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SCAPS-1D Simulation of Inverted Planar Perovskite Solar Cell with SnO_2 as Window Layer

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Abstract

In this paper, the film solar cell is simulatedusing SCAP -1D software in an extremely efficient method. Planar topologies are becoming more and more common in natural-terminal halide perovskite solar cells (PSC) or PV (photovoltaic) cells research sectors due to their easier fabrication method and low temperature processability useful for flexible and tandemstructures. The majority of charge transportmaterials examined for p-i-n or inverted planar cells are organic, which have weak conductivity, poor chemical stability, and greater processing costs. Due to their ease inovercoming the disadvantages of their organic counterparts to a certain extent, solution processed inorganic metal oxide transport layers are becoming increasingly popular. Using all-metal oxide transport layers, a straightforward yet thorough 1D simulation investigation of inverted planar PSC is described in this work.

Keywords

NiO_x, $MAPbI_3$, SnO_2, SCAPS-1D

Introduction

Since its launch in 2009, PSCs [1] have gained attention in the PV world. PSC's efficiency increasedquickly over time, rising from 3.81% in 2009 to19.7% in 2017. In sensitized solar cell designs,initial PSCs are described. Later solid hole conductors, such as 2,2′,7,7′-tetrakis(N,N-di-p-methoxyphenyl-amine) and 9,9′-spirobifluorene(spiro-MeOTAD) [2], are utilized, and reasonable efficiencies are achieved. Prior to sensitized excitonic solar cells, which serve simply as a scaffold for the deposition of perovskite in later device designs, earlier PSCswere reported in a semiconducting/insulating mesoporous electrode configuration. This showed how perovskite PV cells vary from conventional sensitized excitonic PV cells andhow PSCs do not require electron injection to electron transport material. Later, perovskites with planner junctions are also researched and developed to pretty high efficiencies.

Experimentation

Program for simulation

A simulation tool called SCAPS is used tosimulate the characteristics of one-dimensionalsolar cells. Controlling every aspect of the device and the material is advantageous. The model's input parameters can be changed, and trends in current and the voltage J and V, respectively. QE statistics can be quantified. Numerous software tools, such as AMPS-1D, ASA PC-1D [3]. Due to the simulation results for thin film solar cells being in close accord with the current experimental findings, SCAPS-1D has become very popular. Therefore, we employ this tool inour endeavors.

Numerous alternative current and direct current electrical metrics, including J to V, Ct o V, Q-E, and others, can be determined using SCAPS under varied AM sun spectrum values and illumination conditions. SCAPS also calculates the electric shunt impedance. It establishes in generation, recombination profile frequency of the capacitance spectroscopy, capacitive V spectroscopy, carrier current density, V_{OC}, J_{SC}, FF, QE, and other parameters.

Structure

In this paper, NiO_x [4] perovskite [3], and SnO_2 as the absorber level, buffer level, and window level, respectively, in this experiment as depicted in figure 1. With a sun-like illumination capacity of 1000 W/m² and AM 1.5 global spectrums, lights have been illuminated from the front contact. Using the SCAPS-1D package, all layer parameters, including band gap (BG), thickness, mobility of, and in or di-electric value were entered.

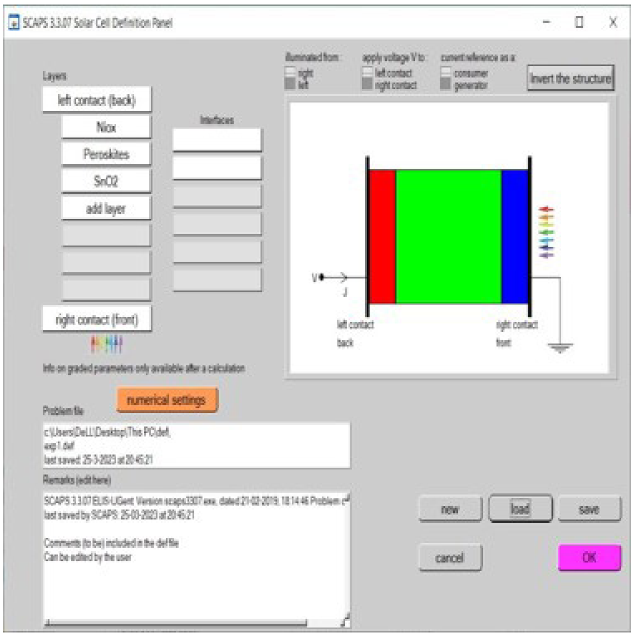

Figure 1: Diagram of inverted planar PSC or PV cell with SnO_2 as window layer.

