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Effect of Series Resistance and Layer Thickness on PCE & Fill Factor in Pervoskite Solar Cell with MoO3: PC60bm

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***Abstract*—**This paper reports a study on the effect of series resistance and layer thickness on the performance of an perovskite photovoltaic cell which is based on active layer of Molebdenum tri Oxide(MoO3) and Methyl ester(PC60bm). Electrical simulation has been examined on FTO: MoO3: perovskite layer : PC60bm -Au structure with GPVDM (General Purpose Photovoltaic Device Model) software. We used the GPVDM software to investigate the effect of series resistance and layer thickness on power conversion efficiency (PCE) and fill factor (FF) in an perovskite solar cell which is based on MoO3: PC60bm as an absorbing layer. The changes were made by applying the different series resistance and layer thickness value. The results show that the power conversion efficiency can be increased by changing the value of the series resistance and layer thickness, in our case the power conversion efficiency has been increased from 16.66% to 20.42% and fill factor has been change from 66.29% to 71.22%.

Keywords*—Perovskite photovoltaic cell, MoO3: PC60bm, GPVDM, series resistance, thickness effect.*

1.INTRODUCTION

Perovskite photovoltaics (PPVs) have attracted considerable interest over the past two decades due to their advantages over organic solar cells. PPVs are lightweight, cheap and non-toxic compared to organic solar cells. They are also robust and versatile mechanically. Perovskite solar cells, as the name implies, transform light from oxide molecules into electricity. For these solar cells, Oxide and Methyl ester molecules are widely used. Their long chain relocation via alternating double and single connections helps to effectively transfer the electron in the cell. The highest occupied molecular orbitals (HOMOs) and the lowest unoccupied molecular orbitals (LUMOs) are these orbits. An optical band gap in the half conductor area is the power disparity between the low-energy HOMOs and the highenergy LUMOs. Because of their versatile material properties and low-cost processing, Perovskite cells have been a very remarkable area of research in recent years.

In the early 2000s, Perovskite solar photovoltaic cells were developed. Since 2009, organic chemistry has had a fast growth and the first discovery of photoconductivity in organic compounds was published in 1906. The product, Solarmer, developed for the first time Organic Photovoltaic. BHJ-based organic solar cells (Bulk Hetro-junction) are composites of P3HT (Poly3-hexylthiophene) and PCBM (phynyl-C-70buteric acid methyl ester) [1-2]. Gpvdm (OPVDM's new name) is a free general-purpose device,This type of cell gives low value of PCE.

Originally designed to simulate organic solar cells, it has now been expanded to simulate other system categories, including OLEDs, OFETs and many other forms of solar cells of 1st, 2nd and 3rd generation. The 4th generation is based on perovskite physical model solves drift-diffusion of electron and hole as well as continuity equations of the carrier in position space to describe the load movement within the device.

The model facilitates the study of the effect on system performance of product parameters such as mobility, energetic disorder, doping, and recombination crosssections. All internal device parameters such as current density load frequency, position distribution of trapped carriers and energy storage can be controlled through either the graphical interface or directly from output data. The system includes both an electrical and an optical solver, allowing simulation of current / voltage characteristics and the optical model profile within the device. The model is available for Windows and Linux (x86 and ARM) and it is easy to use graphical interface. Gpvdm is a tool used to simulate and design solar cells to harvest the energy of the sun.

