Investigating the Performance Parameters of Nanostructure Lead Free Perovskite Solar Cell

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Abstract

This paper describes how an organic/inorganic nanostructure perovskite photovoltaic solar cell is simulated and optimized. The simulated solar cell consists of a sandwiching of ETL/ Perovskite/Cu_2O with Cu_2O Hole Transportation Layer (HTL) and as a ETL layer different materials like TiO2, ZnO, SnO_2, CdZnS , C60, Ws2 PCBM, Cds and IGZO being the electron transport layer (ETL) and).The experimental results in the study effort were in excellent agreement with the device features and various materials are modeled. The gadget had a typical n-i-p intersection configuration. The optimum absorber thickness effects of absorbing quality, interface defect density, ETM & HTM effects and the front and rear interface contact electrodes were all investigated. $CH_3NH_3SnI_3$, HTL/ $CH_3NH_3SnI_3$, and ETL/ $CH_3NH_3SnI_3$ are the main characteristics of the open circuit voltage. The current is primarily measured by the thickness of $CH_3NH_3SnI_3$ in short-circuit systems, since both the VBO (Valence Band Offset) and the LBO (Leading Band Offset) values are controlled. The front-back electrode interface significantly affects the filling factor. It is worth noting that in ideal conditions, power conversion efficiency is reached. Real devices with a PCE were produced after the initial optimization of the $CH_3NH_3SnI_3$ absorber layer preparation. From a theoretical and experimental standpoint, it may be useful in recommending and enhancing device strategy.

Keywords-SCAPS-1D, Perovskite, ETL, HTL, Lead free, $CH_3NH_3SnI_3$

Introduction

Energy is required for humans to exist. This energy is generated continuously by technologies that have evolved throughout time. The resource that is being utilized is one of the most important aspects that describe energy production. Renewable and Non-renewable resources are the two types of resources accessible. All resources with immediate regeneration, or endless sources of energy, are contained in the first group. The primary sources of renewable energy include solar, wind, hydroelectricity, geothermal, and tide (H. Ibliha, M.S Thesis "Solar Cells with Nove l Buffer Layers," University of Missouri-Kansas City, 2015). The second group includes all energy sources such as petroleum, natural gas, and coal that may be used in a finite amount or with a generation time long enough to be considered finite in quantity (M. K. Siddiki, Ph.D Thesis "All Solution Processible Polymer Multijunction Solar Cells," South Dakota State University, 2012.). The amount of energy that can be recovered from these resources is frequently significant.

Although the energy gained from these resources is currently lower than that gained from non-renewable sources, the prospect of a potentially limitless supply of energy has piqued interest, particularly considering the potential depletion of non-renewable sources (M. De Bastiani, Ph. D. Thesis "The Stability of Third Generation Solar Cells Università Degli Studi Di Padova," October 2016.). Industries, scientists, and academics have collaborated throughout the years to find a solution to the ever-increasing energy demand. The outcome of research and development, followed by industrialization, is modern energy sources that are used in daily life. Among the numerous nonrenewable and renewable energy sources, solar energy has always aroused people's interest.

Photosynthesis demonstrates that the energy given by the Sun in the form of light is something natural. The solar cell's basic premise is to convert sunlight into a useable source of energy. The solar cell is an optoelectronic device that can convert both artificial or ambient light and direct Sun light into electric current. The term light, on the other hand, refers to the electromagnetic radiation released by the Sun on the Earth's side. Like a black body with an estimated temperature of 5777° K, the Sun generates electromagnetic waves over the spectrum of frequencies (C.Spiegel,"Horizon Energy Curriculum." [Online]. Available:Https://www.Horizoncurriculum.Com /Chapter-2 / 2-1-Introduction/.).

Solar Cell Device

When photons clash with atoms, massive quantities of energy are released. Energy from the sun comes to Earth in small particles called photons. When it stands in direct sunlight, your skin feels heated because photons have travelled all the way from the Sun and are colliding with the atoms in your skin to generate heat. Solar cells are also known as photovoltaic cells because they generate electricity from light.

A photovoltaic cell captures a photon from the sun using semiconductors, which are specific metals. When photons collide with semiconductors, they can generate electricity rather than heat. It can generate energy from sunlight by employing semiconductors to construct solar cells. In a solar cell, silicon is a common semiconductor. When a photon collides with silicon, it can occasionally liberate an electron. The solar cell catches and drives all the electrons emitted by the silicon in one direction, resulting in an electric current (Bagher, A. M., Vahid, M. M. A., & Mohsen, M. (2015). "Types of Solar Cells and Application". American Journal of Optics and Photonics, 3(5), 94-113.).

Fig. 1 shows how solar cells are frequently utilized on spaceships such as the International Space Station. These solar cells are also employed on the earth's surface, which receives a lot of sunlight all year. The lighter a solar cell gets the more electricity generates (Gordillo-Guzmán, G., Virgüez-Amaya, O., Otálora-Bastidas, C., Calderón-Triana, C., & Quiñones-Segura, C. (2020). "Synthesis and Optimization of Properties of Thin Films of FA-X (MA1-X) PbI3 Grown by Spin Coating with Perovskite Structure to Be Used as Act) Fig. 1 depicts the solar cell device's external structure.

