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A COMPREHENSIVE OVERVIEW ON ADVANCES IN SOLAR PHOTOVOLTAIC TECHNOLGY

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Abstract
Renewable energy sources, including solar photovoltaics (PV), are viewed as a clean and sustainable answer to the urgent problems of climate change and the depletion of fossil fuels. The process of converting incident sunlight energy into electrical energy is known as solar photovoltaic technology. The initial generation of solar cells were made from silicon. More advancements are required, according to research, for solar cells to operate more efficiently and absorb more of the sunlight that strikes them. To address these issues, amorphous silicon solar cells and thin film technologies were further developed. From first-generation solar cells to dye-sensitized solar cells, quantum dot solar cells, and some more current technologies, we have examined a gradual progression in solar cell technology in this review. The potential for these many generations of solar cell technologies to establish themselves is also discussed in this article. With minimal to no negative environmental effects both locally and internationally, solar energy has the potential to be used as a source of energy for transportation, distributed heat and power generation, and energy storage systems.

Keywords: *solar photovoltaic, energy, cell, renewable.*

Introduction

Current worldwide trends show that renewable energy is becoming more important than conventional energy sources (including coal, gas, oil, and nuclear). In actuality, renewable energy has hit a tipping point and, while starting from a low foundation, is exhibiting signs of significant growth in its share of the energy supply. Solar photovoltaics (PV) is regarded as "the cleanest and safest method to generate power even at the GW output scale" among the diverse array of currently available renewable energy sources. Since the nineteenth century's discovery of the PV effect, the technology has dramatically advanced both vertically – in terms of solar cell types, technological generations, and efficiencies – and horizontally – in terms of its related technical fields in chemistry, physics, electronics, and mechanics as well as on the level of production and deployment in the market.

With constant technological advancements and efforts to boost efficiency, PV technology has decreased its unit prices to around one-third of what they were five years ago. PV will undoubtedly keep expanding quickly and eventually rank among the world's major energy producers. The PV sector has been expanding at a compound annual growth rate of more than 35% over the past ten years. According to a report on solar photovoltaic electricity enabling the world, 345 GW, or 4%, of electricity will be produced by PV by 2020, and 1081 GW by 2030. Significant cost reductions, advances in solar technology, complementary renewable energy policies, and diversified finance will all contribute to this exponential expansion [1-4]. The present state of the PV technology materials used in solar cells, such as the Copper Zinc Tin Sulfide (CZTS), Organic Solar Cell, Perovskite Solar Cell, and Quantum Dot Solar Cell, has been evaluated in this study.

CdTe Solar Cell

Over time, CdTe solar technology has undergone substantial development. The efficiency of certified cells utilising a glass/SnO_2/CdS/CdTe structure and an anneal in a $CdCl_2$ environment followed by Cu diffusion achieved 10% in the 1980s and approached 15% in the 1990s. Using sputtered Cd_2SnO_4 and Zn_2SnO_4 for the transparent conducting oxide (TCO) layers, cell efficiency reached 16.7% in the 2000s. First Solar and General Electric traded new world-record cell efficiencies in the last ten years, up to 22.1%. The cost of CdTe solar technology has continually decreased, and it is scalable and bankable. By the end of 2020, First Solar anticipates 7.6 GW of annual capacity, and modules are being placed all around the world for various uses. (As shown in Figure 1)

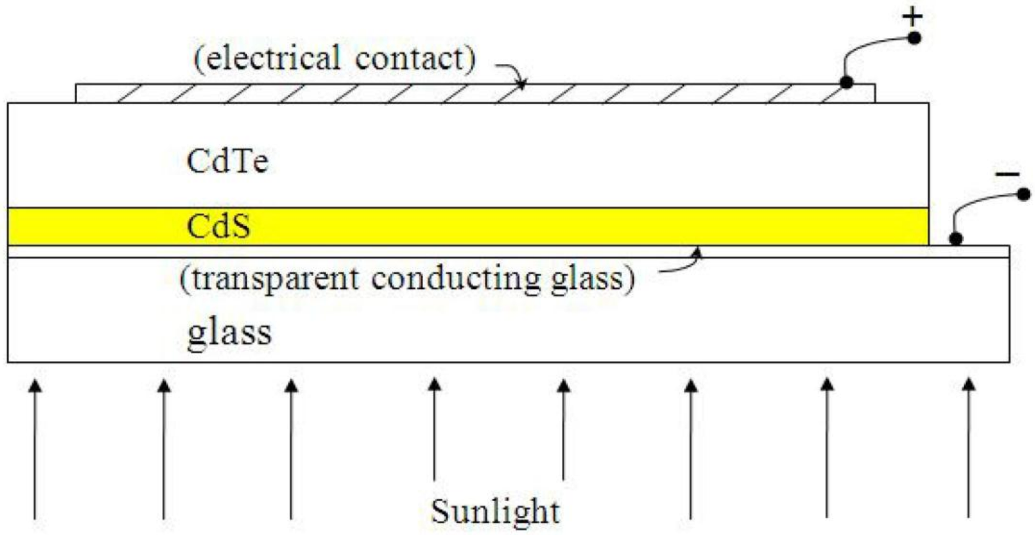

Figure.1. Schematic diagram of CdTe Solar Cell

Although utility-scale power plants have received the majority of installations, roof-top systems and photovoltaics integrated into buildings are increasingly using CdTe technology [5]. The most recent performance improvements were in part from refining the optical characteristics of the cell, getting rid of parasitically absorbing CdS, and adding lower-bandgap CdSexTe1-x.

