Perovskite Solar Cell Device Modeling and Performance Based on Resemblance with Thin Film Inorganic Solar Cells Structure

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Abstract. The Extraction of photons radiation absorption is the best in the solar energy for photovoltaic cells working operations. In recent years’ research in Perovskite solar cell technologies have been an extremely enchanting. perovskite Organic-inorganic materials are in an expand growth in power conversion efficiency.In laboratory level the materials of Inorganic Perovskite solar cell have been tested but their power conversion efficiency is still finite. This paper work mainly focused to finding absorber layer optimum condition and also to simulate proposed structured perovskite solar cell. For simulations we used SCAPS-1D software simulator. The structure proposed of the solar perovskite cell employs resemblance with supplementary solar inorganic cells like CdTe, Cu (In, Ga) Se2 and CIGS.CH3NH3PbI3-xClx is layer absorber preowned as extremely efficacious absorberfor its great attention. The open circuit voltage for a condition is 1.112 V obtain and more than the efficiency value is 25%. The outcome of work, purpose of contacts like forefront and rear has a significant effect on top of the fill factor and efficiency also. By varied the parameter of thickness in layers of divergent best outcome has been attained and also shown quantum efficiency (QE) and I-V characteristics.

Keywords: CH3NH3PbI3-xClx, Perovskite Solar Cell, Thickness, SCAPS-1D, Quantum efficiency, Conversion efficiency.

1. Introduction

In neoteric years’ research in solar Perovskite cell technologies have been an extremely enchanting for its tunable bang-gap energy and high absorption. It has acquired good efficiency and high open circuit voltage [1]-[6]. The absorption of the light can increase with buffer layer in the organic-inorganic solar perovskite cells commonly employ mesoporous TiO2 [2][3][5]. Replacement of TiO2 with ZnO use as buffer layer, the reason is ZnO has very good electrical properties for light absorption [7]. With CH3NH3PbI3-xClx as absorberand TiO2 as buffer layer the efficiency achieved is 22.7% in recent years, in simulation solar perovskite cell [8]. The development in level of efficiency, can be achieved for performance technique of solar Perovskite cell, but woefully there was data which is insufficient. For good grasp of performance technique, Widely used utensil simulation for inorganic other cells as silicon Cu2ZnSn(S,Se)4, CdTe[9][11][12][13][14] etc. By using the simulator for structural perovskite solar cells study in numerical analysis operation and performance. For study simulations, Solar Cell capacitance Simulator (SCAPS) we preowned in this paper work. The absorber layer thickness effect and concentration variation doping effect of the perovskite solar cell also examined. For best design performance analysis, the proposed structured perovskite solar cell is compared with real device.
2. **Structure of Solar Perovskite Cell**

To swotting the analysis mechanism of solar cell as shown below structure is used in simulator for ZnO as buffer layer.

![Diagram](image)

**Figure 1.** structure Proposed for solarperovskite cell

The structure Proposed for solar perovskite cell contain of Glassy conductive oxide (GCO)/absorber/buffer /hole transport material (HTM)/Au. The Glassy conductive oxide (GCO) is hinge on SnO2:F (FTO) material it has 4.4eV working function. In this simulation the buffer ZnO used which is regularly called as “blocking layer”. The CH3NH3PbI3-xClx is absorber used in this proposed structure and the (HTM) used is 9,9’ spirobifluorene (Spiro-OMeTAD),tetakis(N,N-p-dimethoxy-phenylamino)–2,2’,7,7’- respectively. This work mainly aims on analysis performance by doping concentration and thickness absorber changing and using buffer layer ZnO material. The structure perovskite solar cell has resemblance with the solar inorganic cell CIGS (GCO/CIGS /buffer/rear contact/substrate). The mechanism of the device is mostly form on optical variables, electrical variables and material variables of allsimulation layers.

