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STUDYING ABOUT DIFFERENT CLASSIFICATION OF SOLAR CELLS AND THEIR USES

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ABSTRACT

One way that sunlight may be turned into energy is via the use of solar cells, which are electrical devices. Light striking the solar cell causes it to create both a current and a voltage. This procedure necessitates, first, a solar cell made of a material whose electrons are excited to a higher energy state upon light absorption, and second, the transfer of this excited electron from the solar cell to an external circuit. Once the electron has lost its kinetic energy in the external circuit, it is free to return to the solar cell. Photovoltaic energy conversion may be accomplished using a wide range of materials and procedures, but in reality, the vast majority of photovoltaic energy conversion makes use of semiconductor materials in the form of a p-n junction. In this article, we will examine the many kinds of solar cells and the uses to which they may be put in the context of the advancement of renewable energy sources like solar power.

Keywords: - Solar cell, Solar Energy, Power, Application, Silicon

I. INTRODUCTION

Solar energy that reaches Earth in vast quantities. The Sun is a fusion reactor that has been continuously burning for almost 4 billion years. In only one minute, it generates enough power to meet global demand for a whole year. It generates as much power in 24 hours as our existing population needs in 27 years. As a matter of fact, "the amount of solar radiation striking the earth over a three-day period is equivalent to the energy stored in all fossil energy sources." Solar energy is a renewable resource that may be used without cost and will never run out. As stated in the article, "the first practical solar cells were made less than 30 years ago," so we have gone a long way. There is no longer any reason not to consider solar electricity for your house, given the proliferation of solar professional firms developing customized and bespoke solar power systems for individual homes. Increases in productivity were most noticeable with the development of the transistor and related semiconductor technologies. Photovoltaic solar energy has a number of benefits that make it "one of the most promising renewable energy sources in the world." It produces no waste, causes no pollution, can run for 20–30 years with no upkeep and oversight, and costs very little to operate. It's one of a kind since there's no need for a massive infrastructure overhaul. It is simple for outlying regions to generate their own power by erecting a system of any size. Distributing solar energy generators is easy, and once installed in a house, school, or company, they are safe to use and make very little noise. More solar power generation capacity may be added as populations increase. Today, the fastest-growing market for photovoltaics is in developing nations, where solar power is in high demand. The lack of access to electricity during daylight hours makes solar power the most viable option. "Governments are finding its modular, decentralized character ideal for fulfilling the electric needs of the thousands of remote villages in their countries."

It's a lot more realistic than extending pricey power lines to outlying locations where people don't have the money to pay for regular energy. Limitations in available sunlight and initial investment are the only real drawbacks of solar energy. The quantity of sunshine a place gets "varies greatly" based on factors such latitude, season, time of day, and cloud cover. In this post, we'll look at the many kinds of solar cells since harnessing solar energy efficiently is crucial.

II. TYPES OF SOLAR CELLS AND APPLICATION

Solar cells are typically named after the semiconducting material they are made of. These materials must have certain characteristics in order to absorb sunlight. Some cells are designed to handle sunlight that reaches the Earth's surface, while others are optimized for use in space. Solar cells can be made of only one single layer of light-absorbing material (single-junction) or use multiple physical configurations (multi-junctions) to take advantage of various absorption and charge separation mechanisms. Solar cells can be classified into first, second and third generation cells. The first generation cells—also called conventional, traditional or wafer-based cells—are made of crystalline silicon, the commercially predominant PV technology, that includes materials such as polysilicon and monocrystalline silicon. Second generation cells are thin film solar cells, that include amorphous silicon, CdTe and CIGS cells and are commercially significant in utility-scale photovoltaic power stations, building integrated photovoltaics or in small standalone power system.

The third generation of solar cells includes a number of thin-film technologies often described as emerging photovoltaics—most of them have not yet been commercially applied and are still in the research or development phase. Many use organic materials, often organometallic compounds as well as inorganic substances.

Despite the fact that their efficiencies had been low and the stability of the absorber material was often too short for commercial applications, there is a lot of research invested into these technologies as they promise to achieve the goal of producing low-cost, high-efficient solar cells.