Perovskite photovoltaic cells

The mineral $CaTiO_3$ is known as perovskite, named for the Russian mineralogist L.A. Perovski, and is a class of compounds that crystallise in the same structure, ABX_3, with A and B being cations and X being an anion species. A is a monovalent organic cation in hybrid organo-lead perovskites, B is Pb(II) or Sn(II), and X is a halogen anion. Longer charge carrier diffusion lengths, reduced material prices, minimal recombination losses, and the option of substituting cations and anion for different bandgap energies are all benefits of employing these materials in solar cells [6,7].

Compared to any other PV technology, the efficiency of perovskite solar cells has grown dramatically in a very short period of time.

Methylammonium lead halide perovskite material films can be used to create solar cells that are more stable and effective. Thus, the utilisation of superior Perovskite films has had a big influence on cutting-edge solar cell technology. In order to effectively improve the surface morphology of Hybrid Perovskite Solar Cells, a variety of additives, including inorganic salts, organic halide salts, inorganic acids, fullerene, polymers, and even water, have been doped into the perovskite layers. In general, if additives are doped into perovskite layers, hybrid perovskites can become more crystalline, resulting in highly pure and smooth layers of perovskite material.

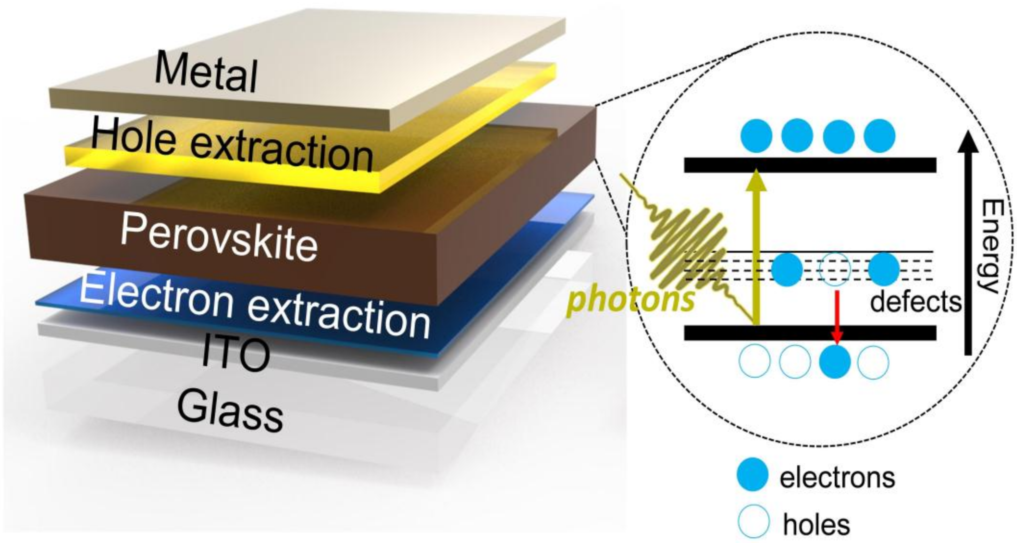

Figure.2. Schematic diagram of Perovskite cell

In general, if additives are doped into perovskite layers, hybrid perovskites can become more crystalline, resulting in highly pure and smooth layers of perovskite material.

Tandem Cells

Record performance Tandem cells offer the potential to achieve efficiencies that are substantially greater than single junction photovoltaics, which are approaching their practical limits [8]. As area-related balance-of-systems expenses currently account for the majority of the cost of solar systems, this in turn creates the possibility of lower costs. Tandem cells have traditionally been employed in concentrator and space applications, but with the development of new materials and production methods, they are now being considered as a direct alternative to single junction cells. Multi-junction cells based on III-V have produced efficiencies of up to 48% when used in concentrated form. Common module efficiencies are around 20%, while bifacial design can produce an extra 10%–20% of energy.

Quantum Dot Solar Cells

A quantum dot solar cell is constructed in such a way that it utilises minute particles called quantum dots (a few nanometers in size) for the photovoltaic effect by absorbing incident sunlight photons [9,10]. It contains large amounts of components including silicon, CIGS (copper indium gallium selenide), and cadmium telluride (CdTe). Quantum dots feature enormous bandgaps that can be adjusted in size to operate at a variety of energies. The bandgap in bulk materials is fixed by the material selection. This characteristic makes quantum dots appealing for multi-junction solar cells, which increase efficiency by harvesting various wavelengths of the sun's spectrum. Efficiency has surpassed 16.5% as of 2019.

