PHOTOVOLTAIC SYSTEM IN RESEARCH

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ABSTRACT today's crisis in the field of energy supplies, environmental control, population increase, poverty and shortage of food and materials are closely interrelated. It is gradually realized that they demand a holistic, systematic and integrated approach to deal with. Energy from sun. The sun gives out 3.7 × 10^26 watt of power in to space, out of which the earth intercepted is equivalent to1.7 × 10^17 watt. Solar energy emitted by sun within three minutes is equal to the world energy consumption during a year. Photovoltaic (PV) panels use silicon cells, which transform solar radiation into direct current. The energy is used simultaneously (for example to pump water) or is stored in batteries to provide electricity.

Keywords: solar energy, solar cell, photovoltaic cell,silicon , glass, reneawable.

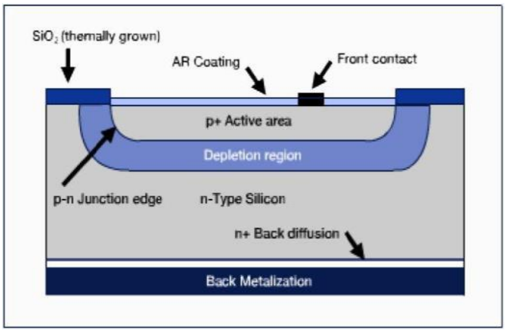
1. INTRODUCTION

A photovoltaic system converts light into electrical direct current (DC) by taking advantage of the photoelectric effect Solar PV has turned into a multi-billion, fast-growing industry, continues to improve its cost-effectiveness, and has the most potential of any renewable technologies together with CSP. Concentrated solar power (CSP) systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Commercial concentrated solar power plants were first developed in the 1980s. CSP-Stirling has by far the highest efficiency among all solar energy technologies.

In 2011, the International Energy Agency said that "the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries' energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating climate change, and keep fossil fuel prices lower than otherwise. These advantages are global. Hence the additional costs of the incentives for early deployment should be considered learning investments; they must be wisely spent and need to be widely shared Though the solar energy is freely available everywhere, there is still an initial expenditure on the equipment for harvesting this radiant energy by developing solar cells, panels and modules . These small and tiny solar cells produce no noise during their operation. On the other hand, the big power pumping devices produce un- bearable sound pollution, and therefore they are very disturbing to the society Nowadays, due to the de- creasing amount of renewable energy resources, the per watt cost of solar energy device has become more important in the last decade, and is definitely set to become economical in the coming years and grow as better technology in terms of both cost and applications.

2. THE WORKING MECHANISM

The working mechanism of solar cells is based on the three factors: (1) Adsorption of



light in order to generate the charge careers, holes (p-type) and electrons (n-type) (2) Separation of charge careers, and (2) the collection of charge careers at the respective electrodes establishing the potential difference across the p-n junction. The generation of voltage difference noticed at the p-n junction of the cell in response to visible radiation is utilized to do the work

The p-n junction and the depletion region are of major importance to the operation of a photodiode.

These photodiode regions are created when the p-type dopant with acceptor impurities (excess holes), comes into contact with the n-type silicon, doped with donor impurities (excess electrons). The holes and the electrons, each experiencing a lower potential on the opposite side of the junction, begin to flow across the junction into their respective lower potential areas. This charge movement establishes a depletion region, which has an electric field opposite and equal to the low potential field, and hence no more current flows.

3. First Generation Solar Cell

Wafer Based

As it is already mentioned, the first generation solar cells are produced on silicon wafers. It is the oldest and the most popular technology due to high power efficiencies. The silicon wafer based technology is further catego-rized into two subgroups named as

- Single/ Mono-crystalline silicon solar cell.
- Poly/Multi-crystalline silicon solar cell.
- Monocrystalline silicon cells are the cells we usually refer to as silicon cells. As the name implies, the entire volume of the cell is a single crystal of silicon. It is the type of cells whose commercial use is more widespread nowadays (Fig. 8.18).
- The manufacturing process of the wafer, all of it, a single crystal of silicon, which will constitute the cell, begins by extracting the silicon from the sand.

In this first extraction process, silicon still contains a large number of unwanted impurities and we usually refer to it as metallurgical grade silicon. The subsequent refining process first involves manufacturing SiHCl 3 (trichlorosilane) with it, which in a first phase will still contain a large number of unwanted elements. This is done because SiHCl 3 is a liquid compound, with liquids being easier to purify than solids. After this purification process, SiHCl3 of high purity is obtained. Then it is necessary to "recover" the solid form of silicon. Mixing SiHCl3 with H2 and heating it gives polysilicon (solid) and HCl. This polysilicon, although it is more purified, still does not constitute a monocrystal. The final production of the monocrystal can be done by the process known as Czochralski. The final result is a circular bar of silicon (ingot, ingot), which can measure several meters and have a diameter of several inches. This bar, by means of a cutting process, is from which the wafers with which the monocrystalline silicon solar cells are manufactured are finally extracted. During the cutting processes of silicon a large amount of material is wasted (40%–50%)

- Multicrystalline silicon cells.
- Multicrystalline cells are produced using numerous grains of monocrystalline silicon. In the manufacturing process, molten polycrystalline silicon is cast into ingots, which are subsequently cut into very thin wafers and assembled into complete cells. Multicrystalline cells are cheaper to produce than monocrystalline ones because of the simpler manufacturing process required. They are, however, slightly less efficient, with average efficiencies being around 12%.
- Amorphous silicon.