1. Amorphous Silicon Solar Cell (A-Si)

Amorphous silicon (a-Si) is the non-crystalline form of silicon. It is the most well-developed of the thin film technologies having been on the market for more than 15 years. It is widely used in pocket calculators, but it also powers some private homes, buildings, and remote facilities. United Solar Systems Corp. (UniSolar) pioneered amorphous-silicon solar cells and remains a major maker today, as does Sharp and Sanyo. Amorphous silicon panels are formed by vapor-depositing a thin layer of silicon material – about 1 micrometer thick – on a substrate material such as glass or metal. Amorphous silicon can also be deposited at very low temperatures, as low as 75 degrees Celsius, which allows for deposition on plastic as well. In its simplest form, the cell structure has a single sequence of p-in layers. However, single layer cells suffer from significant degradation in their power output (in the range 15-35%) when exposed to the sun. The mechanism of degradation is called the StaeblerWronski Effect, after its discoverers. Better stability requires the use of a thinner layers in order to increase the electric field strength across the material. However, this reduces light absorption, hence cell efficiency.

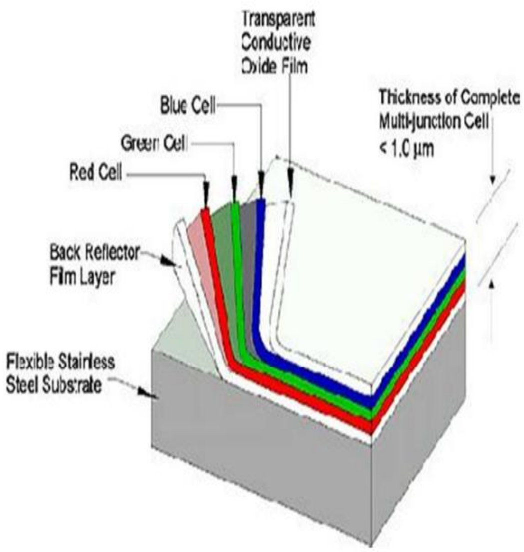

Figure 1. Amorphous silicon is Uni-Solar. They use a triple layer system.

2. Biohybrid Solar Cell

A biohybrid solar cell is a solar cell made using a combination of organic matter (photosystem I) and inorganic matter. Biohybrid solar cells have been made by a team of researchers at Vanderbilt University. The team used the photosystem I (a photoactive protein complex located in the thylakoid membrane) to recreate the natural process of photosynthesis to obtain a greater efficiency in solar energy conversion. These biohybrid solar cells are a new type of renewable energy.

3. Buried Contact Solar Cell

The buried contact solar cell is a high efficiency commercial solar cell technology based on a plated metal contact inside a laser-formed groove. The buried contact technology overcomes many of the disadvantages associated with screen-printed contacts and this allows buried contact solar cell to have performance up to 25% better than commercial screen-printed solar cells. A schematic of a buried contact solar cell is shown in the figure below.

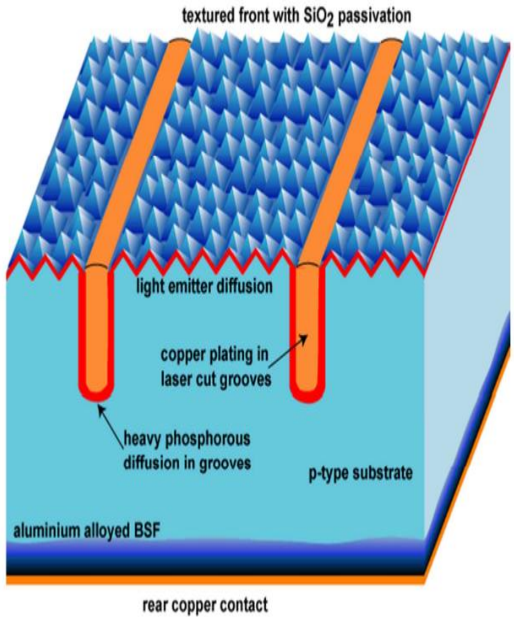

Figure 2. Cross-section of Laser Grooved, Buried Contact Solar Cell.

4. Cadmium Telluride Solar Cell (CdTe)

Cadmium telluride (CdTe) photovoltaics describes a photovoltaic (PV) technology that is based on the use of cadmium telluride, a thin semiconductor layer designed to absorb and convert sunlight into electricity.[10] Cadmium telluride PV is the only thin film technology with lower costs than conventional solar cells made of crystalline silicon in multi-kilowatt systems.

