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History and Efficiency of Perovskite Solar Cell (PSC) Source of Renewable Green Power

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Abstract - Perovskite is a calcium titanate mineral species. It has the properties of calcium titanium oxide. When originally tested in 2009, solar cells made from perovskites generated only around 3.5% of solar energy into usable power. Efficiencies in hybrid perovskite solar cells have recently surpassed 20%, prompting speculation that they would soon replace more conventional silicon photovoltaics. Recently, PSC topologies have been reduced from meso-structured to planar heterojunction, making it easier to achieve the goal of a low-cost, high-efficiency design in real-world applications. When exposed to air, oxygen and water vapor cause perovskites to destabilize over time. It's no secret that all nations are paying closer attention to the advancement of renewable energy in light of the worldwide energy and environmental crises. Solar electricity, because to its cheap cost and abundant supply, is one of the most promising renewable energy sources. Despite significant advancements in high-performance solar cells over the last several decades, the high cost of modules remains a major barrier to widespread use of photovoltaic technology.

Keywords - Perovskite Solar Cell, Efficiency, Renewable, Green, Power

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1. INTRODUCTION

For their light harvesting capabilities, perovskite solar cells (PSCs) combine an organic semiconductor with an inorganic lead or tin halide material. Methylammonium lead halides, a kind of perovskite, has a cheap production cost and is simple to manufacture. Perovskite solar cells have the highest projected growth rate of any solar technology, with an efficiency increase from 3.8% in 20102 to 25% in 20193. PSCs, which aim to achieve greater efficiency at lower manufacturing costs, have garnered significant business interest, with modules from start-up businesses already promising commercialization. According to Figure 1, the perovskite crystal structure is ABX3. The unique properties of perovskites include a wide range of absorption spectra, a higher absorption coefficient, the movement of opposing charges, a longer lifetime, and narrower exciton energy bands. In recent years, metal halide perovskite cells have seen significant performance improvements that have led to a significant increase in their overall efficiency as energy converters.

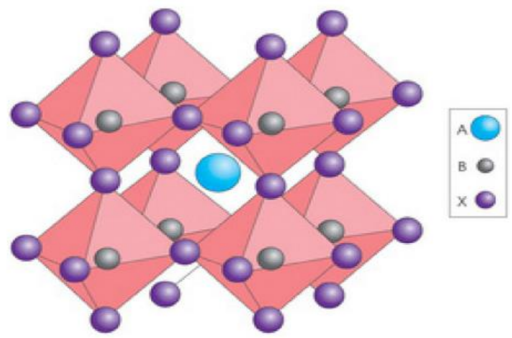

Figure 1: The crystal structure of $CH_3NH_3PbX_3$ perovskites

When it comes to perovskite solar cells, 2,2'7,7'-tetrakis-(N,N-di-p-methoxyphenyl amine)-9,9'-spirobifluorene doped CH3NH3SnI3 has shown to be the hole transport material of choice. However, spiro-prohibitive OMETAD's price and challenging synthesis pose a serious challenge to its eventual commercialization. Because of this, we must choose novel HTM materials that can sub in for spiro-OMETAD. Inorganic CuI has advantages over the more complex spiro-OMETAD, including superior chemical stability, cheap cost, and a simple manufacturing technique. On top of that, CuI may be deposited at low temperatures using the solution process approach. To a certain extent, CuI is compatible with many different substrates. TiO2 is employed as an electron transport substance in the construction of the building (ETM). TiO2's key disadvantages for widespread use in commercial solar cells are its expensive price and limited electron mobility.

2. LITERATURE REVIEW

Kharade, et al (2019) The impact of the Perovskite solar cell compared to other energy storage systems is reported here. In a perovskite solar cell, the "active layer" is a perovskite-organized chemical that is often a cross between an inorganic lead or tin halide and a naturally occurring inorganic compound. Perovskite solar cells have become a viable choice in the solar energy market due to their decreased production costs and greater efficiency. We anticipated promising findings by modeling this solar cell in MATLAB and comparing the results to those obtained from actual experiments. For this, we resorted to the employment of an artificial neural network (ANN). For a more efficient solar cell, we have to fix the mistakes made while estimating the number of covered neurons in ANN. The results show that Perovskite solar cells are more reliable than alternative energy storing methods.