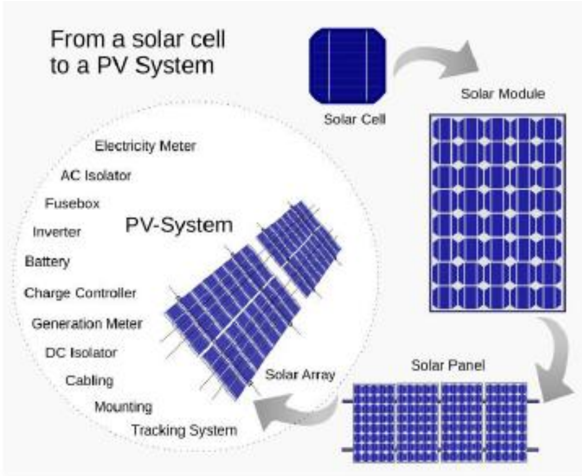

Fig. 1Solar cell to PV system (Gordillo-Guzmán, G., Virgüez-Amaya, O., Otálora-Bastidas, C., Calderón-Triana, C., & Quiñones-Segura, C. (2020). “Synthesis and Optimization of Properties of Thin Films of FA-X (MA1-X) PbI3 Grown by Spin Coating with Perovskite Structure to Be Used as Act)

The internal structure of the device is shown in Fig. 2 which shows the way solar cell operates the induction of light into an active layer and the generation of electrons and holes transfer to a transport layer following this, and finally the collection of photo current in the electrode (NationalRenewableEnergyLaboratory,“PhotovoltaicResearchNREL.”[Online].Available:Https://www.Nrel.Gov/Pv/.)

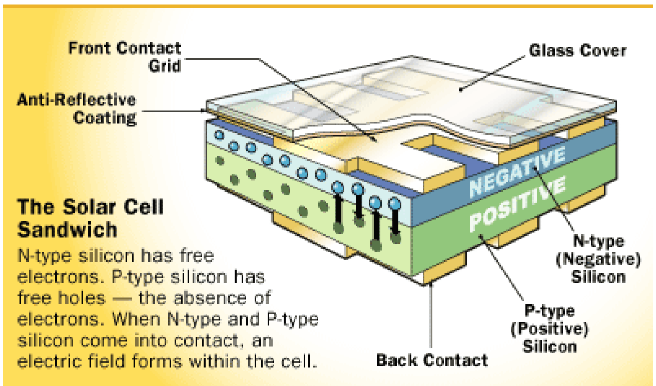

Fig. 2Working Architecture of Solar Cell Device (NationalRenewableEnergyLaboratory,“PhotovoltaicResearchNREL.”[Online].Available:Https://Www.Nrel.Gov/Pv/.)

The generation of electricity does not arise from the buildup of light-generated carriers. A voltage as well as a current must be created to create electricity. A mechanism known as the "photovoltaic effect" generates voltage in a solar cell. The p-n junction collects light-generated carriers, which causes holes to migrate to the p-type side and electrons to the n-type side of the junction. There is no charge accumulation in a short circuit since the carriers escape the apparatus as the current produced by light. If the light transporters are not let out the solar cell, the compilation of light-generated carriers generates an equivalent rise in holes in the p-type material and an enhance the electrons on the n-type side of the p-n junction. This charge separation reducing the net electric field and causes a diametrically opposite electric field at the connection. Because the electric field acts as a barrier to the forward bias diffusion current's passage, lowering the electric field raises the diffusion current. Then there was a voltage across the p-n junction, indicating a new equilibrium. The solar cell current differs among the current and the IL in the forward direction. The forward bias of the junction grows under open circuit circumstances until the point where the net current is zero and the light-generated current is perfectly stable by the forward bias diffusion current. The "open-circuit voltage" is the voltage necessary to bring these two currents into balance (C. Honsberg and and S. Bowden, “PVEducation.” [Online]. Available: http://Pveducation.Org/Pvcdrom/Solar-Cell-Structure).

Working Principle of Typical Silicon (Si) Solar Cell

Solar cells are electronic devices that change sunlight directly into electricity. To generate energy (electricity), when sunlight falls on the solar cell then it generates a voltage and an electric power. This procedure necessitates two things: first, the passage of that elevated energy electron from the solar cell onto an exterior circuit and second, a material in which light absorption elevates an electron's energy state. Therefore, dissipating this electric power in the outward circuit, the electron reverts to the solar cell. The principle for photovoltaic energy transformation can be met using several processes and materials. But in practically, all photovoltaic energy transformation employs semiconductor materials in the way of a p-n junction.

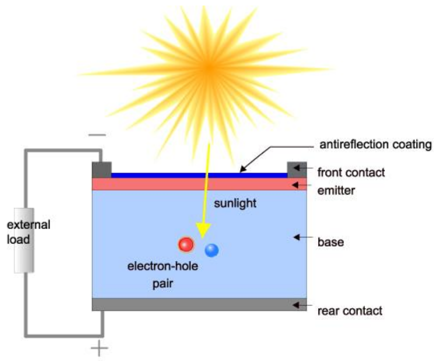

Fig. 3. Cross section of a Solar cell (C. Honsberg and and S. Bowden, “PVEducation.” [Online]. Available: http://Pveducation.Org/Pvcdrom/Solar-Cell-Structure)

Fig.3 show a solar cell that is the "light-generated current" is created through 2-stages. The first stage is the concentration of incoming photons which findings in the formation of electron-hole set. If the band gap has lower energy than the incident photon in the solar cell and electron-hole pairs would be formed. The holes (in n materials) and the electrons (in materials of p-type) are meta-stable and only occur for a period equal to the minority carrier life cycle instead of recombining.

The general function of a solar cell is:

- The production of carriers produced by light.

- The collection of light-produced carriers generates a current.
- A huge voltage is generated across the solar cell.
- Load dissipation and resistance to parasite.