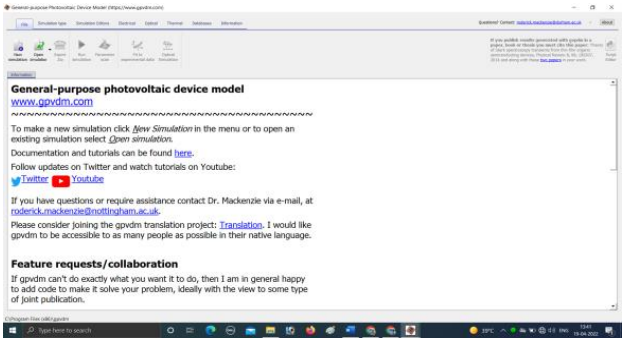

Fig 1: GPVDM Home Window

2.ELECTRICAL SIMULATION

The significant parameters that influence its performance should be explored in order to improve the power conversion efficiency of pervoskite solar cells. The GPVDM software simulates the organic solar cell at various layer thicknesses. This model consists of both electrical and optical properties and is specifically designed to mimic

pervoskite solar cells based on the Oxide (MoO3) and Methyl ester (material [7]. The electrical simulation just reaches the device's active layer. The current density-voltage plotted for Voc and Jsc to be provided. The Voc is defined by the energy gap between the largest molecular orbital occupied (HOMO) representing the donor level and the lowest unoccupied molecular orbital (LUMO) describing the acceptor level [8]. The j-v curve provides the fill factor specified as the ratio between the maximum power point (Pmpp) and the device's theoretical maximum power (Pmax) [8-11].
Fill Factor = Pm/(Voc*Isc)

Here, Voc and Pmax are the voltage and current density in the maximum power point respectively. The power conversion efficiency for a solar cell is defined by the equation.

Efficiency(η)=(FF*Voc*Isc)/Pin

Where, Pin is the power density of the light and Pout is the electric power generated by the bulk hetero junction solar device at maximum power point. [12]

curve (j-v)

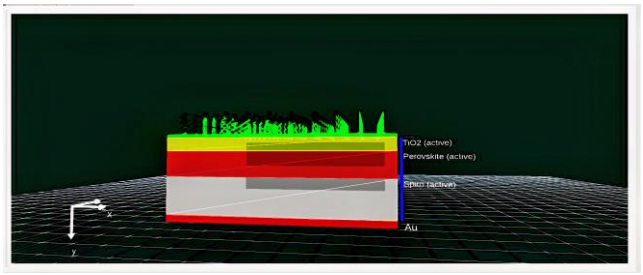

Fig.2: Perovskite Solar Cell Model

Fig.2 demonstrates the FTO: MoO3: perovskite layer : PC60bm -Au based perovskite solar cell design. In this example, the layer configuration followed is FTO: MoO3: perovskite layer : PC60bm -Au, where ETM (Electron Transfer Layer) is MoO3 and HTM (Hole Transfer Layer) is PC60bm[5]. The Flourin-doped Tin Oxide (FTO) film is used as a transparent electrode because it has strong visible region transmittance and conductive capacity [12].

Original parameters chosen from PSC electrical parameters are shown in Table 1. The electrical and optical parameters of perovskite solar cells are derived from the FTO layer and Au dependent gpvdm software database, and the layer thickness values are taken as 1e-07 and 1e-07 respectively [13].

Table.1 Parameter specification of materials
Our analysis is focused on the observation of different layer thickness effects on the efficiency of power conversion [14]. Table 1 displays the reference value of the simulation parameters.

Table 1.Specification of active layers

S.No.	Parameters	MoO3	PC60bm
1	Layer Thickness (m)	3e-07 (variable)	3e-07 (variable)
2	Relative permittivity	20	20
3	Electron tail slope (ev)	0.06	0.06
4	Hole tail slope (ev)	0.06	0.06
5	Doner Concentration (m-3)	1e+25	1e+26
6	Acceptor Concentration (m-3)	1e+25	1e+26