Organic Solar Cell

Organic solar cell technology, which works with conductive organic polymers or tiny organic molecules so that light is absorbed and charge carriers are created by the photovoltaic effect, is a type of photovoltaic technology that uses organic semiconductor electronics. The majority of organic photovoltaic cells are polymer solar cells made of tiny organic semiconductor molecules or conjugated polymers. The advantages of plastics and semiconductors are combined in organic solar cells, which also have high optical absorption coefficients, properties controlled with flexible synthesis, and low cost production as some of their qualities. For the construction of organic solar cells, either a bilayer or a bulk hetero-junction architecture can be used. Due to the extremely short diffusion channel lengths of organic materials, bulk hetero-junction is always favoured [11].

Dye Sensitized Solar Cells (DSSC)

A dye-sensitized solar cell is a low-cost solar cell that is based on a semiconductor created between a photo-sensitized anode and an electrolyte, or a photoelectrochemical system. It is a member of the group of thin film solar cells. The DSSC has a number of appealing qualities, such as being easy to construct using traditional roll-printing techniques, being semi-flexible and semi-transparent, which opens up a range of applications not possible with glass-based systems, and the majority of the materials used being inexpensive [12].

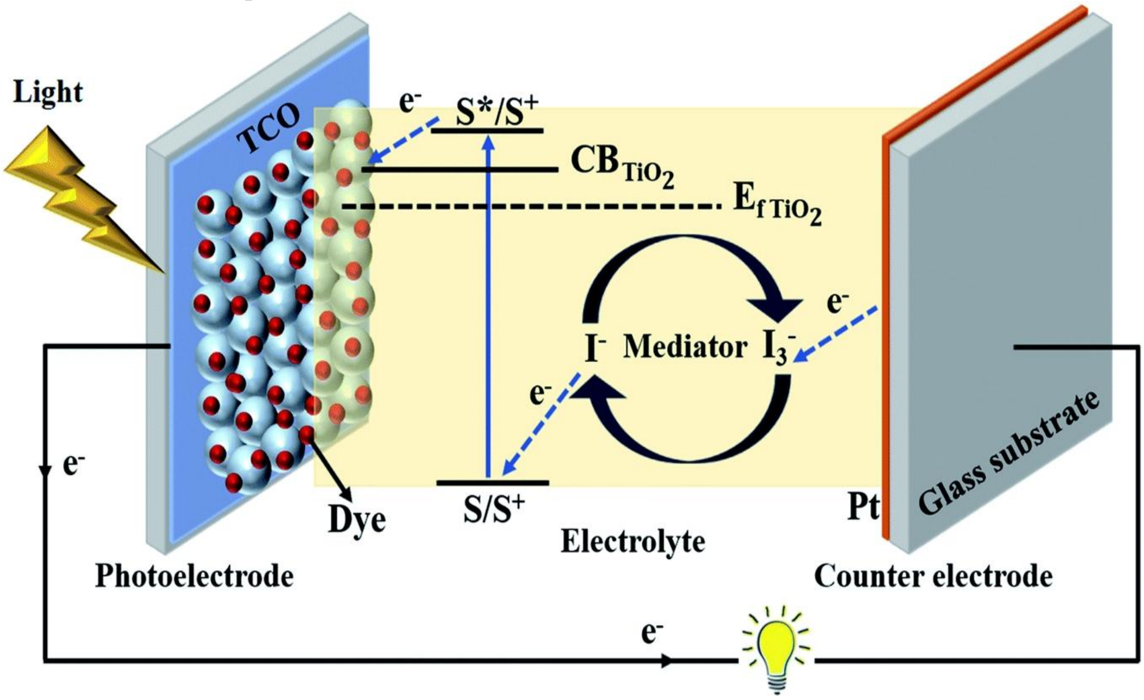

Figure.3. Schematic representation of a dye sensitized solar cell

Utilizing the Co-sensitization technique is another option to improve DSSC efficiency. To make the most of the incident spectrum, two or more sensitising dye agents with varied absorption across a broad solar spectrum are combined. Inorganic dyes frequently contain metal complexes made from heavy metals including ruthenium (Ru), osmium (Os), and iridium (Ir).

Conclusions

In this century, global warming has emerged as a major worry.

Conventional fuels' negative environmental effects, the energy crisis, the erratic price of oil, and the security and safety of energy sources had paved the way for the global energy sector's transformation. Using clean energy, such as solar energy, will help the world's traditional energy system become less carbon-intensive. For the conversion of energy into electricity, hybrid energy systems like solar and wind energy may be used. The solar cell industry has evolved as a result of remarkable solar cell technologies as thin film solar cells, dye sensitised solar cells, multi-junction solar cells, and perovskite solar cells. Additionally, it is crucial to keep developing non-traditional, outdoor-compatible instruments in order to lower PV electricity costs and meet the demands of additional consumers using a variety of materials and technologies.

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