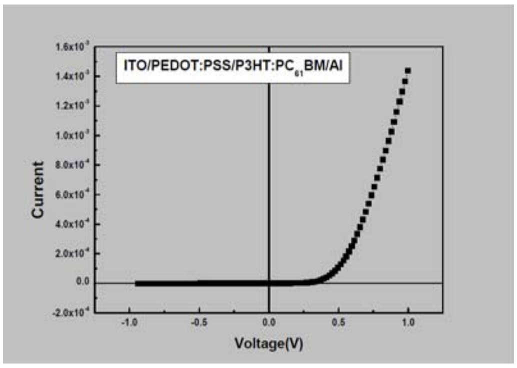

Figure 1.3 (a)

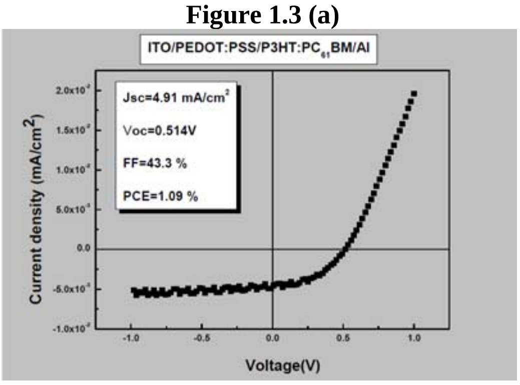

Figure 1.3 (b)

Figure 1.3: (a) and (b): J-V characteristics of P3HT based organic solar cell with PEDOT:PSS as HTL.

Table 1.1: J-V characteristics graph of a P3HT:PCBM device using PEDOT:PSS as HTL

Rotation speed	Voc (volts)	Jsc (mA/cm^2)	Fill Factor (FF)	Power Conversion Efficiency (PCE)
1200 rpm	0.514	4.91	43.3 %	1.09 %

Figure 1.4, shows the J-V characteristics graph of a P3HT:PCBM device (light and dark characteristics) using MoO_3 as HTL and device parameters are shown in Table 1.2. The solar cell showed a fill factor (FF) of 47.4%. The Voc and Jsc values were 0.50 and 5.52 respectively. The power conversion efficiency (PCE) value obtained is 1.29%.

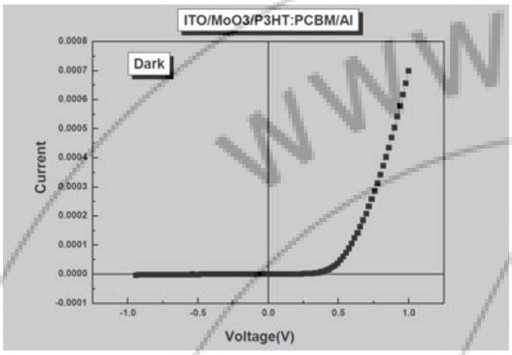

Figure 1.4 (a)

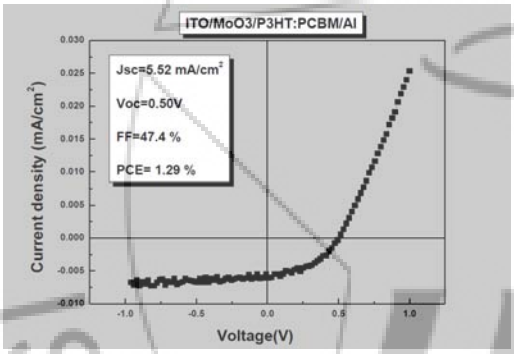

Figure 1.4 (a)

Figure 1.4: (a) and (b): J-V characteristics of P3HT based organic solar cell with MoO_3 as HTL.

Table 1.2: J-V characteristics graph of a P3HT:PCBM device using MoO_3 as HTL

Rotation speed	Voc (volts)	Jsc (mA/cm^2)	Fill Factor (FF)	Power Conversion Efficiency (PCE)
1200 rpm	0.50	5.52	47.4 %	1.29 %

4. Conclusion

We have fabricate several OPV device based on P3HT and finding average PCE in the range of 1.0% to 1.30% in the device geometry of ITO/HTL/P3HT:PCBM/Al in ambient condition. We also examine the effect of different HTL (Hole transport layer) and found that replacement PEDOT:PSS with MoO_3 resulted better PCE. We demonstrated various techniques to fabricate PEDOT:PSS and MoO_3 thin films as a hole transport layer using spin coating and thermally evaporated organic solar cells respectively. Since the extinction coefficient of PEDOT:PSS is much larger than any other materials except P3HT:PCBM and electrodes, the photon absorption of the active layer is highest when PEDOT:PSS is not used. Further PEDOT:PSS is hygroscopic, acidic, corrosive and its properties changes with change of manufacturer. Hence we conclude that the replacement of PEDOT:PSS with alternative materials such as MoO_3 results in better PCE.

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