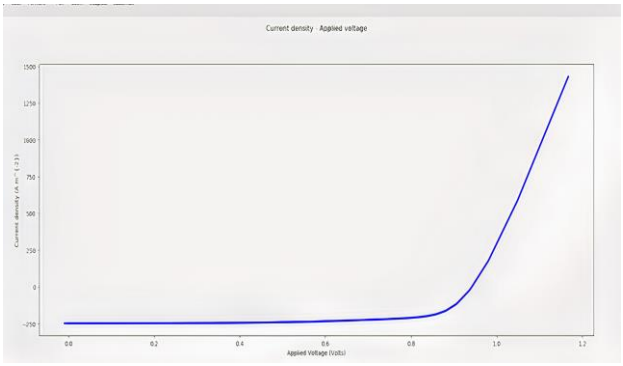

Fig.3: J-V Characteristics for initial layer values

The j-v curve is shown in Fig 3, in which PCE (Power conversion efficiency) is 18.85%, fill factor is 71.22%, short circuit density of current is -20.68A/m and open circuit voltage Voc is 0.94V [15].

3.RESULTS AND DISCUSSIONS

In our simulation, optimization method is used to fix all parameters and modify the values one by one until we have the parameters that give maximum Power Conversion Efficiency. Figure 4 represents the curve effect of MoO3 layer thickness on PCE in pervoskite solar cell.

S.No	Series Resistance(in ohm)	PCE(in%)	Fill Factor(in%)
1	19.5	16.67	64.74
2	25	16.52	64.22
3	40	16.13	62.77
4	10	16.92	65.69
5	5	17.05	66.20
6	19.5	17.08	64.58
7	5	18.85	71.22

Table.2 Effect of Series Resistance in PCE and FF

Table no.2 shows that the variation in power conversion efficiency and fill factor by changing the value of series resistance.In above table we can see that the variation in PCE and FF by using appropriate values of series resistance is inversely proportional to PCE and FF in specific region The minimum value of series resistance gives the higher value of PCE and FF there is some concern of layer thickness, if the value of series resistance is 5 ohm then we get maximum power conversion efficiency and fill factor.

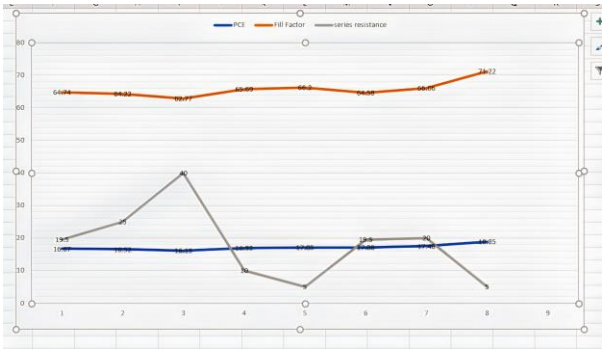

fig.4 Effect of series resistance in PCE and Fill Factor

S.No.	Thickness of MoO3 Layer(in cm)	PCE(in%)	FF(in%)
1	2*e-07	17.08	64.58
2	3*e-07	16.03	67.32
3	4*e-07	18.46	67.62
4	5*e-07	18.50	69.81
5	6*e-07	19.36	70.68

Table.3 Effect of thickness of MoO3 in PCE and FF

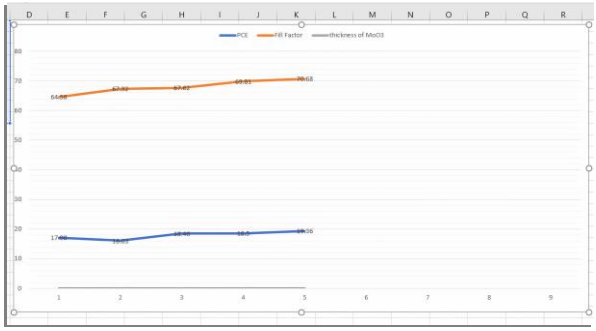

Fig.5 Thickness of MoO3 Vs.PCE Vs.FF

S.No.	Thickness of Pc60bm layer(in cm)	PCE(in%)	FF(in%)
1	2*e-07	17.08	64.58
2	3*e-07	20.42	64.79
3	4*e-07	18.64	67.0
4	5*e-07	16.93	70.55
5	6*e-07	16.93	70.55