Raoult et al (2019) Silicon perovskite tandem solar cells have their optical characteristics analyzed. When combined with a semitransparent perovskite solar cell (PSC) that has a performance cell efficiency (PCE) of 16.6%, the silicon cell achieves a 4T tandem efficiency of 22.3%. Minimizing optical losses in the PSC's near-infrared region is essential for improving the device's performance. There is a lack of precise knowledge on the optical characteristics of the individual layers that make up the PSC, since these qualities are highly dependent on the precise material composition and manufacturing method. The purpose of this research is to estimate the optical indices n and k of the several layers that make up the semitransparent PSC by the use of spectrophotometry, profilometry, and ellipsometry. We are the first to reveal the optical indices of the triple cation perovskite CsMAFA0PbBrI. To determine the optical losses, a transfer matrix-based optical model is utilized. By anticipating how different materials would affect the performance of the bottom silicon cell and the tandem cell, this research will allow for more accurate device design and faster material testing.

Sivestre, et al (2018) Here, herein, we provide the simulation results for a tandem arrangement wherein perovskite is placed on top of Interdigitated Back-Contacted (IBC) c-Si. Perovskite solar cells and inverted back contact c-Si solar cells were modeled and simulated using two distinct models. In addition to detailing the actual experiments, the experimental section provides a concise summary of the production and characterisation procedures. Connecting the top and bottom solar cells in series to create a tandem system yielded the highest efficiency of 25%.

Hasan, Md Nazmul & M. Habib, M. & Matin, Md & Amin, Nowshad. (2017) Tandem solar cells with both silicon and perovskite absorbers have the potential to achieve higher efficiencies than the most effective commercially available single-junction silicon sun cells. Perovskites especially methyl ammonium lead iodide are a kind of lead halide that straddles the organic/inorganic divide thanks to its high efficiency, low weight, and competitive price. This may serve as the absorber layer in a tandem solar cell setup, since its 1.65 eV band gap is complementary to the 1.124 eV band gap of a silicon (Si) solar cell. Si solar cells' efficiency has been at about 25% over the last 15 years, however our tandem technique provides a perfected option.

3. PEROVSKITE SOLAR CELLS SO EFFICIENT

Since halide perovskites include both organic and inorganic chemicals, they are classified as hybrid semiconductors and are the subject of much study in the field of photovoltaics. These perovskites advanced dramatically in a little over a decade. An important part of the solution to climate change is switching to renewable energy sources like solar. Although solar technology has gone a long way since its conception, it still has a way to go before it can replace traditional energy sources. It's not easy, but adopting novel materials might help solve the problem of how to provide reliable solar electricity. Inefficient silicon semiconductors are widely used in today's solar panels. However, in recent years, a viable substitute has developed. Perovskite, a crystalline structure that is both thin and flexible, may make it possible for silicon panels to reach hitherto unattainable efficiency levels. Manufacturers of solar panels may easily and cheaply add a perovskite layer to the glass that covers their products. Manufacturers claim that perovskite is almost ready for commercial application because of its potential answer for solar power efficiency and its affordable price. However, perovskite has a number of drawbacks that might reduce its usefulness.

PSCs have recently been the focus of solar cell research and development because of their high conversion efficiency and low preparation cost. And it’s supposed advantage (over competing materials) might help perovskite eventually displace it as the dominant cell material, thus it's a big potential material. The sun's rays provide an incredible quantity of energy to Earth. The sun's rays can be harnessed to provide enough electricity to meet our needs. Solar cells, which are examples of photovoltaic technology, may use sunshine as a direct energy source. Over the last several decades, many photovoltaic technologies have been developed. These solar cells' low production cost and ease of production have piqued the interest of scientists. The chemical formula of the perovskite is ABO_3. The calcium titanate crystal structure was dubbed a perovskite

(CaTiO3). Perovskites with the chemical formula ABX_3 are a separate group of materials. In addition to a reasonable band gap, high absorption efficiency, and low charge carrier mobility, this family of perovskite materials also has good charge carrier characteristics. In this study, we provide an investigation into the perovskite material methyl ammonium lead halide and its optoelectronic properties. Using a visible-light sensitizer named MAPbX3, the scientists constructed dye-sensitized solar cells. After building and testing a dye-sensitized solar cell, its high PCE and low open-circuit voltage were confirmed.

