Transmission of Sound via a Perovskite Solar Cell

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Abstract—T Perovskite solar cells are becoming a dominant alternative for the traditional solar cells reaching an efficiency of 25.2% in a short span of twelve years (2008-2020). Here, we are going to describe a simple process to 'put a voice on a laser beam' and transmit it over a distance via a perovskite solar cell. This process considered as a fascinating example of amplitude modulation of light using sound vibrations. Therefore, the design and simulation of the perovskite solar cell will be described in details in this work. This design is concerned about the lead-free based perovskite solar cell model with the total proposed structure "Metal contact /PEDOT:PSS/ CH3NH3SnI3/ ZnO/ SnO2:F/ Metal contact". To study the efficiency and the performances of a solar cell, the use of well-known software so-called SCAPS-1D is undertaken to perform the system simulation. The obtained results show also the influence of the doping level of the HTM layer and absorber layer thickness on the performance of the device. So far, only the simulation part has been validated. Despite the cost-effect of the system prototype, however, it could be implemented here in the laboratory as perspective work.

Keywords— Transmission, Perovskite, Laser, PEDOT:PSS, Modulation, SCAPS-1D

I. INTRODUCTION

Telecommunications are defined as the remote transmission of information using electronic and computer-based means and wired, optical or electromagnetic transmission. Transport information from one point to another which establishes the establishment of a series of conventions concerning transmission media, physical quantities linked to propagation and a study on signal propagation

The audio source playing the music delivers electrical signals to a laser via a cable. These signals are made up of irregular and rapid variations of a small electrical voltage. They correspond exactly to acoustic waves (variations in atmospheric pressure) the directly connected speaker would emit and our ears would pick up if we were near this speaker.
The laser therefore receives a voltage which varies rapidly over time. A small value of this voltage causes the emission of a weak laser beam. When the tension increases the intensity of the ray also increases. The variations in the voltage delivered by the audio device are converted into analogous variations in the intensity of the laser beam.
The perovskite solar cell to which the laser beam is directed produces a higher current when the beam is brighter, and a lower current when the beam is weaker. The variations in the intensity of the laser beam are converted into analogous variations in the intensity of the current produced by the perovskite solar cell.
Finally, the current of the cell passes through the speaker, whose membrane performs vibrations corresponding exactly to the variations of the current. Acoustic waves corresponding to these vibrations arise in the ambient air. These acoustic waves are identical to those which a speaker directly connected to the audio device would have produced. we hear the music read by the audio device. Fig. 1 shows the all things we'll need.

Fig.1 Things we'll need.

DOI: 10.46300/91010.2020.14.12

II. DEVICE STRUCTURE AND SIMULATION

II.1. EMETTEUR :

Remove all the batteries from the laser and connect a clip wire inside the laser pointer where the battery touched, after connecting the transformer side between the battery and the laser. Finally connect the headphone socket to the second side of the transformer (coil) and make sure the radio is off and the laser is on. Fig.2 shows the audio jack connection in the mobile phone.

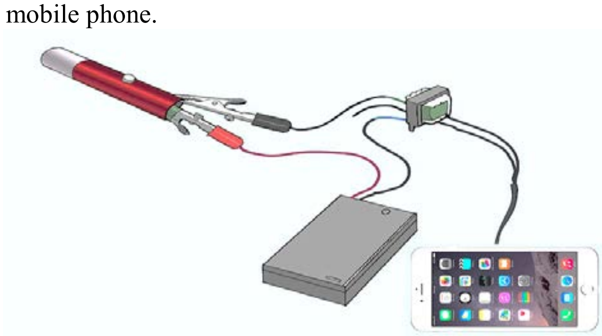

Fig.2 The audio JACK connection in the mobile phone.

II.1.1. AUDIO JACK :

In electronics, a j ack is normally a co axial electrical connection, or else the base, the female element receiving the socket. In some cases, "jack" alternatively designates one or other of the elements: "male" plug or "female" socket, in a set of paired connectors.

Fig.3 From left to right: jack 2,5mm, 3,5 mm et 6,35

II.1.2. TRANSFORMER/ COIL :

A coil, inductor, solenoid, or self-inductance is a common component in electrical engineering and electronics. A coil consists of a winding or winding of a conductive wire possibly around a core of ferromagnetic material. This core is also called in common parlance "ferrite core". The term coil can also designate a device intended to produce high voltages.

Fig.4 Coil

Uses :

- Ensure the elimination of interference from an electrical supply or an analog signal
- The coil acts as a signal amplifier.
- Create a f ilter for a p articular frequency or frequency band.
- Smooth direct currents (noise is eliminated).