Table.4 Effect of thickness of Pc60bm layer in PCE and FF

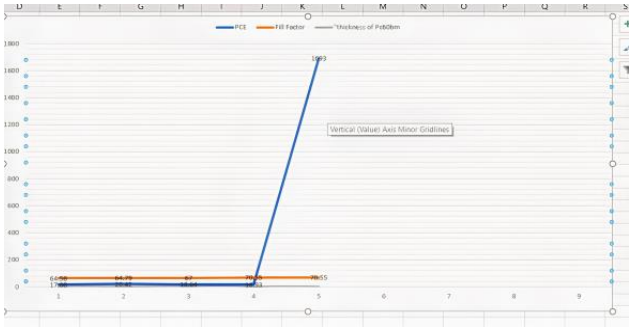

Fig.6 Thickness of Pc60bm Vs.PCE Vs.FF

Figure.5 shows that the variation in PCE and FF(Fill Factor) by varying the thickness of active layer of MoO3.

Fig.6 shows that the variation in PCE and FF by varying the thickness of spiro layer Pc60bm.

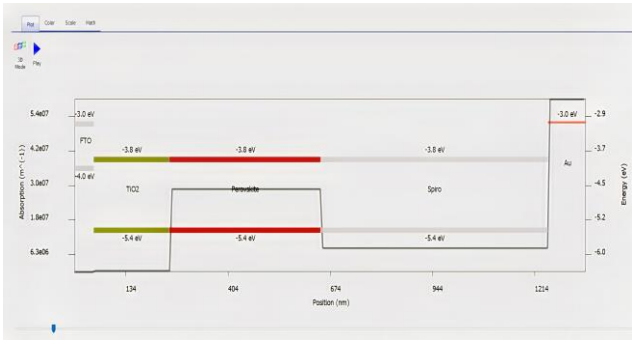

Fig.7 Optical output

Fig.7 shows that the optical output of pervoskite solar cell with different thickness to achieve the maximum power conversion efficiency and fill factor.The properties of pervoskite solar cells have the mejor two are power conversion efficiency and fill factor.The power conversion efficiency(PCE) can be define as the ratio of the electrical power output to optical power input.This perticular property indicates the how system is reliable to use and can get the maximum and affordable output power to the system.In our simulation we get the PCE 16.66% to 20.42% this is affordable limit to achieve the greater output power as compare to the organic solar cells.In present era there is point of discussion is the power conversion efficiency.

The major one property is the fill factor to operate efficiently and accurately to the output.

In present time number of solar model is creating but major problem is its fill factor.In our simulation this major problem has to avoided at certain level by varying the thickness of active layer of perovskite solar cell.The fill factor is the ratio of the actual maximum obtainable power to the product of short circuit current and open circuit voltage.In our simulation we get the fill factor output between the range of 66.29% to 71.22%.

4. CONCLUSION

The perovskite solar cell's PCE was analyzed using the GPVDM solar cell softwere simulation ,result indicates the good choice of series resistance and layer thickness of the active materials used in solar cell considerably increased the PCE ratio.Further PCE enhancements can be done by changing layer thickness.

5. REFERENCES

[1] Priyanka Roy,Yassine Raoui,Ayush Khare "Design and simulation of efficient tin based perovskite solar cells through optimization of selective layers": Theoretical insights.(2022)

[2]C. Yu, Advances in modelling and simulation of halide perovskites for solar cell applications, J. Phys. Energy. 1 (2019).

[3] P.H. Joshi, L. Zhang, I.M. Hossain, H.A. Abbas, R. Kottokkaran, S.P. Nehra, M. Dhaka, M. Noack, V.L. Dalal, The physics of photon induced degradation of perovskite solar cells, AIP Adv. 6 (2016).