The light-produced electron-hole pair is lost if the carrier recombines, and no power or current can be created. By utilizing a-p-n junction to spatially split the hole and the electron, a second mechanism, the collection of these carriers by the p-n junction, precludes this recombination. At the p-n junction the action of the electric champ separates the carriers. The electrical field on the junction when the light produced minority carrier reaches the p-n junction sweeps it across the junction, making it a majority carrier. The light-generated current pass across the external circuit if the base is connected (short circuit in solar cell) and solar cell's emitter. The accumulation of light-generated carriers does not result in the formation of power. A current and voltage must be created to create power.

Review of literature

Ciricillo, M. (2020) explained the **es**tablishment of the First Solar Parks. Near 1982, Arco Solar developed the first solar park, which was basically a solar power plant in Hesperia, California. When this park was fully operational, this could power a 100-kilowatt light bulb for 10 hours. It produced 1,000 kW, or 1 MWh. Arco Solar constructed a second solar park near Carrizo Plains, California, in 1983. It was the world's biggest set of solar arrays at the time with 100,000 PV arrays producing 5.2 MW at complete capacity. While the restoration of oil's popularity threw these facilities into disarray, it revealed the possibility for commercial solar power production (CIRICILLO, M. (2020). Hybridization of a CSP and PV Power Plant from an Existing Coal Power Plant.).

Lienau, C. (2020) has pointed out that German scientist Heinrich Hertz has discovered the first photoelectric phenomena of electrons produced by light from a steel or solid surface. Hertz discovered that when subjected to ultraviolet light rather than more powerful detectable light. This process produced greater power contrary to expectations. Albert Einstein was later awarded the Nobel Prize for his contributions to understanding of the phenomenon. The photoelectric effect is used in modern solar cells to turn sunlight into electricity (Dombi, P., Pápa, Z., Vogelsang, J., Yalunin, S. V., Sivis, M., Herink, G., ... & Lienau, C. (2020). “Strong-Field Nano-Optics”. Reviews of Modern Physics, 92(2), 025003)

Ukoba, K., & Chien-Jen, T. (2019)produced the Silicon Solar Cells. Bell Laboratories physicists found that in comparison to selenium, silicon is highly effective, leading to the creation of the first practical solar cell, which is presently 6 % effective. Solar cells have capability to power electric devices that were developed because of this finding. Western Electric started selling commercial licenses for its silicon PV technology in 1956, but the exorbitant pricing of silicon solar cells has kept the industry from becoming saturated (Chien-Jen, T., & Ukoba, K. (2019). Modeling and Simulation of Nanostructured Copper Oxides Solar Cells for Photovoltaic Application.).

Akhtaruzzaman, M. D. (2017) stated that the New York inventor Charles Fritts constructed the first solar cell by covering selenium with a tiny gold layer. The energy conversion rate of this cell was between 1 and 2%. Most current solar cells have 15–20 % efficiency (Amin, N., Shahahmadi,

S. A., Chelvanathan, P., Rahman, K. S., Hossain, M. I., & Akhtaruzzaman, M. D. (2017). “Solar Photovoltaic Technologies: From Inception toward the Most Reliable Energy Resource”. Encyclopedia of Sustainable Technologies, 11-26).

Nithyananthan, K. (2016) explained the discovered the Sunless Solar Power. A study team from the University of Australia, Berkeley and California discovered new properties of nonmaterial. Magnetic hyperbolic dispersion is one of these features, which implies the material glows when heated. It might convert heat into energy without the use of sunlight if paired with thermos photovoltaic cells (Sreega, R., Nithyananthan, K., & Nandhini, B. (2017).” Design and Development of Automated Solar Panel Cleaner and Cooler”. IJEEE, 9, 186-197..)

El Mogy, T., & Rabea, D. (2015) stated that the using an industrial printer, solar cells as thin as paper may now be produced. Solar cells can output up to 50 watts per square meter from a single strip and have a 20% power conversion efficiency. The strips are flexible and affordable to create, which is wonderful news for the 1.3 billion people living in underdeveloped nations (El Mogy, T., & Rabea, D. (2021). “An Overview of 3D Printing Technology Effect on Improving Solar Photovoltaic Systems Efficiency of Renewable Energy”. Proceedings of the International Academy of Ecology and Environmental Sciences, 11(2), 52-67.).

Lakhtakia, A., Singh, R., & Alapatt, G. F. (2013): The National Renewable Energy Laboratory produced a novel solar cell made of gallium arsenide and gallium indium phosphide in 1994 that had a conversion efficiency of more than 30%. The test center created thin-film solar cells that transformed 32 % of the sunlight it gathered into useful electricity at the turn of the century (Singh, R., Alapatt, G. F., & Lakhtakia, A. (2013). “Making Solar Cells a Reality in Every Home: Opportunities and Challenges for Photovoltaic Device Design.” IEEE Journal of the Electron Devices Society, 1(6), 129-144.).

Jones, G. G., & Bouamane, L. (2012) explained that in space solar energy is used. Solar energy gained popularity once the government employed it to power space exploration equipment, following years of studies to increase its commercialization an efficiency. Vanguard 1, the first solar-powered satellite, has completed more than 197,000 orbits around the Earth in 50 years in space. This study cleared the path for future study to increase production and to reduce cost (G., & Bouamane, L. (2012). “Power from Sunshine”: A Business History of Solar Energy. Harvard Business School Jones, G Working Paper Series.)

Jenkins, T. (2005) discovered the Selenium's Photoconductivity. Willoughby Smith, an English electrical engineer, found selenium's photoconductivity, which means when it absorbs light, it is electrically conductive. Richard Evans Day and the Grylls Adams after three years discovered that electric power could produce by selenium from sunlight without the use of heat or readily breakable moving components. This finding demonstrated that solar energy was simple to maintain and extract, with fewer moving parts than another source of energy like coal-fired plants (Jenkins, T. (2005).” A Brief History of... Semiconductors”. Physics Education, 40(5), 430.)