The general characteristics of amorphous silicon solar cells are given, the main difference between these cells and the previous ones is that, instead of the crystalline structure, amorphous silicon cells are composed of silicon atoms in a thin homogenous layer. Additionally, amorphous silicon absorbs light more effectively than crystalline silicon, which leads to thinner cells, also known as a thin film PV technology. The greatest advantage of these cells is that amorphous silicon can be deposited on a wide range of substrates, both rigid and flexible. Their disadvantage is the low efficiency, which is on the order of 6%. Nowadays, the panels made from amorphous silicon solar cells come in a variety of shapes, such as roof tiles, which can replace normal brick tiles in a solar roof.

Thermophotovoltaics

These are photovoltaic devices that, instead of sunlight, use the infrared region of radiation, i.e., thermal radiation. A complete thermophotovoltaic (TPV) system includes a fuel, a burner, a radiator, a longwave photon recovery mechanism, a PV cell, and a waste heat recuperation system (Kazmerski, 1997). TPV devices convert radiation using exactly the same principles as photovoltaic devices, outlined in previous sections. The key differences between PV and TPV conversion are the temperatures of the radiators and the system geometries. In a solar cell, the radiation is received from the sun, which is at a temperature of about 6000 K and a distance of about 150 × 106 km. A TPV device, however, receives radiation, in either the broad or narrow band, from a surface at a much lower temperature of about 1300–1800 K and a distance of only a few centimeters. Although the blackbody power radiated by a surface varies at the fourth power of the absolute temperature, the inverse square law dependence of the power received by the detectors dominates. Therefore, although the power received by a non-concentrator solar cell is on the order of 0.1 W/cm2, that received by a TPV converter is likely to be 5–30 W/cm2, depending on the radiator temperature. Consequently, the power density output from a TPV converter is expected to be significantly greater than that from a non-concentrator PV converter. More details on TPVs can be found in the article by Coutts (1999).

- In addition to the above types, a number of other promising materials, such as cadmium telluride (CdTe) and copper indium diselenide (CuInSe2), are used today for PV cells. The main trends today concern the use of polymer and organic solar cells. The attraction of these technologies is that they potentially offer fast production at low cost in comparison to crystalline silicon technologies, yet they typically have lower efficiencies (around 4%), and despite the demonstration of operational lifetimes and dark stabilities under inert conditions for thousands of hours, they suffer from stability and degradation problems. Organic materials are attractive, primarily due to the prospect of high-output manufacture using reel-to-reel or spray deposition. Other attractive features are the possibilities for ultra-thin, flexible devices, which may be integrated into appliances or building materials, and tuning of color through the chemical structure (Nelson, 2002).

- Another type of device investigated is the nano-PV, considered the third-generation PV; the first generation is the crystalline silicon cells, and the second generation is amorphous silicon thin-film coatings. Instead of the conductive materials and a glass substrate, the nano-PV technologies rely on coating or mixing “printable” and flexible polymer substrates with electrically conductive nanomaterials. This type of photovoltaics is expected to be commercially available within the next few years, reducing tremendously the traditionally high costs of PV cells.

Third Generation Solar Cells

Third generation cells are the new promising technologies but are not commercially investigated in detail. Most of the developed 3rd generation solar cell types are [2]:

1) Nano crystal based solar cells.

2) Polymer based solar cells.

3) Dye sensitized solar cells.

4) Concentrated solar cells

Nano Crystal Based Solar Cells:-

Nanocrystal based solar cells are generally also known as Quantum dots (QD) solar cells. These solar cells are composed of a semiconductor, generally from transition metal groups which are in the size of nanocrystal range made of semiconducting materials. QD is just a name of the crystal size ranging typically within a few nanome- ters in size, for example, materials like porous Si or porous TiO_2, which are frequently used in QD [32]. The structure of the QD solar cells are shown in Figure 4 [10]. With the advance of nanotechnology, these nano- crystals of semiconducting material are targeted to replace the semiconducting material in bulk state such as Si, CdTe or CIGS. This idea of the QD based solar cell with a theoretical formulation were employed for the design of a p-i-n solar cell over the self-organized in As/GaAs system [32]. Generally, the nanocrystals are mixed into a bath and coated onto the Si substrate. These crystals rotate very fast and flow away due to the centrifugal force. In conventional compound semiconductor solar cells, generally a photon will excite an electron there by creating one electron-hole pair [33]. However, when a photon strikes a QD made of the similar semiconductor material, numerous electron-hole pairs can b
Polymer Solar Cells

