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Opto-Electro Simulation of Organic Solar Cell at Different Active Layer Thickness and Charge Carriers Mobility Based on P3HT: PCBM Materials

Nikhil Rastogi

Department of Physics, School of Basic Sciences & Technology, IIMT University, Meerut, U. P. India

Abstract: In this research work, bulk heterojunction organic solar cell is simulated optically and electrically at different active layer thickness and different hole mobility by General-purpose Photovoltaic Device Model (GPVDM) software. Organic bulk heterojunction solar cell consists of mixture of poly (3-hexylthiophene) (P3HT) and [Rait, S. e*t al*., 2007]-phenyl C61-butyric acid methylester (PCBM) as active layer material, Indium Tin oxide (ITO) is a transparent electrode, Poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT: PSS) is an electron blocking layer and Al a back electrode. In this work, the optical reproduction has been done at various dynamic layer thicknesses for example 180 nm, 200 nm and 220 nm, and electrical reproduction at various opening portability 1×10-4cm2/Vs, 1×10-5cm2/Vs, 1×10-6cm2/Vs and 1×10-7cm2/Vs individually. It is seen that current-voltage (j-v) attributes are impacted by the opening portability. The best current-voltage (j-v) trademark is acquired at 1×10-6cm2/Vs versatility and the best ingestion at 200 nm. It is inferred that in the natural BHJ sunlight based cell the effectiveness increments, when versatility diminishes (from 10-4 to 10-6) where as over 10-7 portability, the productivity further abatements. On the off chance that the versatility is expanded from 1×10-5cm2/Vs the separation likelihood is expanded and will be greatest at 1×10-6cm2/Vs, and again increment the portability the separation won't further increment and effectiveness is decline.

Keywords: GPVDM software, carrier mobility, bulk heterojunction, organic solar cell.

INTRODUCTION

Daylight based cell or photovoltaic cell is the optical contraption that adherents sun radiation to control. The green plant achieves some practically identical work, the follower light to substance energy so a social occasion of sun situated cells asserted regular daylight based cells. The sun supplies us an immaculate and boundless resource of energy and help us with moderating the energy crises and world tainting. Normal sun fueled cells subject to frame polymers are a ton promising for a humble and versatile choice as opposed to inorganic daylight based cells. Today a couple of sun situated cell developments exist in which regular sun based cells are one of the more current classes of innovations. Natural daylight based cell (OSC) devices attract progressively more interest in latest several years. These devices yield an energy change capability of around 6% to 7% for single convergence cell [Green, M. A. e*t al*., 2009] similarly a few cells [Kim, J. Y. e*t al*., 2007]. This is essentially less diverged from adequately recognized silicon photovoltaic contraptions, which has viability above 20%. Regardless, normal photovoltaic (OPV) contraptions partake in a couple of advantages like, versatile substrates, the shot at negligible cost creation [Kalowekamo. J. e*t al*., 2009], room temperature dealing with and thin film structure. Regular sun fueled cells contain a mix of polymer P3HT (advocate) and PCBM (acceptor) as the photoactive layer. In mass heterojunction (BHJ) regular sun based cells, the held episode photons make immovably bound electron-opening sets, which can isolate into (charge carrier) electrons and openings at the nearby giver/acceptor interface. The electrons and openings are then sent to their different anodes [Brabec, J. e*t al*., 2001; Rait, S. e*t al*., 2007]. Investigation tries to some degree as of late have generally further developed normal sun based cell execution [Li, G. e*t al*., 2005; He, Z. e*t al*., 2012] and power change efficiency (PCE) valves better than 10% have actually been refined [You, J. e*t al*., 2013]. All through the long haul, colossal investigations attempts have been performed at developing low band opening polymers to grows maintenance and accumulate more daylight based energy for which the more short out current can be conveyed.