5. Toxicity of Cadmium

Cadmium is one of the top 6 deadliest and toxic materials known. However, CdTe appears to be less toxic than elemental cadmium, at least in terms of acute exposure.

This is not to say it is harmless. Cadmium telluride is toxic if ingested, if its dust is inhaled, or if it is handled improperly (i.e. without appropriate gloves and other safety precautions).

The toxicity is not solely due to the cadmium content. One study found that the highly reactive surface of cadmium telluride quantum dots triggers extensive reactive oxygen damage to the cell membrane, mitochondria, and cell nucleus. In addition, the cadmium telluride films are typically recrystallized in a toxic compound of cadmium chloride.

The disposal and long term safety of cadmium telluride is a known issue in the large-scale commercialization of cadmium telluride solar panels. Serious efforts have been made to understand and overcome these issues.

III. CLASSIFICATION OF SOLAR CELL BASED ON DIFFERENT MATERIALS

Solar cells may be divided into three varieties depending on the materials they are formed of: silicon semiconductor, semiconductor compound, and other material based solar cells. Figure 1.3 displays the comprehensive material-based categorization.

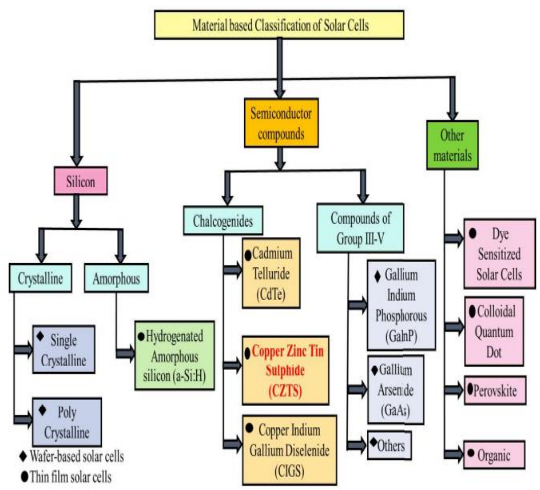

Figure 3. Classification flow diagram of solar cell based on different materials

1. Silicon Semiconductor Type Solar Cells

Silicon based solar cells can be classified into three types:

- **Monocrystalline Silicon (Mono c-Si) Solar Cells**

Wafers are used to construct these solar cells from a single, large silicon crystal that has been grown in a lab. Wafers may reach widths of up to 200 m. These cells may be the oldest technology, yet they are still widely used in homes and businesses because to their reliability and efficiency. Monocrystalline silicon cells are uniformly black in color and soon lose efficiency at temperatures above 25 oC because they absorb the vast majority of the sun's spectral energy. Their productivity plummets as a consequence.

- **Polycrystalline Silicon (Poly c-Si) Solar Cells**

Wafers made of polycrystalline silicon are cultivated by simultaneously expanding a large number of individual silicon crystals. These cells are less costly to produce than monocrystalline silicon cells, although being somewhat less effective.

- **Amorphous Silicon Solar Cells**

Amorphous silicon is one material used in thin-film solar cells. A substrate composed of glass, metal, or plastic is covered with a very thin layer of silicon. Sometimes, silicon is formed into many layers and then doped with different chemicals to boost performance. These solar cells are versatile enough to be installed in different orientations. However, the efficiency of amorphous silicon cells is much lower than that of monocrystalline and polycrystalline cells.

2. Compound Semiconductors

Compounds with two or more elements form semiconductors. Although group IV elements are the most common semiconductors in solar cell devices, compounds from groups III and V, as well as compounds from groups II and VI, are also often used. Most semiconductors in this category are either ternary compounds, such as CZTS and CZTSSe (kesterites), or binary compounds, such as GaAs and GaP, or compounds, such as CdTe and CIGS (chalcopyrites) and groups I and IIIVI of the periodic table. In solar cells, these semiconductors are used in the second and third generation.

GaAs is comparable in structure to monocrystalline silicon and has a high absorption coefficient and an adequate band gap. It's perfect for concentrated photovoltaic since it's efficient and works well at higher temperatures. Since it is so expensive to manufacture, GaAs is often reserved for sectors like space applications.