Gratzel, M. (2001) discovered the photovoltaic effect. In 1839 French physicist Edmond Becquerel found the photovoltaic impact for the first time. This process occurs when a material absorbs light, and a voltage is produced. Silicon crystals are used in most contemporary solar cells to achieve this effect (Gratzel, M. (2001). “Photo Electrochemical Cells”. Nature, 414(6861), 338-345.)Solar energy has gone a long way in the past 200 years, beginning with the study of the properties of light and progressing to the development of novel systems for converting it into energy. This technology is advancing at an unparalleled pace, and there are no signs that it would slow down any time soon. It is important to keep up with the newest solar news and innovations to assess if solar energy is suitable for individuals (H. Zhu, J. Wei, K. Wang, and D. Wu, “Applications of Carbon Materials in Photovoltaic Solar Cells,” Sol. Energy Mater. Sol. Cells, Vol. 93, No. 9, Pp. 1461–1470, Sep. 2009)

Research Objectives

The objectives of the study are.

- To study the different technology to fabrication for solar cell and their environmental and economic effect.
- To formulate material to device resolution for the solar cell structure.
- To provide IV characterization for the anticipated solar cell and it analytical, simulation and fabricated result analysis and comparisons.

Research Philosophy

Solar energy such as solar irradiation is considered the most abundant renewable energy source on the planet. it has both the energy capacity and the time necessary to supply the world's energy needs in the foreseeable future. Given the enormous amount of energy that sunshine has the potential to deliver, solar power now accounts for just a relatively small (about 0.5 %) part of the worldwide electricity market. Solar photovoltaic systems must be highly efficient, confident, sensitive, and cost competitive to meet the needs of the present market and develop the global installed PV capacity. In this regard, the photovoltaic industry would be responsible for improving photovoltaic cells, reducing the associated loss mechanism, and intent on optimizing process design, as well as reducing the complexity and costs of manufacturing in anticipation of the upcoming introduction of increasingly complex constructions, among other things.

Consequently, careful selection of elements suitable design and geometrical distribution, the use of passive methods, and the use of suitable numerical modeling techniques are all required. In this study, A thorough investigation of the fundamental concepts of physical processes such as the generation and recombination operations, motion, the selection of load carriers, and the fundamental analytical 1-D p-n junction model is required for a proper understanding of the action of solar cell structures, among other things. In addition, the theoretical efficiency limitations as well as the key loss processes that impact the output of silicone solar cells are elucidated in this paper.

The Sun "maintains the whole of man's existence and gives all of resources." The sun provides electricity to all forms of life, beginning with photosynthesis, and plants absorb sunlight and convert it into cumulative growth and production energy, so ensuring the continued survival of the planet. As a result, the sun is the most powerful and plentiful natural energy source on the planet. This star is about 4.6 billion years old and has been around for 5 billion hydrogen fuel years.

Renewable solar energy is the most valuable resource of electrical and thermal power since it is created directly from the largest quantity of radiated energy from the Sun to the planet. As a result, solar energy has several benefits, including the reduction of greenhouse gas (GHG) emissions and the usage of other harmful air chemicals. It is both cost-effective and widely available around the world in both urban and rural areas. Furthermore, as previously noted that solar energy is still almost limitless which means that by 2050. it is the second-largest source of electricity in the world. Furthermore, with a few exceptions, such as nuclear and geothermal energy, most of the world's energy sources, including wind, hydro, biomass, and fossil fuels are derived directly from solar energy.

Research Approach

Japanese scientists Kojima and colleagues discovered in 2009 that the organic metal halide perovskite is near to dyes and can absorb sunlight. Perovskites may be utilized as sensitizers in dye-sensitized solar cells with a liquid electrolyte to achieve a power transfer effectiveness of 3.8 %, according to the researchers. Kim made the first public announcement of PCE-9.7 % all-solid-state perovskite solar cells in 2012. Perovskite solar cells, which provide high-level performance at a cheap cost, have piqued the curiosity of academics throughout the globe in recent years, and their popularity has expanded rapidly. The National Renewable Energy Laboratory (NREL) has authorized the greatest conversion performance achieved so far in 2016 which is 22 %.

More improvements in the performance of perovskite solar cells would result in a reduction in conversion efficiency and manufacturing costs. These solar cells are among the most intriguing new photovoltaic cells on the market today, and they have significant scientific worth and significance. The number of publications on perovskite solar cells, as well as the highest efficacy verified by the National Renewable Energy Laboratory, is fast growing.

Perovskite solar cells have advanced significantly in recent years; yet many critical aspects may limit the development of perovskite solar cells. First, external environmental conditions (such as humidity, temperature, and UV radiation) have a considerable impact on the stability of organic plum halide perovskite, resulting in poor equipment stability and considerable issues during the subsequent encapsulation of cells.

To increase the practicality of such devices while also producing a simple and efficient system of product packaging. It is essential to produce equipment with high stability compositions such as light absorbent plates, electron pan transport layers, and electrode materials, among others. SecondCu_2OHole Transportation Layer loose transport content, which is utilized in perovskite solar cells, is awfully expensive to produce (10-fold gold selling price). Furthermore, new hole transportation materials must be developed and synthesized to facilitate the widespread industrial use of perovskite solar cells. Third, the standard techniques discussed above do not make it simple to deposit a wide range of continuous perovskite films, and as a result, additional ways should be improved to prepare large-area and high-quality perovskite solar energy cells in the future. Fourth, the lead ($P_{b)}$ substance used in perovskite solar cells is exceedingly hazardous, which would make it impossible to manufacture and promote perovskite solar cells in the industrial setting if they were employed.