In ITO/PEDOT: PSS/P3HT: PCBM/Al normal mass heterojunction daylight based cells, P3HT (3-hexyl thiophene) is an electron promoter material that effectively transports positive openings, PCBM [Rait, S. e*t al*., 2007]-phenyl C61-butyric destructive methyl ester) is an electron acceptor materials. It effectively moves electrons starting with one iota then onto the next. The ITO (Indium Tin Oxide) film is used as a clear terminal. Since, it has high transport around there and cutoff of good conduction. PEDOT: PSS or poly (3, 4-ethylenedioxythiophene) poly (styrenesulfonate) is an initial transportation layer. PEDOT: PSS may be used as pad layers between the direct cathodes and dynamic layer of materials to deter the electron and opening trade off base. In this examination we present optical and electrical affectation of mass heterojunction (BHJ) sun fueled cell using GPVDM programming at different unique layer thicknesses. The essential advantage of the mass heterojunction sun situated cell is that a huge piece of made excitons show up at a nearby supporter acceptor interface, where they related into free charge carriers [Rastogi, N. e*t al*., 2017]. These powerful Excitons harvesting lead to higher power change efficiencies for BHJ daylight based cell. The regular sun controlled cell has two fighting connection, extraction and recombination of the charge carriers, both cycle are coordinated by the adaptability of charge carrier. As addition charge carrier versatility would a useful result

***Corresponding Author:** Nikhil Rastogi

on transport, working with extraction, but on other hand it increases the recombination.

Heterojunction Structure and Charge Carriers Generation:

Mass heterojunction is a combination of interpenetrating combination of electron contributor and electron acceptor formed natural materials that permits assimilation of light, the age of charge transporters (excitons), parting of excitons at giver acceptor interface, and transport of positive and negative charges to inverse cathodes. Mass heterojunction (BHJ) are generally produced by shaping the two form polymers, projecting and afterward permitting isolating the two stages, normally with the assistance of tempering interaction. The two form polymers will self collected into an interpenetrating network associating the two anodes [Lee, M. M. e*t al*., 2012].The structure of bulk heterojunction solar cell is shown in fig.1.

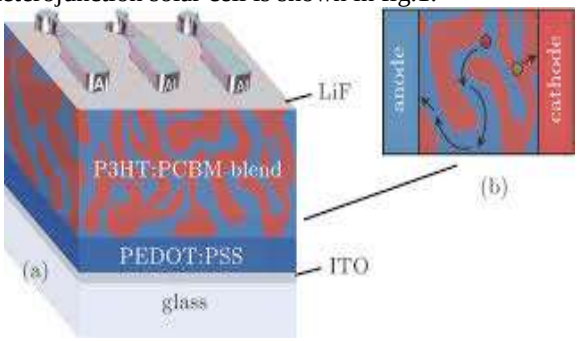

Fig 1: Bulk Heterojunction solar cell

Later the catch of a photon, electron move to the acceptor areas, then, at that point, are brought through the gadget and gathered by the one cathode and openings moves inverse way and gathered at opposite side. Assuming the scattering of the two materials is especially bigger, it will bring about helpless charge move through the dynamic layer. In control move, the two contributors and acceptor add to the age of charge transporters.

Natural sun powered cells produce regular versatile excitons later retention of light. To isolate the excitons into free charge transporters a contributor acceptor framework should be utilized [Heeger, A. J. e*t al*., 2014]. When the excitons arrives at the contributor/acceptor interface the electron will move to the material with ale electron proclivity and the opening will be acknowledged by the material with the lower ionization potential. Because of the lower excitons dispersion lengths to 1-10 nm in polymeric materials [Tang, C. W. e*t al*., 1986; Markov, D. E. e*t al*., 2005] a basic bilayer construction will bring about low efficiencies, since just photons consumed inside this separation from D/An interface will add to the gadget current[Singh, N. e*t al*., 2015]. An expansion in the created photograph current can be accomplished by utilizing an interpenetrating organization of contributor and acceptor materials [Granström, M. e*t al*., 1998; Halls, J. J. M. e*t al*., 1995]. In a perfect world in mass heterojunction (BHJ), all assimilated photons will be nearby contributor acceptor interface and these can be adding to the created photocurrent.

SIMULATION

Electrical Simulation

Bulk heterojunction solar cell ITO/PEDOT: PSS/P3HT: PCBM/Al is reproduced by the GPVDM programming at various arrangement obstruction of the gadget. GPVDM programming is explicitly intended to reproduce mass heterojunction natural sun based cells, for example, those dependent on the P3HT: PCBM materials. The model contains both an electrical and optical properties, empowering both flow voltage attributes to be recreated just as optical properties [Rastogi, N. e*t al*., 2016; Peumans, P. e*t al*., 2003]. The electrical model just covers the dynamic layer of the gadget. In this model, there are two sort's of charge transporter electrons (holes), free electrons (holes) and caught electrons (holes). Free electrons (holes) have a finite mobility of $\mu^{o}_{e}(\mu^{o}_{h})$ and trapped electrons (holes) cannot move at all and have a mobility of zero. We take the ratio of free to trapped carriers and multiply it by the free carrier mobility to evaluate the average mobility.