3. **DeviceSimulation Parameters**

Solar Cell capacitance Simulator (SCAPS) simulator preowned for the study of device performance. The proposed structure cell shown in Figure 1. The specifications of simulationpreowned are grasp from literatures of divergent.Absorber layer and HTM specifications are grasp from the merit value [7]. The energy band gap diagram of the proposed structure cell is shown in Figure 2. From the energy band diagram of the proposedstructure cell can be make out that it can mop up more sunlight for less energy bandgap of layer in mop up. So, further holes and also the free electrons can produce which will conduct to produce additional current i.e.raises and fill factor and also the efficiency.
**Figure 2.** Proposed Structure Cell OperationEnergySimulation Device in Bandgap

The device parameters simulation preowned below shown. Table I encapsulate device of the parameter’s simulation preowned. From literature the optical and also properties of electrical are grasp [7] to HTM, GCO materials and also Absorber. The ZnO is a layer buffer and from another parameter’s considerations from the literature [6]. Parameters simulation are grasp from literatures in below shown Table I. The N_D and also N_A for donor concentration and also the acceptor. E_G is energy bandgap z is electron affinity, Sr is relative permittivity, μ_p and μ_n are for hole mobility and electron respectively. The valence band offset and conduction band offset among absorber/buffer layers are stick to be 0.0 eV by customize the electron affinity of the HTM and buffer respectively. Best option selection of HTM and also the buffer considerations.

As shown thermal velocity in simulation the of hole and also electron is $10^7$ cm/s. Value $10^5$ is set to be levant value used for absorption constant. The set value of $10^{13}$ cm$^{-3}$ is used for the density and absorber-type carrier. So, this kind of layer is nearly intrinsic. For attain further practical result in each layer we have calculated defect density N_t. The set value for absorber layer N_t is $2.5 \times 10^{13}$ to which dedicate the diffusion carrier span of holes and also the electron of value 1.0 μm. The inadequacy set is energetic distribution and also neutral type Gaussian with the 0.1 eV value characteristic. Hole’s and also electron for selected area for cross section is $2 \times 10^{-14}$ cm$^2$. Under standard AM1.5 G by setting temperature 300 K and photon flux the simulation was done.

**Table I.** Solar Perovskite cell Parameters preowned in the process of simulation.

| Parameters | GCO | ZnO | CH3NH3PbI3-xClx | Spiro-OMeTAD |
|------------|-----|-----|-----------------|--------------|
| E_G (eV)   | 3.5 | 3.3 | 1.55            | 3.0          |
| Thickness (nm) | 200 | 80  | 600             | 350          |
| N_A (cm$^{-3}$) | --- | --- | ---             | 2$ \times 10^{18}$ |
| N_D (cm$^{-3}$) | 1$ \times 10^{18}$ | 5$ \times 10^{17}$ | 1$ \times 10^{13}$ | --- |
| N_e (cm$^{-3}$) | 2.2$ \times 10^{18}$ | 1$ \times 10^{19}$ | 2.2$ \times 10^{18}$ | 2.2$ \times 10^{18}$ |
| N_v (cm$^{-3}$) | 1.8$ \times 10^{19}$ | 1$ \times 10^{19}$ | 1.8$ \times 10^{19}$ | 1.8$ \times 10^{19}$ |
| Sr         | 9.0 | 9.0 | 6.5             | 3            |
| μ_n (cm$^2$/Vs) | 20  | 50  | 2               | 2$ \times 10^{-4}$ |
| μ_p (cm$^2$/Vs) | 10  | 5   | 2               | 2$ \times 10^{-4}$ |
| N_t (cm$^{-3}$) | 1$ \times 10^{15}$ | 1$ \times 10^{15}$ | 2.5$ \times 10^{13}$ | 2.5$ \times 10^{13}$ |
| X(eV)      | 4.0 | 3.9 | 3.9             | 2.45         |
4. **Analysis of Results and Discussions**

The Efficiency achieved is greater than 25% with this simulation process. The Voltage value 1.112 V is for high open circuit condition equipped that show reproduction successful of practically attain results [3]. Percentage of 82% is attained in Fill Factor that show superior inclusion in the layer of absorber. The Perovskite Solar Cell characteristics of I-V curve is shown under in Figure 3. Table I parameters calculations.