Results and Discussion

The term "band gap" or "BG" in the context of semiconductors refers to a fundamental material property. It represents the least energies required to excite an electron from the valence band, which is filled with electrons, to the conduction band, which is vacant and allows for electron mobility. Figure 2 presents J-V characteristic and as a function of BG (eV) values. Figure 3 presents output characteristics. Table 1 presents optical properties of different levels used in SCAPS (electrical).

Conclusion

The SCAPS-1D software was utilized in this study for the design and analysis of an inverted planar perovskite PV cell.

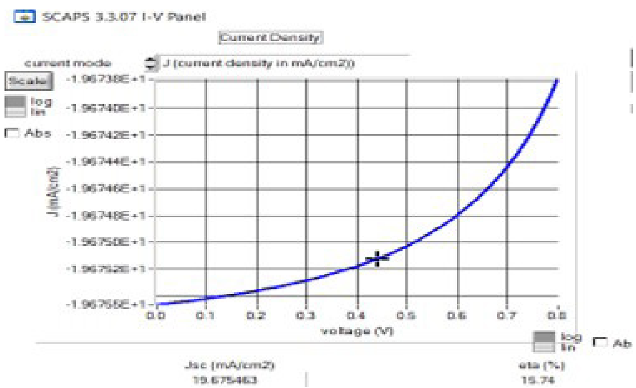

Figure 2: J-V characteristic and as a function of BG (eV) values.

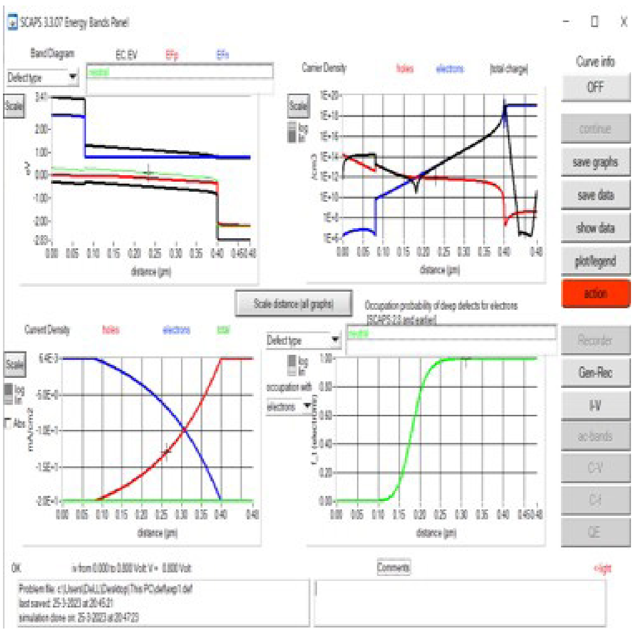

Figure 3: Output characteristics.

Table 1: Optical properties of different levels used in SCAPS (electrical).

Material properties	Absorber layer (NiO_x)	Buffer layer ($MAPbI_3$)	Window layer (SnO_2)
Thickness	80 (nm)	320 (nm)	80 (nm)
Energy BG (eV)	3.7	1.6	3.6
Electron affinity (eV)	2.1	4.1	3.93
Dielectric permittivity	10.7	10	8
CB effective density of state (cm^{-3})	2.0×10^{19}	2.0×10^{18}	3.16×10^{18}
VB effective density of state (cm^{-3})	1.0×10^{19}	1.0×10^{18}	2.5×10^{19}
Electron thermal velocity (cm/s)	1.0×10^{7}	1.0×10^{7}	1.0×10^{7}
Hole thermal velocity (cm/s)	1.0×10^{7}	1.0×10^{7}	1.0×10^{7}
Electron mobility (cm^2/Vs)	12	100	20
Hole mobility (cm^2/Vs)	2	10	10
N_D	0	1.0×10^{9}	1.0×10^{19}
N_A	1.6×10^{14}	1.0×10^{9}	0

The buffer layer ($MAPbI_3$) of the PSC was investigated to enhance its efficiency. The simulated device parameters aligned well with our experimental findings. The device featured a conventional p-i-n junction arrangement, as per the simulation results. Various aspects were examined, including the optimal absorber thickness, the impact of absorber quality, interface defect density, VBO and CBO effects,and interface contact at front and back electrodes. Based on our findings, we concludethat a BG of 1.4 eV would be ideal for the CIGS layer with SnO_2 as the window layer. Photon production and recombination peaked ata distance of two meters. The success of producing invert planar perovskite PV cells with a SnO_2 window layer will be greatly influenced by the guidance offered by these models.

Acknowledgements

None.

Conflict of Interest

None.

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