$$\mu_e(n) = \frac{\mu_e^{\circ} n_{\text{free}}}{n_{\text{free}} + n_{trap}}$$

Thus if all carriers were free the average mobility would be $\boldsymbol{\mu^{o}_{e}}$ and if all carriers were trapped the average mobility would be zero. It should be noted that only $\mu^{o}_{e}(\mu^{o}_{h})$are used in the model for computation and using μ_e (n) is an output parameter Figure 2 is showing the electrical simulation window.

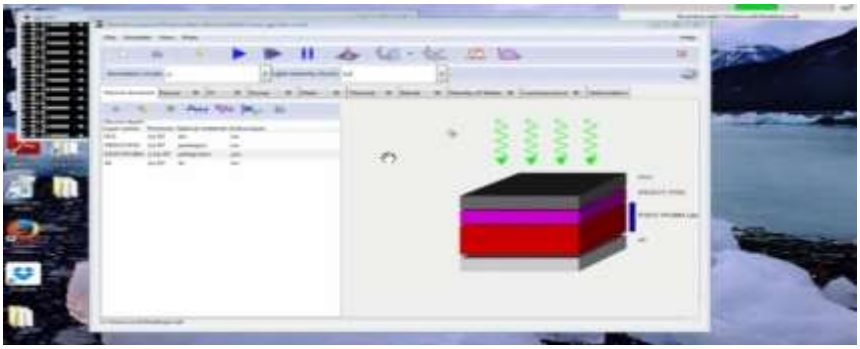

Fig 2: Electrical simulation window

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Optical Simulation

Mass heterojunction sunlight based cell ITO/PEDOT: PSS/P3HT: PCBM/Al is imitated by the GPVDM programming at different plan deterrent of the device. GPVDM writing computer programs is expressly planned to recreate mass heterojunction normal sun based cells, for instance, those ward on the P3HT: PCBM materials. The model contains both an electrical and optical properties, engaging both stream voltage credits to be reproduced similarly as optical properties [Rastogi, N. et *al*., 2016; Peumans, P. et *al*., 2003]. The electrical model simply covers the powerful layer of the contraption. In this model, there are two kind's of charge carrier electrons (openings), free electrons (openings) and got electrons (openings). Free electrons (openings) have a limited versatility of μoe(μoh) and caught electrons (openings) can't move by any stretch of the imagination and have a portability of nothing. This is finished by putting a 'yes' in segment (dynamic layer) in the figure 3.