In the future, it is possible that a component with low toxicity or non-toxicity may be discovered to replace Pb. Fifth, the physical process of perovskite solar cells at the microscopic level is still not completely understood. As a result, a comprehensive theoretical model is necessary to comprehend why conversion efficiency is increasing. The goal of theoretical research is not only to enhance the efficiency of perovskite solar cells, but also to make the development of novel materials and systems simpler and more efficient. According to the 12 nonmaterial papers consensus, all the limitations listed above must be addressed before the perovskite solar cell technology may be used in its totality.

Increase the availability of a sustainable and energy-efficient alternative to meet global energy demand, resulting in the production of solar power and a decrease in harmful greenhouse gas emissions (GHE). This article provides a succinct overview of the fundamental physical concepts that govern the use of solar cell technology. In the first instance, a comprehensive study presented on sophisticated technical solutions to increase the efficiency of silicone solar cells, which have been developed in the photovoltaic industry since the middle of the twentieth century.

In addition, an overview of the most often used solar cell layouts is provided, as well as illustrations of the primary processes associated with the PV effect. All of this raises public knowledge of the basic operating principle of silicone sun cells. Following that, there is a review of the set of charge carriers that may be used with a p-n connection as well as a list of fundamental equations that describe the ideal features of semi conductive devices in the approximated setting of drift diffusion. In the first position, the basic 1D model is investigated to investigate the ideal, I-V lighted solar cell that may be used to augment the cause of the basic processes associated with Solar Cell operation.

The analysis is carried out through approximation using the SCAPS-1D programmed analysis system (Solar Cells Capacitance Simulator, University of Gent, Belgium). It was discovered that Cu_2O/Perovskite/structure was the most effective combination for determining the primary solar perovskite (SC) photovoltaic characteristics.

Research method

The working of a silicone solar cell is based on Alexander Becquerel's well-known 1839 photovoltaic phenomena. Once the electron-hole pairs are formed due to the light absorption mechanism. They travel around within the crystal lattice and before recombining extract power from the PV cell. The reason of these electrical currents is produced is due to the transport of the electron-hole charges. Therefore, the well-known Drift-Diffusion (D-D) paradigm transport is the appropriated mechanism to explain the action of charge carriers in the substrate under the control of light and/or electric field. Thereby, contributing to a variation from the thermal equilibrium conditions. Basically, the D-D approximation consists in the solution of a collection of five basic equations which derive the ideal properties of semiconductor devices like Si solar cells.

A. Poisson equation

Poisson equation defines the electrostatics by applying the divergence of the static electric field ξ to the charge density ρ.

$$\nabla \cdot \xi = \nabla^2 \varphi = \frac{\rho}{\varepsilon} (1)$$

Where an electro-static potential and e is is a primitive material. The load density is provided in a semiconductor unit,

$$\rho = q(\wp - n + N_D^+ - N_A^-)(2)$$

Where N_A^- and N_D^+ are the densities of ionized acceptors and donors and p and n are the holes and electron concentrations individually.

The current flow of electrons and pants is well known to be transferred into a semiconductor system. This can be done through two-basic transmission processes drift-diffusion (D-D). First, as an electrical field ξ is applied across the semiconductor, the drift mechanism occurs, while a concentration gradient is used for diffusion transport. Thus, there is a description of the total current electric and trough densities indicated by, J_n and J_p,

$$J_n = q\mu_n n\xi + qD_n \nabla_n (3)$$
$$J_p = q\mu_p n\xi + qD_p \nabla_p (4)$$

Where there is a mobility between electron and hole, and D_n and D_p are the coefficients of electron and hole diffusion. The first terms on the right-hand side (4) and equation (5) are the drift currents, while the second terms suggest the estimate of diffusion currents. The coefficients of mobility and dissemination are linked as follows Einstein.

$$D_n = u_n \frac{KT}{q} \text{ and } D_p = u_p \frac{KT}{q} (5)$$

The simulator calculates the propagation and transport mechanisms for solar cell devices in accordance with the popular Drift Diffusion (D-D) model.

B. Continuity equations

Two more expressions are needed to describe the full range of semiconductor equations. The above equations equate the difference in current densities with the production and recombination of the associated carriers. Moreover, the rule on preservation of charges is taken into consideration. The electron and hole continuity equations can be described under constant-state conditions as,

$$\frac{1}{q} \nabla \cdot J_n = R_n - G_n (6)$$
$$\frac{1}{q} \nabla \cdot J_p = R_p - G_p (7)$$

Where G describes the electron-hole pair optical generation rate. Respectively R_n and R_p are the electron and hollow recombination rates. Belt gap, electrical permittivity, mobility, and diffusion coefficients are regardless of location for a uniformly doped semi-conductor. The equations (1), (3), (4), (6) and (7) thus constitute the basis for a reduced semi-conductor equation edition.

Result analysis

To Study the Different Technology for Fabrication for Solar Cell and Their Environmental and Economic Effect

In compared to traditional energy sources, Solar Photovoltaic (PV) delivers considerable social and environmental advantages contributing to sustainable development. In 2011, the global PV market was growing extremely highly (27.4 GW). This is good news since energy production from PV does not cause greenhouse gas emissions, which is a clean alternative to fossil fuels and especially help in less-developed places, towards creating jobs and economic growth. However, PV modules may have effects on employees and the environment throughout their life cycle (from the mining and procurement of raw materials through manufacture, disposal and/or recycling). Large-scale PV deployment also requires land not available or competing with other uses of land.