II.1.3. LASER:

The acronym laser stands for “light amplification by stimulated emission of radiation.” Lasers work as a result of resonant effects. The output of a l aser is a co herent electromagnetic field. In a co herent beam of electromagnetic energy, all the waves have the same frequency and phase.
In a b asic laser, a ch amber called a cav ity is designed to internally reflect infrared (IR), visible-light, or ultraviolet (UV) waves so they reinforce each other. The cavity can contain gases, liquids, or solids. The choice of cavity material determines the wavelength of the output. At each end of the cavity, there is a mirror. One mirror is totally reflective, allowing none of the energy to pass through; the other mirror is partially reflective, allowing approximately 5% of the energy to pass through. Energy is introduced into the cavity from an external source; this is called pumping [1].

II.2. RECEIVER :

The receiver is the simplest part. You simply connect the perovskite solar cell to the microphone jack, and plug it into the amplifier or stereo phono input. It does not matter which way the wires are connected to the perovskite solar cell. Fig.5 shows the general diagram of the receiver part.

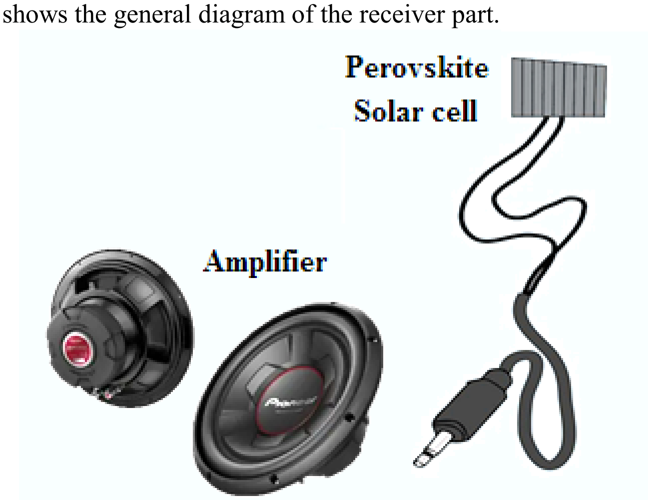

Fig.5 General diagram of the receiver part.

II.2.1. PEROVSKITE SOLAR CELL:

The proposed perovskite solar cell structure is “metal contact /TCO/ZnO(n) / CH3NH3SnI3 / PEDOT:Pss(p) / metal contact.” In this solar cell, a planer p-i-n heterojunction architecture with the layer configuration of n-doped ZnO and p-doped PEDOT: Pss layers are used as electron transport layer and hole transport layer, respectively. The cell is illuminated schematically as shown in Fig.6.

ISSN: 1998-4316

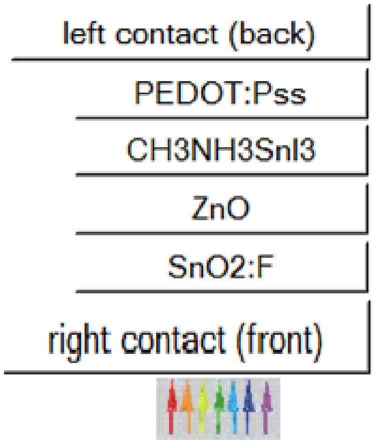

Fig.6 Schematic representation perovskite solar cell (PSC)

a- Simulation parameters:

The values of device and material parameters used in SCAPS-1D for simulation that are adopted from theories and literatures are shown in the following Table 1. Effective conduction band and valence band densities of PEDOT:Pss are 2.20 x 10^{17}cm^{-3} and 1.80 x 10^{19}cm^{-3}, respectively, and are considered in this proposed structure [08].Thermal velocities of the electron and hole of ZnO are both set to be equal to10^{7}cm/s for this structure. The defects are set to be single and neutral defect with a total density of 1 x 10^{15} cm^{3}, located at 1.6 eV above the top of valence band (Ev). The constant A(α), is assumed to be as 10^{5} to obtain the absorption coefficient, alpha (α), where $\alpha = A\alpha * (hvEg)^{1/2}$ [08].