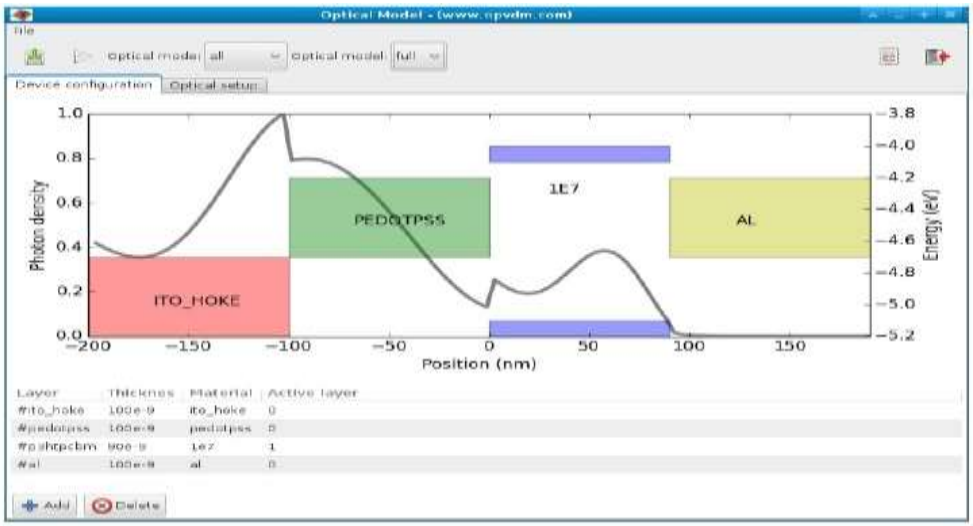

Fig 3: Optical Simulation Window

RESULT AND DISCUSSION

In this paper ITO/PEDOT: PSS/P3HT: PCBM/Al mass heterojunction sunlight based cells are planned by the GPVDM programming to examine the optical properties. The assimilation of P3HT: PCBM dynamic layer are more viable for the frequency from 350nm to 750nm. The optical reenactment (frequency 150-750 nm) is made at various dynamic layer thickness, ITO thickness 20nm, PEDOT: PSS thickness 20 nm, Al thickness 20nm and the dynamic layer thickness are 180nm, 200nm, 220nm, and the retentions at various dynamic layer thickness are appeared in the figures 4 a, b and c.

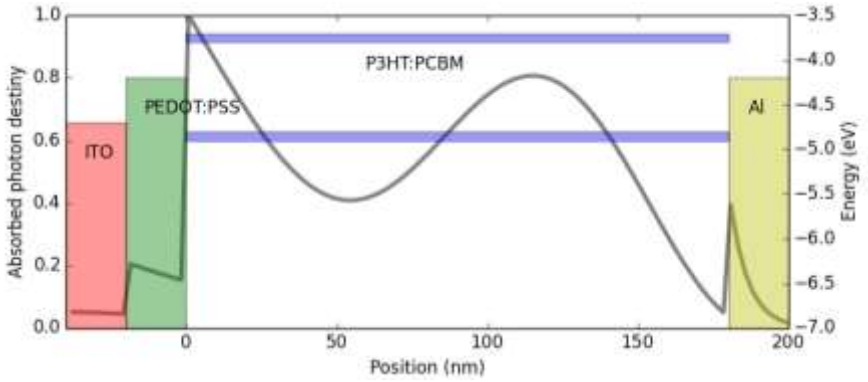

Figure 4(a): Active layer thickness 180 nm

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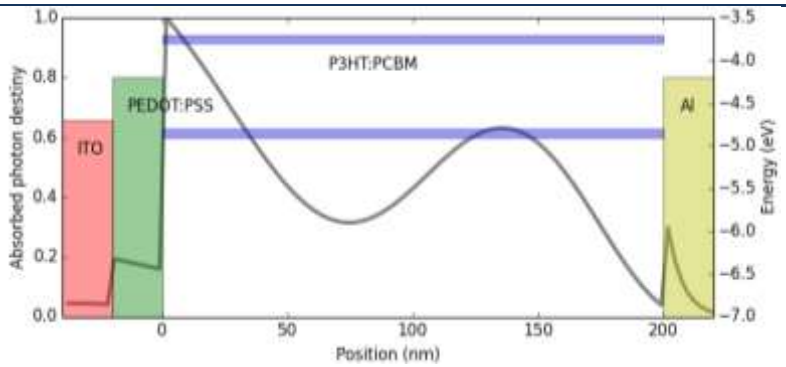

Figure 4(b): Active layer thickness 200 nm

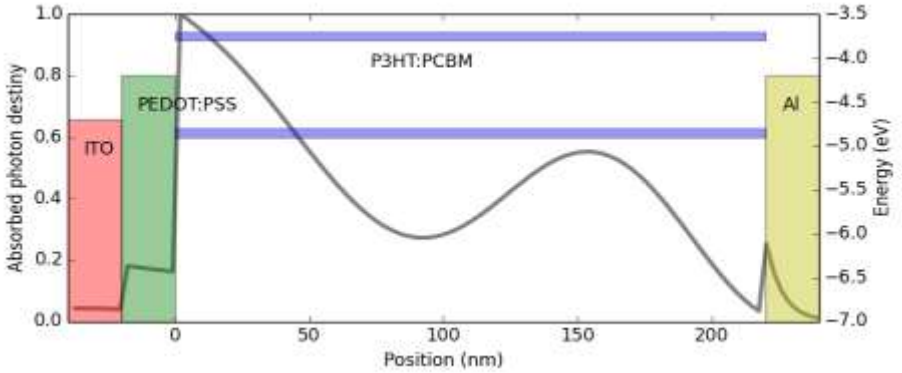

Figure 4(c): Active layer thickness 220 nm

Illumination current-voltage attributes are recreated at various opening versatility, $1\times10^{-4}cm^2/Vs$, $1\times10^{-5}cm^2/Vs$, $1\times10^{-6}cm^2/Vs$ and $1\times10^{-7}cm^2/Vs$, which is appeared in figure 5. It is obvious from the current-voltage trademark bends that the short current thickness is most extreme at $1\times10^{-6}cm^2/Vs$ and least at $1\times10^{-4}cm^2/Vs$.