4. HIGH-EFFICIENCY PEROVSKITE SOLAR CELLS

- **Intramolecular Exchange:**Perovskite films' optoelectronic qualities are strongly dependent on their layer thickness and uniformity, making their deposition a vital area of research for highly efficient PSCs. In order to make high-quality FAPbI3 films, Woon Seok Yang and colleagues describe crystallisation of FAPbI3 by Dimethyl sulfoxide (DMSO) molecules intercalated in lead iodide (PbI2) are directly exchanged for formamidinium iodide molecules. This type of film fabrication allowed them to develop PSCs based on FAPbI3 that can achieve efficiencies more than 20% in power conversion.

- **Cesium-Containing Triple-Cation Perovskite Solar Cells:** By incorporating inorganic cesium into triple-cation perovskite compositions, Michael Saliba and colleagues were able to boost PCEs to 21.1% while simultaneously increasing stability, reducing phase impurities, and decreasing susceptibility to processing conditions. The study of Csx perovskites showed that the flexibility of customising high-quality perovskite films may be increased by include all three cations. Following 250 hours in operation, they produced PCEs of over 21% and 18%, respectively, after stabilization.

- **Bandgap-Tunable Solar Cells Based on Perovskite:**On November 7th, 2016, The new model was revealed by researchers at UC Berkeley and Lawrence Berkeley National Laboratory. Claims are made for an initial steady-state efficiency of 18.4%, a maximum efficiency of 21.7%, and a peak efficiency of 26%. Using a tandem solar cell composed of two materials, including a layer of hexagonal boron nitride only one atom thick, high efficiency was attained. In spite of the fact that methyl and ammonia are organic molecules shared by both perovskite compounds, tin and iodine are found in just one of them, while lead and iodine doped with bromine are found in the other. Both of them preferentially absorb light, however one takes in infrared at 1 eV while the other prefers amber at 2 eV. Since the two perovskite materials bring down each other's electronic performance, previous attempts to combine them have failed. In fact, the solar cell is capable of soaking up almost the full visible light spectrum.

Perovskite Solar Cell Source of Renewable Green Power

Electromagnetic radiation from the sun provides the earth with 2.91015 kW of energy per day, which is almost 100 times the annual energy consumption of the whole planet. The use of solar energy isn't cutting edge. Its rich history dates back to the seventh century B.C. In the beginning, we used glass and mirrors to reflect the sun's rays and kindle fires. Now, everything from homes to cars can get their energy from the sun. The amount of solar energy reaching Earth has been measured, and it comes out to around 100 watts per square foot, or 1000 watts per square meter. The very low current and voltage capabilities of a solar cell delayed the development of solar concentrators until the 1970s. Structures and automobiles alike may now be powered by the sun. However, solar cell efficiency has not yet risen over 16–17%, and the cost of solar-generated electricity is $5–6 per watt.Perovskite is a mineral species having the chemical formula CaTiO3, which stands for calcium titanate. It was called after the Russian mineralogist who first identified it, Lev Perovski, when he made the discovery in the Ural Mountains in 1839 (Gustav Rose) (1792–1856). CaTiO3 is the prototypical member of the family of chemicals known as XIIA2+VIB4+X2 oxides. Perovskite structure (- 3), often written as CH3NH3PbI3, is a chemical formula. In 1926, V.M. Goldschmidt was the first to describe the crystal structure seen in Fig. 2.

5. CONCLUSION

We can conclude that better research into the relationship between the different material characteristics, the device designs, and In order to bring low-cost, high-efficiency perovskite solar cells to market, it is necessary to improve the device's power conversion efficiency (PCE). Organometal halide-based perovskite solar cells are a relatively new kind of photovoltaic device. The now-ubiquitous and efficient perovskite solar cells may trace their ancestry back to dye-sensitized cells. Perovskites are a class of crystalline materials that may be synthesized by several chemical processes. In 2009, organic-inorganic perovskites were first introduced to the solar industry. PSCs have developed rapidly during the last several years, making them a viable contender for the next generation of low-cost, high-efficiency solar cells. Recent years have seen intensive research on

PSCs as a response to the urgent need for cheap, high-efficiency solar cells.

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