Strong obstacles to the diffusion of PV technology appear to be these possible difficulties. Conventional production procedures in photovoltaic (Silica-Based) having their origins in the electronics sector, many of the compounds present in electric waste are also present in solar photovoltaic (PV). There are various hazardous, flammable, and explosive substances to be used in the production of solar cells. Many of these components provide a health risk to solar cell manufacturers. Solar panels frequently compete with farming, causing soil erosion. In many nations, the disposal of electronic items is becoming an increasing hazard for the environment and health. The reuse of solar panels is now not economically feasible since the quantities of waste created are too small.

To Formulate Material to Device Solution for the Solar Cell Structure

A flexible thin metal sheet (<125 μm) is often utilized as a substratum to produce flexible solar cells. Metal foils are very flexible due to their high metal ductility. Due to its cheap cost, outstanding heat, and chemical resilience, the most often applied variable iron substructure is stainless steel film. The original noted usage of solar cells (which might also be flexible) may be dated from the 1980s, with the instance of a thin film solar cell C_{dS} and amorphous silicon hydrogenated .The film is now being used for commercially flexible solar panels such as GSHK's and Global Solar Firm's solar CIGS Panels. Aluminum alloy foil was used as the substrates for commercial flexible solar cells as an example of a Nano molar product published on a low-cost aluminum alloy foil.

In addition to the stainless-steel foil, it was also used as a roll-to-roll product. Other solid surface (metal), like titanium, is also employed to make perovskite solar cells in recent years (PSCs). The titanium dioxide nanowire array anode manufactured on the Ti-foil substrate has been used for PSCs with a 13.07% power conversion efficiency (PCE). The marketing of this substrate may be impractical, however, given the high costs of the Ti-foil. The metal foil has strong visual reflectiveness over the observable spectrum and consequently, the solar cell's top electrode must be optically transparent, so that photons are transmitted in the active materials.

Based on the efficiency, stability, and other PV metrics of perovskite-based solar cells, the width of ETL layer plays a key impact. When a solar cell is erected in open sun exposed regions, there is worry about greater temperatures at certain times when daylight temperatures in summers are at their height, which in turn have a significant impact on the performance of the PSC. The performance of the solar cell is considerable at lower temperatures (shown in Figure 5) with an effect slowing with a temperature of 27.40%, Voc = 0.9858 V, Jsc = 33.44 mA/cm2, FF = 83.09%.

The J-V PSC curve illustrates variations in temperature, which shows that Voc has decreased considerably as the temperature has been raised, but the J_{SC} stayed practically constant.

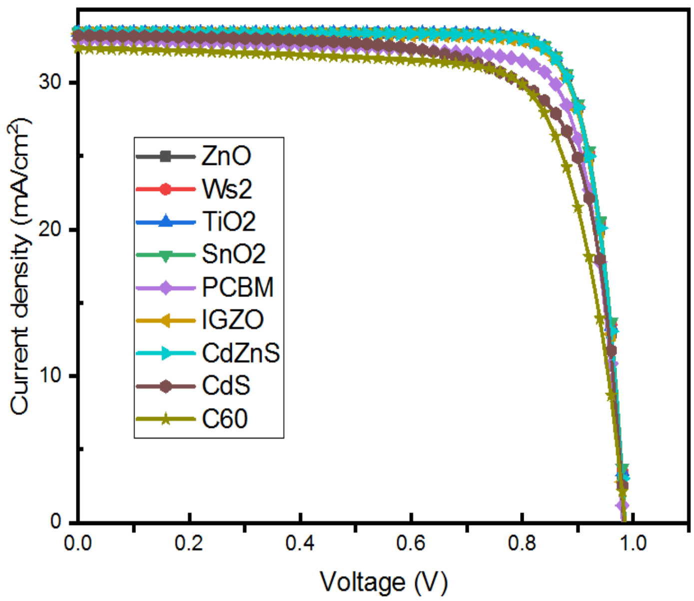

Fig.4. Effect of different ETL layer on JV characteristics

Fig. 4 represent J-V characteristic curve for different ETL layer. Many ETL layers are shown in this graph with their current density to voltage and easily identified their unique color.

The glass medium is the most common ceramic substratum in solar cells. The glass substratum is heat resistant to chemical assaults and humidity. The weak hardness of the glass, however, undermines its flexibility, resulting in a substantially lower safe bending radius in comparison to a metal film or plastic substratum. The width of the glass substratum may reduce to 100 μm using new glass-making equipment and the glass is thus very flexible. Willow glass was manufactured as a type of flexible glass substratum from Corning from researchers in the production of flexible solar cells. The flexible glass substratum was used in the manufacture of soft solar cells etc. For instance, a flexible PSC built on glass with 18.1% PCE.Other ceramic substrates have been created for solar cells in addition to a glass substrate, such as a zirconia ribbon substratum. It is stated a copper zinc tin sulfide (CZTS) cell manufactured using a zirconia-based flexible substratum that has a PCE rate of 11.5%.

There is an (HTL) Hole Transport Layer. On the other side of the absorber, with the rim of the valence ring slightly higher than that of the holes to make flowing easier, while the rim of the holes is higher than the edge of the absorber to refrain the electrons and prevent them from flowing in the HTL. The neighboring ETL metal electrode must be Fermi below ETL. The HTL-contacting metal electrode must have a Fermi level above the HTL. There are two techniques of aligning the bands after choosing the suitable material. They may be pulled to a reference level known as the level of vacuum. This is the line-up before the substance gets contacted. They are oriented to the level of Fermi after interaction with the materials. The Fermi level is a horizontal line throughout the building under thermal balance. The Fermi levels are the same as electrons and cracks possibility. Intrinsic semi-conductors are at the center of the energy gap with their Fermi level. If the material is doped, the farm level changes towards the bands. The Fermi metal level is below the vacuum level and is based on the material's work function. The drive rim of a semiconductor material resides in the electron's affinity below the vacuum level.