[4]A. Miyata, A. Mitioglu, P. Plochocka, O. Portugall, J.T.W. Wang, S.D. Stranks, H. J. Snaith, R.J. Nicholas, Direct measurement of the exciton binding energy and effective masses for charge carriers in organic-inorganic tri-halide perovskites, Nat. Phys. 11 (2015).

[5] C.C. Stoumpos, C.D. Malliakas, M.G. Kanatzidis, Semiconducting tin and lead iodide perovskites with organic cations: phase transitions, high mobilities, and near-infrared photoluminescent properties, Inorg. Chem. 52 (2013).

[6] S.D. Stranks, G.E. Eperon, G. Grancini, C. Menelaou, M.J.P. Alcocer, T. Leijtens, L. M. Herz, A. Petrozza, H.J. Snaith, Electron-hole diffusion lengths exceeding 1 micrometer in an organometal trihalide perovskite absorber, Science 80 (342) (2013).

[7]D.A. Valverde-Chavez, ´ C.S. Ponseca, C.C. Stoumpos, A. Yartsev, M.G. Kanatzidis, V. Sundstrom, ¨ D.G. Cooke, Intrinsic femtosecond charge generation dynamics in single crystal CH3NH3PbI3, Energy Environ. Sci. 8 (2015).

[8]P. Roy, N. Kumar Sinha, S. Tiwari, A. Khare, A review on perovskite solar cells: evolution of architecture, fabrication techniques, commercialization issues and status, Sol. Energy 198 (2020).

[9]F.U. Kosasih, C. Ducati, Characterising degradation of perovskite solar cells through in-situ and operando electron microscopy, Nano Energy 47 (2018).

[10]D. Liu, T.L. Kelly, Perovskite solar cells with a planar heterojunction structure prepared using room-temperature solution processing techniques, Nat. Photonics 8 (2014).

[11] Y. Reyna, M. Salado, S. Kazim, A. Perez-Tomas, S. Ahmad, M. Lira-Cantu, Performance and stability mixed FAPbI3(0.85)MAPbBr3(0.15) halide perovskite solar cells under outdoor conditions and the effect of low light irradiation, Nano Energy 30 (2016)

[12] Y. Zhang, H. Zhang, X. Zhang, L. Wei, B. Zhang, Y. Sun, G. Hai, Y. Li, Major impediment to highly efficient, stable and low-cost perovskite solar cells, Metals 8 (2018).

[13] M. Konstantakou, T. Stergiopoulos, A critical review on tin halide perovskite solar cells, J. Mater. Chem. A. 5 (2017).

[14] Y. Takahashi, H. Hasegawa, Y. Takahashi, T. Inabe, Hall mobility in tin iodide perovskite CH3NH3SnI3: evidence for a doped semiconductor, J. Solid State Chem. 205 (2013).

[15] Y. Liao, H. Liu, W. Zhou, D. Yang, Y. Shang, Z. Shi, B. Li, X. Jiang, L. Zhang, L. N. Quan, R. Quintero-Bermudez, B.R. Sutherland, Q. Mi, E.H. Sargent, Z. Ning, Highly oriented low-dimensional tin halide perovskites with enhanced stability and photovoltaic performance, J. Am. Chem. Soc. 139 (2017).

[16] F. Gu, S. Ye, Z. Zhao, H. Rao, Z. Liu, Z. Bian, C. Huang, Improving performance of lead-free formamidinium tin triiodide perovskite solar cells by tin source purification (solar RRL 10⁄2018), Sol. RRL. 2 (2018).

[17] E. Kayesh, K. Matsuishi, T.H. Chowdhury, R. Kaneko, T. Noda, A. Islam, Enhanced photovoltaic performance of perovskite solar cells by copper chloride (CuCl 2) as an additive in single solvent perovskite precursor, Electron. Mater. Lett. 14 (2018).

[18] K.P. Marshall, M. Walker, R.I. Walton, R.A. Hatton, Enhanced stability and efficiency in hole-transport-layer-free CsSnI3 perovskite photovoltaics, Nat. Energy 1 (2016).