Table 1. Simulation parameters of CH3NH3SnI3 PSC

Parameters	*SnO2 :F*	*ZnO*	*CH3NH3SnI3*	*PEDOT*
Thickness(nm)	500	50	900	200
E_g *(ev)*	3.5	3.2	1.3	3.6
χ *(ev)*	4	4.26	4.17	1.57
εr	9	9	8.2	3
N_c (cm^{-3})	2.20 x 10^{18}	2.00 x 10^{18}	1.00 x 10^{18}	2.20 x 10^{17}
N_v (cm^{-3})	1.80 x 10^{19}	1.80 x 10^{19}	1.00 x 10^{18}	1.80 x 10^{19}
μ_e (cm^2/Vs)	20	200	1.60	10
μ_h (cm^2/Vs)	10	5	1.60	400
N_D (cm^{-3})	2.00 x 10^{19}	1.50 x 10^{17}	-	-
N_A (cm^{-3})	-		1.50 x 10^{16}	2.00 x 10^{19}
References	[04,10,11,]	[07,08,09]	[03,05,06]	[12,13]

b-Results and discussion.

The proposed structure is simulated in SCAPS simulating software tool, considering all the parameters of defect states to make the structure more realistic in physical environment. The efficiency of this perovskite solar cell is achieved 24.17% of efficiency, along with the short-circuit current density (Jsc) of 41.72 mA/cm^2 and the open circuit voltage (Voc) of 0.7853V.

The fill factor of this solar cell is observed as 73.77%.

c- Influence of doping of the active layers on the pv parameters.

The doping level of the HTM (PEDOT:Pss) varied and optimized the performance of the proposed solar cell. Figure 05 shows the relation between the doping level of PEDOT:Pss and the efficiency of the cell. It is observed that the efficiency of the cell is increased with increasing doping level and the optimum level of Acceptor doping concentration 2.0x10^{19}cm^{-3} is considered for PEDOT:Pss layer.

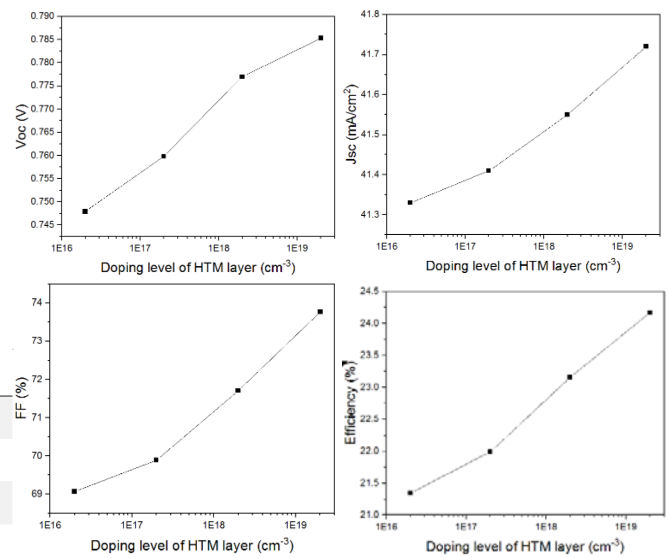

Fig.7 Representing the variation of solar cell parameters with the doping level of HTM layer

d- Influence of absorber layer thickness on solar cell characteristics with different htm layer.

The simulated parameters such as PCE, FF, Jsc, Voc of the CH3NH3SnI3 solar cells, with varying perovskite thickness is as shown in Figure 06. Maximum PCE of 24.17% with Jsc=41.72 mA/cm^2, FF= 73.77%, Voc=0.7853 V is achieved when the thickness reaches 900 nm.

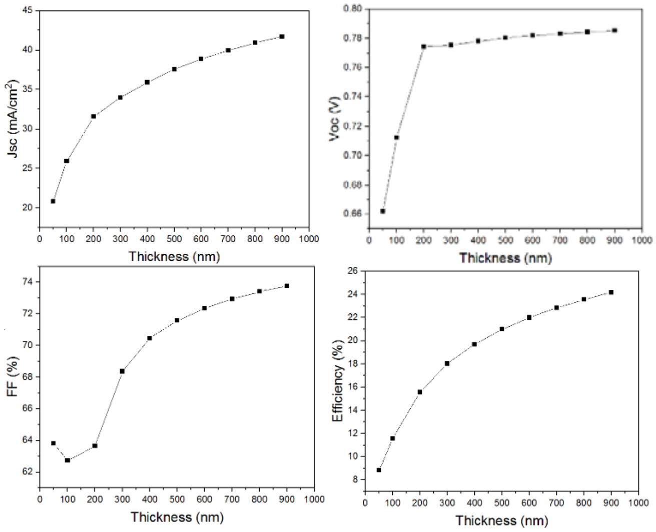

Fig.8 Representing the variation of solar cell parameters with the thickness of absorber layer

Increases of efficiency with increasing thickness representing the increase in the generation of the electron, hole pairs in the absorber layer. The main reason for the increase of efficiency with the increase of thickness is the increase of optical density.