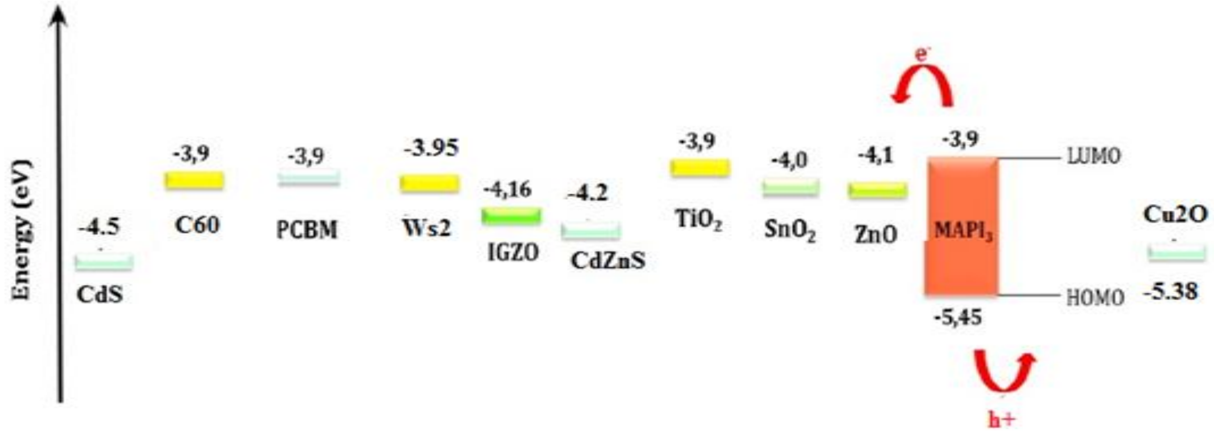

Figure. 5. Band's alignment between ETL, Perovskite and HTL

As shown in Fig. 5 the alignment of the energy strips depends on the solar cell layers' function. The absorber material claims that the perovskite has a power gap that corresponds to a maximum conversion efficiency of around 1.35 eV. On one side, an ETL transport layer must be added whose conductive rim Ec is somewhat lower than the conductive rim of the absorber whereas, at the same time. Its valence ribbon edge is less than that of the absorber to reflect and prevent the holes from flowing into the ETL.

To provide IV characterization for the projected solar cell and it analytical, simulation and fabricated result analysis and comparisons

Cells of photovoltaic (PV) are nearly completely formed of silicon processed in an exceptionally pure crystalline form, which collects photons from the light of the sun and then sets them out as electrons, which causes an energy flow after the cell has been linked to the external load. Various measures may be used to assess the performance of the solar cell, such as its electrical output and conversion efficiency. The primary electrical function of a photovoltaic cell is shown in a typical solar cell function curve which is the power-voltage relationship. The intensity of the sun radiation (isolation) hits the cell, and the rising temperature of the solar cell lowers its voltage (V).

Solar cells provide current voltage electricity (DC) and current time energy. It can thus develop I-V solar cell curves illustrating the current against the voltage for a photovoltaic system. Characteristics of Solar Cell I-V Curves are essentially a graph of solar cell or module operations illustrating the current-voltage relationship under existing irradiance and temperature circumstances. I-V curves provide the necessary information to setup a solar system to function as near as feasible to their ideal peak power point (MPP).

Therefore, the experimental data were originally acquired and checked with the simulation models under current circumstances. To prevent mistakes and to reduce the 1V curve, a high accuracy pyrometer was used to measure the sun irradiation. MATLAB and characteristics I-V and

P - V are graphically shown in all. Table -1 summary the PCE result computed for various ETL materials and fixed layers of HTL and perovskite.

The most efficient material for this operation isCu_2O Hole Transportation Layer(HTL).The doping dosage for all these ETLs is 1 x 10^{16} cm^3 and the doping absorption is determined. For a thickness of 0.1μm, each ETL layer may therefore be considered as affecting several performance measures like ETL (n- type) fill factor (FF), PCE ($Ch_3NH_3PbI_3$), short-circuit (Jsc),open-circuit voltage (Voc), and HTL device structure (Cu_2O, p-type). Effect on performance measures and current density vs. voltage characteristics as reported in Table 1

Table-1
Performance solar cell obtained from simulations for each ETL material

ETL	Voc(volts)	Jsc(mA/cm^2)	FF(%)	PCE (%)
SnO_2	0.9858	33.44	83.09	27.40
TiO_2	0.9855	33.44	82.99	27.35
Ws_2	0.9855	33.38	83.09	27.32
ZnO	0.9844	33.44	82.94	27.31
CdZnS	0.9847	33.44	82.81	27.27
IGZO	0.9824	33.37	82.67	27.16
PCBM	0.9820	32.88	80.00	25.83
CdS	0.9843	33.23	73.93	24.18
C_{60}	0.9850	32.36	75.02	23.93

The SnO_2 material form of an ETL layer provides the highest level of PCE based on these data (27.40 %). This is because the ETL can produce different tape a structure when the absorber layer is created .Fig.6 shows the kind of band structure that ETL may create with a layer of absorber. The greatest efficiency may be found at above 27 % for ZnO, SnO_2, TiO_2, CdZnS ,Ws2 and IGZo. It also considers that several of its input parameters seem to be similar, but also affect the flow of electrons and deficient density.

As shown in Fig.6 SCAPS-1 D software was used to simulate the Electron Layer (ETL) and Cu_2O as Hole Transportation Layer (HTL) for 8 distinct materials (TiO_2, ZnO, SnO_2, PCBM, Cd_S,

C_{60}, IGZO, Ws_2, and CdZnS). The findings generated in these works reveal that the most essential influence on PCE is in harmonizing ETL's maximum valence band (MVB) with perovskite materials directly associated with each material's band gaps and electron affinity. The alignment of the band not only affects the improved effectiveness of the cells but also the mobility of materials that have nearly identical band adjustment characteristics.