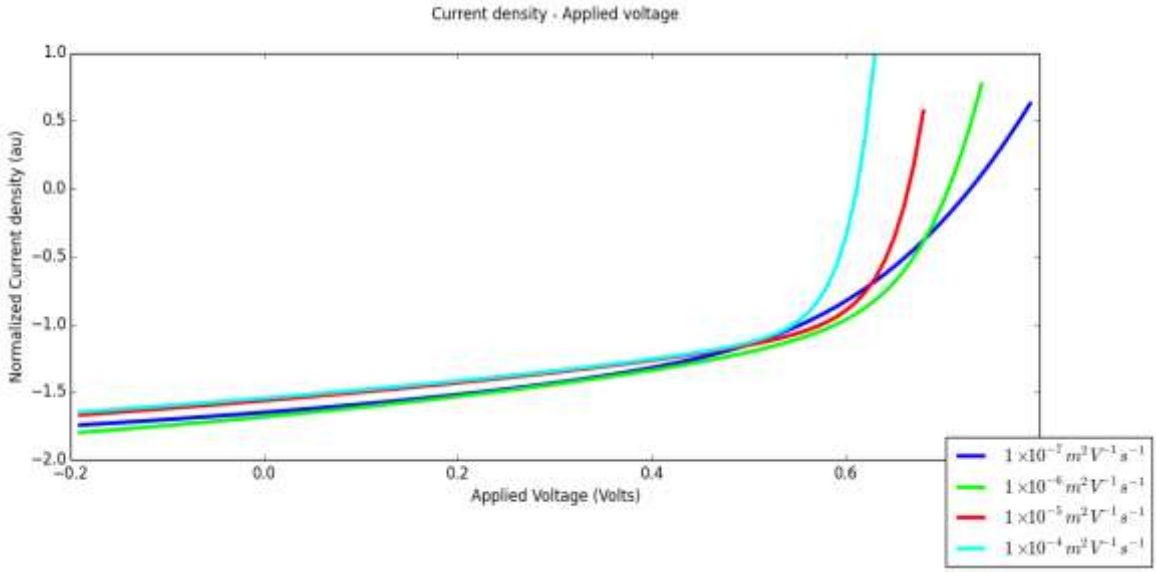

Figure 5: Current Voltage characteristics at different hole mobility

It is clear from the twists that in normal BHJ daylight based cell the usefulness increases when transportability decreases (from 10-4 to 10-6). The extended recombination of electron-opening join and diminish detachment capability, decrease viability however the incident in open circuit voltage at higher carrier conveyability is responsible for the reduction of usefulness. If the compactness is extended from 1×10-5cm2/Vs the partition probability is extended and will be most noteworthy at 1×10-6cm2/Vs, and again increase the adaptability the division won't further augmentation and adequacy is decrease. Obviously the sun arranged cell is more capable at unmistakable flexibility range.

Conclusions

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In this work, we have presented optical and electrical entertainment of the P3HT: PCBM based mass heterojunction sun fueled cell for different powerful layer thickness. The maintenance illustration of the powerful layer of normal sun arranged cell changes with thickness. We get ingestion best near the terminals at which the best maintenance happens at thickness 200 nm. The short out current is affected by the electron and opening movability and most outrageous short out current obtained at 1×10-6cm2/Vs. Thusly by changing the powerful layer thickness and adaptability the effective maintenance and usefulness of P3HT: PCBM based daylight based cells can be updated.

It is contemplated that current-voltage (j-v) characteristics are affected by the initial transportability. The best current-voltage (j-v) brand name is procured at 1×10-6cm2/Vs adaptability and the best ingestion at 200 nm. It is in like manner surmised that in the regular BHJ sun arranged cell the capability increases, when adaptability lessens (from 10-4 to 10-6) while north of 10-7 convenientce, the usefulness further decreases. In case the flexibility is extended from 1×10-5cm2/Vs the partition probability is extended and will be generally outrageous at 1×10-6cm2/Vs, and again increase the movability the detachment won't further augmentation and capability is decline.

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