A Survey on Cigs Solar Cell Technology

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***Abstract* - Thin film solar cells are favorable because of their minimum material usage and rising efficiencies. The three major thin film solar cell technologies include amorphous silicon (α-Si), copper indium gallium selenide (CIGS), and cadmium telluride (CdTe). In this paper, the evolution of each technology is discussed in both laboratory and commercial settings, and market share and reliability are equally explored. The module efficiencies of CIGS and CdTe technologies almost rival that of crystalline solar cells, which currently possess greater than 55% of the market share. α-Si is plagued with low efficiency and light-induced degradation, so it is almost extinct in terrestrial applications. CIGS and CdTe hold the greatest promise for the future of thin film. Longevity, reliability, consumer confidence and greater investments must be established before thin film solar cells are explored on building integrated photovoltaic system.**

***Keywords* - Thin Film, CIGS, Solar Cells, Copper, Consumers.**

I. INTRODUCTION

Thin-film solar cell, type of device that is designed to convert light energy into electrical energy (through the photovoltaic effect) and is composed of micron-thick photon-absorbing material layers deposited over a flexible substrate. Thin-film solar cells were originally introduced in the 1970s by researchers at the Institute of Energy Conversion at the University of Delaware in the UnitedStates.

The technology continuously improved so that in the early 21st century the global thin-film photovoltaic market was growing at an unprecedented rate and was forecast to continue to grow. Several types of thin-film solar cells are widely used because of their relatively low cost and their efficiency in producing electricity

1. Types of Thin-Film Solar Cells

Cadmium telluride thin-film solar cells are the most common type available. They are less expensive than the more standard silicon thin-film cells. Cadmium telluride thin-films have a peak recorded efficiency of more than 18 percent (the percentage of photons hitting the surface of the cell that are transformed into an electric current). By 2014 cadmium telluride thin-film technologies had the smallest carbon footprint and quickest payback time of any thin-film solar cell technology on the market (payback time being the time it takes for the solar panel's electricity generation to cover the cost of purchase and installation).

Copper indium gallium selenide (CIGS) is another type of semiconductor used to manufacture thin-film solar cells. CIGS thin-film solar cells have reached 20 percent efficiency in laboratory settings and 14 percent efficiency in the field, making CIGS a leader among alternative cell materials and a promising semiconducting material in thin-film technologies. CIGS cells traditionally have been more costly than other types of cells on the market, and for that reason they are not widely used.

Gallium arsenide (GaAs) thin-film solar cells have reached nearly 30 percent efficiency in laboratory environments, but they are very expensive to manufacture. Cost has been a major factor in limiting the market for GaAs solar cells; their main use has been for spacecraft and satellites.

Amorphous silicon thin-film cells are the oldest and most mature type of thin-film. They are made of no crystalline silicon, unlike typical solar-cell wafers. Amorphous silicon is cheaper to manufacture than crystalline silicon and most other semiconducting materials. Amorphous silicon is also popular because it is abundant, nontoxic, and relatively inexpensive. However, the average efficiency is very low, 10 percent.

2. Applications Of Thin-Film Solar Cells

Applications of thin-film solar cells began in the 1980s with small strips that were used for calculators and watches. Throughout the early 21st century the potential for thin-film applications increased greatly, because of their flexibility, which facilitates their installation on curved surfaces as well as their use in building-integrated photo voltaics. However, standard and rigid photovoltaic's, such as classic crystalline silicon panels, outperform thin-films in efficiency. With the exception of cadmium telluride thin-films, nonflexible photovoltaic cells have faster payback times, and their construction is more durable, which has advantages in many applications. The advantages of both types of solar cells raise two questions: What does the consumer or client prefer? and Which type will perform best for a particular application?

As thin-film solar cells continue to improve in efficiency, it is predicted that they could overtake the classic inflexible photovoltaic technologies that have been in use since the mid-20th century. Sheets of thin-films may be used to generate electricity increasingly in places where other photovoltaic cells cannot be used, such as on curved surfaces on buildings or cars or even on clothing to charge handheld devices. Such uses could help to achieve a sustainable energy future.

3. CIGS solar cell Technology

CIGS solar cell, in full copper indium gallium selenide solar cell, thin-film photovoltaic device that uses semiconductor layers of copper indium gallium selenide (CIGS) to absorb sunlight and convert it into electricity. Although CIGS solar cells are considered to be in the early stages of large-scale commercialization, they can be produced by using a process that has the potential to reduce the cost of producing photovoltaic devices. As the performance, uniformity, and reliability of CIGS products improve, the technology has the potential to expand its market share significantly and may eventually become a "disruptive" technology. Additionally, given the hazards of cadmium extraction and use, CIGS solar cells offer fewer health and environmental concerns than the cadmium telluride solar cells with which they compete.

CIGS solar cells feature a thin film of copper indium selenide and copper gallium selenide and a trace amount of sodium. That CIGS film acts as a direct bandgap semiconductor and forms a hetero junction, as the bandgaps of the two different materials are unequal. The thin-film cell is deposited onto a substrate, such as soda-lime glass, metal, or a polyamide film, to form the rear surface contact. If a nonconductive material is chosen for the substrate, a metal such as molybdenum is used as a conductor. The front surface contact must be able to conduct electricity and be transparent to allow light to reach the cell. Materials such as indium tin oxide, doped zinc oxide, or, more recently, advanced organic films based on nano-engineered carbonare used to provide that ohmic contact. The cells are designed so that light enters through the transparent front ohmic contact and is absorbed into the CIGS layer.

There electron-hole pairs are formed. A "depletion region" is formed at the heterojunction of the p- and n-type materials of the cadmium-doped surface of the CIGS cell. That separates the electrons from the holes and allows them to generate an electrical current (see also solar cell). In 2014, laboratory experiments produced a record efficiency of 23.2 percent by a CIGS cell with a modified surface structure. However, commercial CIGS cells have lower efficiencies, with most modules attaining about 14 percent conversion.

During the manufacturing process, the deposition of CIGS films onto a substrate is frequently done in a vacuum, using either an evaporative or a sputtering process. Copper, gallium, and indium are deposited in turn and annealed with a selenide vapor, resulting in the final CIGS structure. Deposition can be done without a vacuum, using nanoparticles or electroplating, though those techniques require more development to be economically efficient at a large-scale. Novel approaches are being developed that are more similar to printing technologies than traditional silicon solar-cell fabrication. In one process, a printer lays droplets of semiconducting ink onto an aluminum foil. A subsequent printing process deposits additional layers and the front contact on top of that layer; the foil is then cut into sheets.

CIGS solar cells can be manufactured on flexible substrates, which makes them suited for a variety of applications for which current crystalline photovoltaic's and other rigid products are not suitable. For example, flexible CIGS solar cells give architects a greater range of possibilities in styling and design. CIGS solar cells are also a fraction of the weight of silicon cells and can be manufactured without glass to be shatter-resistant. They can be integrated into vehicles such as tractor trailers, airplanes, and cars, as their low profile minimizes air resistance and they do not add significant weight.

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