Several of these compounds are used in thin-film photovoltaic systems, and they include cadmium telluride (CdTe), kesterites (CZTS), and copper indium gallium selenide (CIGS). These solar cells are lightweight and flexible because the semiconductors are employed in sheets with thicknesses varying from a few nanometers to tens of micrometers. Since their absorption coefficients are higher than those of other crystalline semiconductors, just a very thin layer of these materials is needed to effectively absorb sunlight. CdTe and CIGS solar cells are very efficient, with conversion efficiencies of up to 21%. There are a few major issues with these cells despite the fact that they function effectively and are cheap to create. These cells contain significant amounts of elements that are either uncommon, expensive, or potentially harmful, such as indium and cadmium. However, solar cells based on kesterites may achieve both high conversion efficiency and low manufacturing costs. Sulfur-selenium alloy (CZTSSe), selenide (CZTSe), and copper-zinc-tin sulfide (CZTS) have all been the focus of extensive study. Kesterites have a high absorption coefficient and a changeable bandgap, making them an attractive material for solar cells.

3. Other Material based Solar Cells

Solar cell technologies based on novel materials and barriers other than the standard p-n junction barrier have been the subject of ongoing research. Quantum dot cells, perovskite, DSSCs, organic, or polymer solar cells are only few of the emerging cell technologies being researched to generate inexpensive and highly effective solar gadgets. Quantum dots in quantum dot cells employ nanotechnology to control the size of semiconducting materials. Nanoparticles (composed of less than 10,000 atoms) may be engineered to absorb all visible light by tailoring their size. Despite quantum dot cells' great theoretical efficiency, their performance in laboratory tests has been disappointing thus far. Another potential technique is perovskite solar cells, which are built from the same material as tin halide or hybrid organic-inorganic lead but have a different crystal structure. Despite their short lifespan, they are quite cheap to manufacture and perform as efficiently as commercially available silicon cells. Organic solar cells have the potential to be manufactured at a low cost, much like their inorganic counterparts. By adjusting the polymers' functional group, the cell's band gap may be made more or less flexible, which is a boon to its electrical performance. However, the efficiency of organic solar cells remains low.

IV. USES OF SOLAR CELL

Biogas solar cells are easily transportable, long-lasting, and cheap to maintain. It was originally put to use in communication satellites in 1950, after its discovery. Let's have a look at some practical uses for solar cells: The many uses of solar cells are as follows:

- Transportation
- Solar cells in calculators
- Solar cell panels
- Solar cell advantages

1. Solar Cell for Transportation

Automobiles can run on solar power. Photovoltaic cells are the solar energy generators. This energy is either stored in a battery or used to power the vehicle's engine. The first solar-powered automobile was created by Ed Passerini. In 1977, the first motorized vehicle was introduced.

2. Solar Cells in Calculators

Photovoltaic cells are the solar energy source for calculators. These calculators can be powered by the sun. Solar energy is used to power devices like calculators. Solar-powered calculators perform well under bright sunlight.

3. Solar Cell Panels

Solar panels are stored up there, on the roof. It's a solar water heater, and you can use it to warm up your shower. You may take a relaxing soak with this water. It also has a role to play in the production of electricity. This energy may be stored in a backup battery and used in the event of a power outage. Alternatively, this energy may be stored and used to create power in the home, lowering the household's reliance on the grid and so saving money.

4. Solar Cell Advantages

Solar power is a sustainable resource. Helps you save cash by decreasing your monthly power costs. Since upkeep is straightforward and cheap, costs are similarly modest. It's a great replacement for fossil fuels and other nonrenewable energy sources.

V. CONCLUSION

In the present research, the use of Ag, Au, and Cu nanoparticles to enhance the solar cell's light harvesting performance was investigated. The metal nanoparticles used in this study were synthesized by a simple, low-cost two-electrode electrodeposition technique. Surface plasmon resonance (SPR) was shown to be influenced by the particle size, the surrounding dielectric environment, and the interparticle spacing of these metal nanoparticles. Therefore, experimental efforts were made to maximize these features while making and evaluating the nanoparticles, such that after being inserted in the solar cell, they would mostly exhibit the SPR effect in the visible and NIR parts of the solar spectrum. After optimally incorporating Ag, Au, and Cu nanoparticles, the performance of the resulting TiO2/CdS QDSSC type of solar cell was assessed. Photogenerated current, open circuit voltage, fill factor, and efficiency all saw notable boosts in the solar cell's electrical assessment. The SPR effect of the solar cell's metallic nanoparticles is mostly to blame for this. The present research has the potential to make important contributions to the photovoltaic, optoelectronic, biosensor, etc. industries.

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