II.2.2. Amplifier :

A speaker converts electrical signals into sound waves, It receives the audio signal (electrical energy), which it transforms into mechanical energy. Indeed, the voice coil of the loudspeaker has encountered moving signal audio signal is received. Then the loudspeaker transforms this mechanical energy into acoustic energy, because the membrane. This is connected to the voice coil and therefore reproduces the same movements as the latter. It is by moving under the action of the voice coil that the membrane creates an acoustic pressure, sound.

In this work, Connect the solar cell to the amplifier or stereo, and turn the volume up until you hear a hissing noise, then turn it down slightly until the hiss isn't noticeable. The volume control should be high, corresponding to an ear-splitting level if it was playing music.

III. CONCLUSION

The lead free CH3NH3SnI3 perovskite solar cells with different parameters are analysed by using one-dimensional device simulation. In this work ZnO is proposed as the electron transport layer (ETL) for lead free CH3NH3SnI3 based perovskite solar cells and the performance of the cell is also studied. The thickness and doping level of PEDOT:Pss layer are varied to study the optimized performance. Simulated result reveals that the efficiency of this solar cell is 24.17%. In future, the results of this proposed structure need to be validated in this new wireless technology to transmit the data or sound signal from one section to other section through the laser beam of the system.

ACKNOWLEDGMENT

Authors great fully convey their thanks to the association of renewable energy and sustainable development of Sidi Bel Abbes.

References

[1] Navneesh Singh Malhotra, Harman Malhotra, Transmission of Sound Using Lasers, International Journal of Advanced Research in Computer Science & Technology, Vol. 2, Issue 3 (July - Sept. 2014)

[2] Umari P, Mosconi E and De Angelis F 2014 Sci. Rep. 4 4467

[3] Chen Q Y, Huang Y, Huang P R, Ma T, Cao C and He Y 2016 Chin.Phys. B 25 027104

[4] Noel N K, Stranks S D, Abate A, Wehrenfennig C, Guarnera S,Haghighirad A A, Sadhanala A, Eperon G E, Johnston M B, Petrozza A M, Herz L M and Snaitha H J 2014 Energy Environ. Sci. 9 3061

[5] Hao F, Stoumpos C C, Cao D H, Chang R P H and Kanatzidis M G 2014 Nat. Photon. 8 489

[6] Y.-J. Lee, D. S. Ruby, D. W. Peters, B. B. McKenzie, and J. W. P. Hsu,"ZnO nanostructures as efficient antireflection layers in solar cells,"Nano Letters, vol. 8, no. 5, pp. 1501–1505, 2008.

[7] M. Hossain, O. Daif, N. Amin, F. Alharbi, and N. Tabet,TMS Middle East - Mediterranean Materials Congress on Energy and Infrastructure Systems (MEMA 2015), 2013.

[8] S. Bansal and P. Aryal, "Evaluation of new materials for electron and hole transport layers in perovskite-based solar cells through SCAPS-1D simulations," in 2016 IEEE 43rd Photovoltaic Specialists Conference (PVSC), Portland, OR, USA, June 2016.

[9] Kemp K W, Labelle A J, Thon S M, Ip A H, Kramer I J, Hoogland S and Sargent E H 2013 Adv. Energy Mater. 3 917

[10] Hao F Stoumpos C C Chang R P H and Kanatzidis M G 2014 J. Am.Chem. Soc. 136 8094.

[11] Rutledge SA, Helmy AS. Carrier mobility esnhancement in poly(3,4-ethylenedioxythiophene)-poly (styrenesulfonate) having undergone rapid thermal annealing. Journal of Applied Physics. 2013, 114(13):133708-1–5. Crossref

[12] Mihailetchi VD, Van Duren JK, Blom PWM, Hummelen JC, Janssen RAJ, Kroon JM, Rispens MT, Verhees WJH, Wienk MM. Electron transport in methanofullerene. Advanced Functional Materials. 2003; 13(1): 43–6. Crossref

[13] L. Huang, X. Sun, C. Li, R. Xu, J. Xu, Y. Du, Y. Wu, J. Ni, H. Cai, J. Li, Sol. Energy Mater. Sol. Cells 2016, 157, 1038.

Contribution of individual authors to the creation of a scientific article (ghostwriting policy)

Author Contributions: Please, indicate the role and the contribution of each author:

Abdelhadi SLAMI carried out the simulation and the optimization.
Abdelhadi SLAMI has organized and Yacine AYACHI AMOR executed the experiments of the article.