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A review of thin film solar cell

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ABSTRACT*:*

Due to the recent surge in silicon demand for solar modules, thin-film photovoltaic modules have an opportunity to join the market in considerable numbers. For the corresponding technologies, the dependability, accessibility of cell materials, and comparison of various attributes are all examined. A few crucial elements and solutions for future development are also highlighted with regard to the new solar cell technology. The condensed section of this comparison study aims to assist readers in understanding potential research areas taking into account appropriate solar cell production and application methods.

KEYWORDS: Thin film, Solar cells, dependability, accessibility

INTRODUCTION

Currently, amorphous silicon thin film, cadmium telluride (CdTe), copper indium selenium (CIS), copper indium gallium selenium (CIGS), gallium arsenide, and copper zinc tin sulfur (Cu2ZnSnS4 is referred to as CZTS) are currently the main thin film solar cells. Gallium arsenide and cadmium telluride both contain toxic elements (cadmium and arsenic), while copper in The CZTS is a quaternary compound with a stannite structure, and its band gap is roughly 1.50 eV, which is extremely close to the ideal band gap needed by semiconductor solar cells (1.35 eV).

CZTS can be used in the absorption layer of thin film solar cells because it is a straight band gap semiconductor material with a high absorption coefficient and a multilayer structure. Nontoxic and environmentally friendly CZTS thin film solar cells are one of the best candidate materials for solar absorbing layer [1-5], which is probable to become the perfect preoccupation layer material of next group thin film solar cells. This is in comparison to the currently commercialized crystalline silicon CdTe CIGS due to its abundant component elements in the earth crust.

Because of the success of First Solar and the largely unfulfilled promise of lower cost and flexibility, thin-film solar technologies have seen significant investment.

Compared to wafer silicon cells, they are less efficient, but because of their higher area consumption per watt produced and lower efficiency, they have not yet entered the mainstream of solar products. Amorphous silicon (A-Si), Copper Indium Gallium Selenide (CIGS), and Cadmium Telluride (CdTe) are three thin-film technologies that are frequently utilized to produce photovoltaic energy outdoors. Among these, CdTe technology is the most cost-effective. In 2011, CdTe technology is around 30% less expensive than CIGS technology and 40% less expensive than A-Si technology. Using data from both types of solar cells (conventional silicon cells and CdTe cells), this study demonstrates that thin-film solar cells like CdTe [6].

The dependency on sputtering vacuum-based processes, which are expensive and restrict the core idea of low-cost manufacturing for large-scale production capacity, is the problem with conventional window layers. In order to realize the high-quality and affordable manufacturing process, an alternative deposition technique using solution-based techniques for the window layer is discussed and reviewed. The overview and outlook of the various modification techniques used in each layer [7].

The main drawbacks of the CdTe thin film, on the other hand, include its high work function (5.7 eV) and resistivity. its impact on the semiconductor-metal junction. Finding a metal with a metal work function larger than the CdTe is necessary to change the metal-semiconductor junction. The homojunction of CdTe-based thin films has a greater recombination speed. The characteristics of optoelectronic devices are decreased by a higher recombination rate. One of the greatest ways to overcome this problem is via heterojunction thin film. One of the best heterojunctions, CdS/CdTe is frequently employed in solar cell applications [8-9]

However, research has shown that the performance of metal-insulator-semiconductor Schottky junction solar cells is enhanced by thin insulating layers between the metal and semiconductors. Due to the possibility of minority carriers tunneling over this thin insulating layer, such as silicon dioxide, electron-hole pair recombination and dark current rates can be reduced [10]. The main distinction between pn junction and Schottky junction solar cells is that Schottky junction is created by joining metal and semiconductor, whereas pn junctions are typically created by joining dissimilar semiconductors.