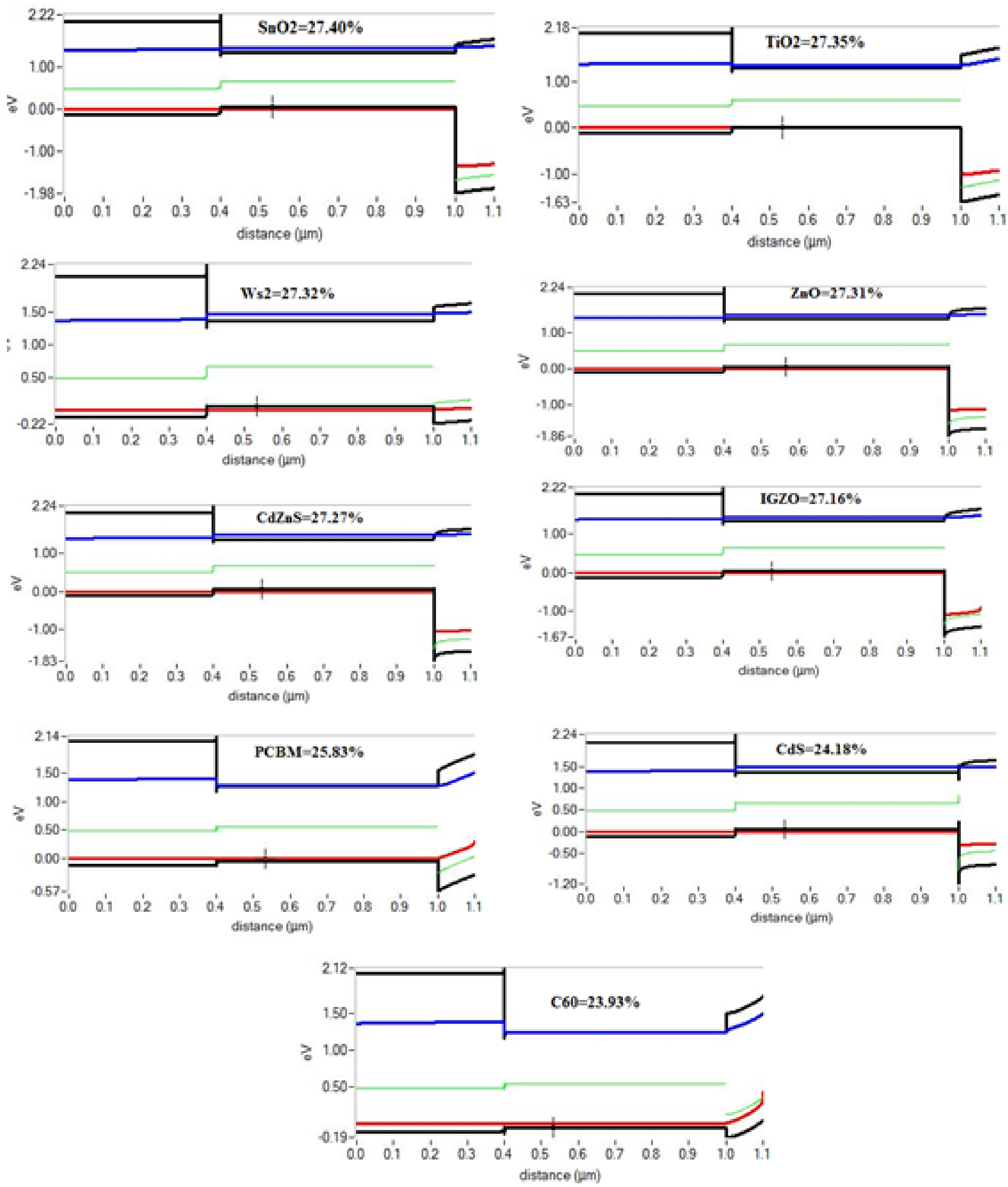

Fig.6 Band diagram of ETL with absorber layer

Conclusions

In this study, the implementation of nanostructure Perovskite solar cells and the impact of various electron transportation fabrics such as TiO_2, ZnO, SnO_2, PCBM, Cd_S, C_{60}, IGZO, Ws_2, and CdZnS Electron Transportation Layer were investigated. The perovskite thickness of solar cell based on $CH_3NH_3SnI_3$, has a major impact on electrical characteristics in comparison to electron and hole transport layers. The findings obtained thus indicate that SnO2/$CH_3NH_3SnI_3$/Cu_2O structure perovskite performs better. For the electron transport layer, hole transport layer and perovskite layer, the layer thicknesses determined for optimum layer are 100 nm, 400 nm and 600 nm. The thicknesses for the solar cell are 18.16µm better than 9.56µm.The device modeling for several perovskite solar cells was conducted for different ETM layers such as (TiO_2, Z_nO, SnO_2, PCBM, Cd_S, C_{60}, IGZO, WS_2) and the impact of band gap on device PCE was investigated using the SCAPS 1D (Solar Cell Capacity Simulator). The NIP structure for perovskite solar cells based on $CH_3NH_3SnI_3$ is extensively studied and simulated using SCAPS-1D software. According to the results of this research, the alignment of the Maximum Valence Band (MVB) of ETL and perovskite materials, which is strongly related to the energy gap and electron affinities of each material, has the greatest effect on PCE. Cell efficiency, as well as mobility among materials with nearly identical band alignment characteristics are all dependent on proper band alignment in specific circumstances.

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