![Figure 3. Perovskite Solar Cell I-V characteristics curve](image)

To achieve better efficiency the important consideration specifications is absorber layer thickness. By tremendously change in the specification’s performance within a necessary highness and succeeding that efficiency is decreased due to the absorber thickness increasing condition. The quality of absorber i.e. with increasing length for carrier diffusion is enough for quality collection of photo-generated arrier. The working of solar cell specifications much contact layers thickness with the absorber. Alter the layer of thickness absorber there will be changes in divergent parameters are shown below in Figure 4.

![Figure 4. Result of Simulation a) Open Circuit Voltage and Current Density b) Fill factor and Efficiency; Working functions in Layer of absorber thickness](image)

In Figure 4. a) it is observed that with the raise in the thickness absorber layer the parameters working conditions different and also the solar perovskite cell acquires finer results. With the thickness improvement, the solar perovskite cell incorporates better photon energy that put in concert further in absorber layer of carriers. The voltage for open circuit acquires lofty with slighter layer thickness and shrink with the raise in layer of thickness. The open circuit voltage (V_{oc}) becomes drenched, After thickness of 700 nm. The current density also drenched after achieve a value about 25 mA/cm² and the maximal value is 25.84 mA/cm². For absorber layer thicker the current density is
shrinking sligher because of depletion thicker of the absorber layer in electric field. If the absorber layer standard is not finesufficient, the thickness increase in layer absorber it will affect current in extra recombination. Thus, compact absorber layer thickness is required but fewer thickness layer reduce the cohort current. In Figure 4, b) exhibit that the FillFactor reduces single with the improvement of in the thickness layer absorber. It is normally happening in every layer of mop up even if it’s a layer of quality with fine mop up. The structure of the cell appears maximal FillFactor for every 50 nm thickness layer and reduces in tiny scale factor behind that. This only happens because the voltage for forward bias turndown the electric field current together with theenlarge in recombination of current in mop up. The curve of efficiency trend is mostly indistinguishable to FillFactor. With the rise in the absorber thickness layer the efficiency reduces in compact values after 600 nm and after that it will saturated.

The Figure 4 represent the harvest of parameters performance as a purpose of variation thickness and specify the superlative thickness of the layer about the absorber. The concert is drenched almost with 600 nm these is nearlinnear to the observation in practically. The absorber layer with quality content is good for good contribution of current in electric field with lower condition. Then noble centering of the absorber layer also has foremost thumb on efficiency parameter. The efficiency of the cell extends its topmost value when it is almost material like intrinsic. If the Concentration doping expand it leads to the reduces efficiency shown in the Figure 5. In our work we utilize concentration doping value $1 \times 10^{13}$ cm$^{-3}$ which relinquish finer performance and also appearresemblance.

![Figure 5. Doping Concentration for swap in efficiency and fill factor](image)

The efficiency of quantum is extremely major parameters that reveal the stranded of active layer in solar perovskite cells [15]. The structure of the cell the measured parameters has eminent quantum efficiency described in Figure 6. The efficiency of quantum versus wavelength curl is specified in Figure 6.

![Figure 6. Device Simulation for QE characteristics strategic](image)

The interpretation simulation in this paper will guide the required absorption of the working structure it will assist in future development in production of solar perovskite cells.
5. Conclusion

The work in this paper device for simulation of solar perovskite cells was carry out make use of simulator SCAPS-1D extensively cast off for solar cells for inorganic. In this paper the study we focused on material that is ZnO which also exhibit tremendously homogeneous aspect make use as TiO$_2$. Handle ZnO as buffer acquire very good efficiency 25.79% with 80% FillFactor of specify finer standard as material for buffer. The result simulation of solar perovskite cell will assist in more advance in performance of the organic cells. We distinguish the outcome of thickness in absorber layer on the parameter’s performance like $I_{SC}$, $V_{OC}$, FF and $\eta$ of the solar perovskite cell. The outcome exploration appear significance of thickness in absorber layer on the parameter’s performance.

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