Thin film solar cells

A single or several thin layers of PV elements are used to create thin-film solar cells (TFSCs), a second-generation technology, on a glass, plastic, or metal substrate. The film's thickness can range from a few nanometres to tens of micrometres, making it noticeably thinner than its rival, the conventional first-generation c-Si solar cell (wafers that are about 200 m thick). Because of this, thin-film solar cells are flexible, lighter, and have little abrasion resistance [11].

Algorithm of a-Si

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For single-junction or micromorph (tandem) structures, this solar cell with a random crystal structure is often built on a glass substrate made of fluorine (F)-doped tin oxide (SnO2:F) or periodically (honeycomb)-textured substrate (HTS). Typically, silver and gallium doped zinc oxide coatings are applied to the substrate in that order to decrease reflective loss and boost conductivity. Then, using CO_2, phosphine (PH_3), diborane (B_2H_6), silane (SiH4), and hydrogen as dopant gases, a diode or triode plasma-enhanced chemical vapor deposition process is typically used to deposit hydrogenated-Si [12]. This is followed by the deployment of a transparent conducting oxide (TCO) film, commonly made of indium tin oxide (In_2O_3:Sn), as the front window. A moth-eye-based anti-reflection coating can then be added to enhance cell performance.

Thin film evaporation techniques

Using a process called thin film deposition, surfaces can be covered with layers of material as thin as a few atoms or as thick as 88 micrometres. Additionally, it can be used to add layers over already applied coatings. The manufacture of thinning out films is the foundation of the semiconductor, photovoltaic, CD, disc drive, and optical device industries of today.

Thin film substrates and their qualities

Thin films are frequently constructed on substrates made of polymer, cloth, or paper as well as nanoparticles with intricate architectural structures. Due to limitations in their geometries, these substrates display various physical characteristics. Additionally, polymers and nanoparticles can self-assemble into a variety of nanostructures and patterns [13]. As a result, it provides a variety of affordable nanofabrication techniques that are used in several applications, including nanoelectronics and biomedical ones.

spray-on coating

The printing ink is run through a nozzle to create a fine aerosol spray coating method. The creation of light-absorbing perovskite thin films employing the spray coating technique. Using this method, produced photocatalytic graphene-TiO2 thin films. Graphene oxide thin films utilizing spray coating [14].

Resources and Procedures

Visualization of Similarities in this Study The Leiden University Center for Science and Technology Studies' Viewer Software is used to map the bibliographic data of publications [15]. An open-source computer program was created and is marketed under the name viewer. The viewer program can synthesize vast amounts of data into maps that are simple to understand and is particularly powerful for graphical display of maps. Co-citation is the frequency with which two documents are cited together by a third document and it is an indication that the articles. With the help of this software, the influence of co-authorship, co-occurrence, bibliographic coupling, and co-citation on authors, organizations, and regions can be studied for various publications.

Sample of thin film and coating

Due to the unique structure of thin film and coating with longitudinal delamination, the Nano scratch test is preferred. Nano scratch testing is frequently used to evaluate the mechanical properties of thin films and coatings, such as abrasion resistance and adhesion. Carbide or carbon-based films are frequently used as a protective coating due to their excellent wear resistance and high hardness [16-20].

For terrestrial applications

Various thin-film photovoltaic technologies have been researched and produced. The ones that have the biggest potential to drastically lower manufacturing costs are already on the market. Which are:

Copper Indium Gallium Diselenide/Sulfide (CIGS)
Amorphous Silicon (a-Si)
Silicone thin film (Si-film)
Cadmium Telluride (CdTe).