[19] S. Shao, J. Liu, G. Portale, H.-H. Fang, G.R. Blake, G.H. ten Brink, L.J.A. Koster, M. A. Loi, Highly reproducible Sn-based hybrid perovskite solar cells with 9% efficiency, Adv. Energy Mater. 8 (2018).

[20] F. Wang, W. Geng, Y. Zhou, H.-H. Fang, C.-J. Tong, M.A. Loi, L.-M. Liu, N. Zhao, Phenylalkylamine passivation of organolead halide perovskites enabling high- efficiency and air-stable photovoltaic cells, Adv. Mater. 28 (2016).

[21] F. Hao, C.C. Stoumpos, R.P.H. Chang, M.G. Kanatzidis, Anomalous band gap behavior in mixed Sn and Pb perovskites enables broadening of absorption spectrum in solar cells, J. Am. Chem. Soc. 136 (2014).

[22] K. Nishimura, M.A. Kamarudin, D. Hirotani, K. Hamada, Q. Shen, S. Iikubo, T. Minemoto, K. Yoshino, S. Hayase, Lead-free tin-halide perovskite solar cells with 13% efficiency, Nano Energy 74 (2020).

[23] M.-G. Ju, J. Dai, L. Ma, X.C. Zeng, Lead-free mixed tin and germanium perovskites for photovoltaic application, J. Am. Chem. Soc. 139 (2017).

[24] A.K. Singh, S. Srivastava, A. Mahapatra, J.K. Baral, B. Pradhan, Performance optimization of lead free-MASnI3 based solar cell with 27% efficiency by numerical simulation, Opt. Mater. 117 (2021).

[25] K. Deepthi Jayan, V. Sebastian, Comprehensive device modelling and performance analysis of MASnI3 based perovskite solar cells with diverse ETM, HTM and back metal contacts, Sol. Energy 217 (2021).

[26] T. Minemoto, M. Murata, Theoretical analysis on effect of band offsets in perovskite solar cells, Sol. Energy Mater. Sol. Cells 133 (2015).

[27] T. Yokoyama, D.H. Cao, C.C. Stoumpos, T. Bin Song, Y. Sato, S. Aramaki, M. G. Kanatzidis, Overcoming short-circuit in lead-free CH3NH3SnI3 perovskite solar cells via kinetically controlled gas-solid reaction film fabrication process, J. Phys. Chem. Lett. 7 (2016).

[28] M. Shasti, A. Mortezaali, Numerical study of Cu2O, SrCu2O2, and CuAlO2 as hole- transport materials for application in perovskite solar cells, Phys. Status Solidi Appl. Mater. Sci. 216 (2019).

[29] H.S. Kim, C.R. Lee, J.H. Im, K.B. Lee, T. Moehl, A. Marchioro, S.J. Moon, R. Humphry-Baker, J.H. Yum, J.E. Moser, M. Gratzel, ¨ N.G. Park, Lead iodide perovskite sensitized all-solid-state submicron thin film mesoscopic solar cell with efficiency exceeding 9, Sci. Rep. 2 (2012).

[30] Y. Yang, M.T. Hoang, D. Yao, N.D. Pham, V.T. Tiong, X. Wang, H. Wang, Spiro- OMeTAD or CuSCN as a preferable hole transport material for carbon-based planar perovskite solar cells, J. Mater. Chem. A. 8 (2020).

[31] S. Guarnera, A. Abate, W. Zhang, J.M. Foster, G. Richardson, A. Petrozza, H. J. Snaith, Improving the long-term stability of perovskite solar cells with a porous Al 2 O 3 buffer layer, J. Phys. Chem. Lett. 6 (2015).

[32] Y. Wang, L. Han, Research activities on perovskite solar cells in China, Sci. China Chem. 62 (2019).

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