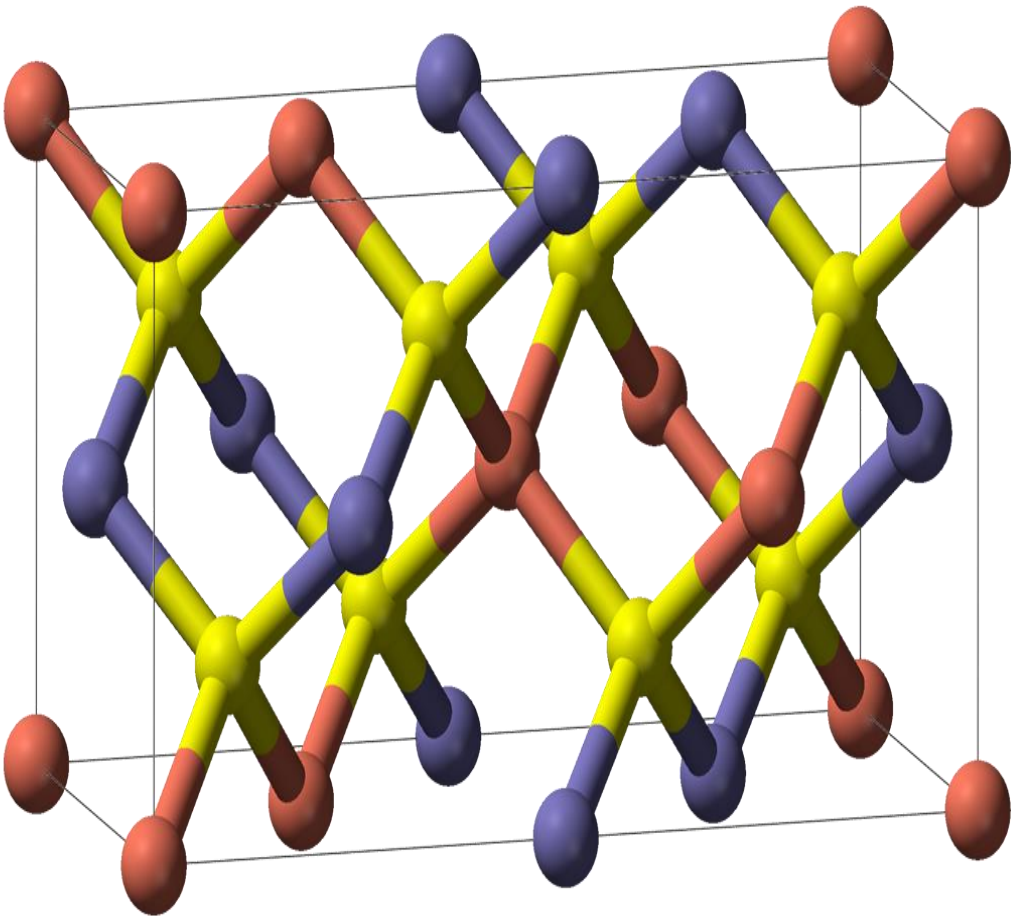

Figure 1 Copper Indium Gallium Diselenide/Sulfide (CIGS)

Figure 2 Amorphous Silicon (a-Si)

Figure 3 Silicone thin film (Si-film)

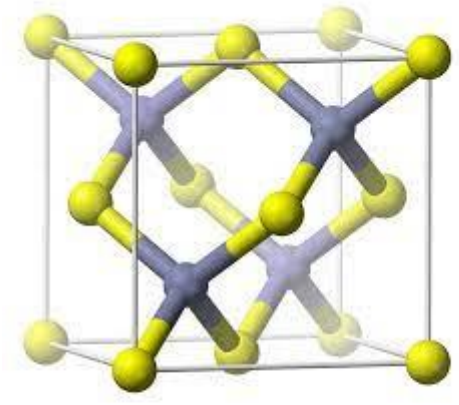

Figure 4 Cadmium Telluride (CdTe).

Conclusion

Solar power is a clean, sustainable, and free of pollution energy source. The development of this energy source demands a precise, in-depth understanding of the potential, taking seasonal fluctuations into consideration. The experimental tools and the models developed in this work allowed for a profound understanding of the sequential growth process of $CuInS_2$ thin and for the identicaction of grain boundary union as the determining factor for the incorporation of Ga and the resulting Ga-depth.

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