Polymer solar cells (PSC) are generally flexible solar cells due to the polymer substrate. The first PSC were in- vented by the research group of Tang et al. at Kodak Research Lab. A PSC is composed of a serially con- nected thin functional layers coated on a polymer foil or ribbon. It works usually as a combination of donor (po- lymer) and a acceptor (fullerene). There are various types of materials for the absorption of sunlight, including organic material like a conjugate/conducting polyme In 2000, Heeger, MacDiarmid, and Shirakawa fetched the Nobel Prize in Chemistry for the discovering a new category of polymer materials known as con- ducting polymers The PSC and other organic solar cells operate on same principle known as the pho- tovoltaic effect, i.e., where the transformation of the energy occurs in the form of electromagnetic radiations into electrical current . Yu et al. mixedpoly [2-methoxy-5-(2’-ethylhexyloxy)-p-phenylene vinylene] (PPV), C60 and its other derivatives to develop the first polymer solar cell and obtained a high power conversion efficiency . This process triggered the development of a new age in the polymer materials for capturing the solar power. After significantly optimizing the parameters, researchers achieved efficiency over 3.0% for PPV type PSCs These unique properties of PSCs opened a new gateway for new applications in the formation of stretchable solar devices including textiles and fabricsA modern recycling concept known as polarizing organic photovoltaics (ZOPVs) was also developed for increasing the function of liquid crystal displays utilizing the same polarizer, a photovoltaic device and proper light conditions/solar panel

Dye Sensitized Solar Cells (DSSC)

Recent research has been focused on improving solar efficiency by molecular manipulation, use of nanotech-nology for harvesting light energy The first DSSC solar cell was introduced by Michel Gratzel in Swiss federal institute of technology DSSCs based solar cells generally employ dye molecules be- tween the different electrodes. The DSSC device consists of four components: semiconductor electrode (n-type TiO_2 and p-type NiO), a dye sensitizer, redox mediator, and a counter electrode (carbon or Pt). The DSSCs attractive due to the simple conventional processing methods like printing techniques, are highly flexible, trans- parent and low cost as well . The novelty in the DSSC solar cells arise due to the photosensitization of nano grained TiO_2 coatings coupled with the visible optically active dyes, thus increasing the efficiencies greater than 10%. However, there are certain challenges like degradation of dye molecules and hence stability issues. This is due to poor optical absorption of sensitizers which results in poor conversion efficiency. The dye molecules generally degrade after exposure to ultraviolet and infrared radiations leading to a decrease in the lifetime and stability of the cells. Moreover, coating with a barrier layer may also increase the manufacturing more expensive and lower the efficiency

Concentrated Solar Cells

Concentrating photovoltaic (CPV) has been established since the 1970s It is the newest technology in the solar cell research and development. The main principle of concentrated cells is to collect a large amount of solar energy onto a tiny region over the PV solar cell, as shown in . The principle of this technology is based on optics, by using large mirrors and lens arrangement to focus sunlight rays onto a small region on the solar cell. The converging of the sunlight radiations thus produces a large amount of heat energy. This heat energy is further driven by a heat engine controlled by a power generator with integrated. CPVs have shown their promising nature in solar world It ca n be classified into low, medium, and high concentrated solar cells depending on the power of the lens systems .Concentrating photovoltaic technology have the following merits, such as solar cell efficiencies >40%, absence of any moving parts, no thermal mass, speedy response time and can be scalable to a range of sizes.

Perovskite Based Solar Cell

Perovskites are a class of compounds defined by the formula ABX3 where X represents a halogen such as I−, Br−, Cl−. and A and B are cautions of different size. Perovskite solar cells are recent discovery among the solar cell research community and possess several advantages over conventional silicon and thin film based solar cells. Conventional Si based solar cells need expensive, multiple processing steps and require high temperatures (>1000˚C) and vacuums facilities. The perovskites based solar cells can have efficiency up to 31%. It can be predicted that these perovskites may also play an important role in next-generation electric automobiles batteries, according to an interesting investigation recently performed by Volkswagen .However, current issues with perovskite solar cells are their stability and durability. The material degrades over time, and hence a drop in overall efficiency. Therefore more research is needed to bring these cells into the market place.

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Advances in Energy Storage

Since the sunlight is not always available, all these businesses of PV solar cells may not work at night and a lot of electricity will go unused . Therefore energy storage is an important factor in solar cell market. A com- parison and summary of various types of solar cells is summarized in. Several energy storage devices are available in the market but those are highly expensive and a short life span. Recently, in 2014, Harvard University researchers developed a new type of battery based on organic molecules called Quinone. It is found in plants and is economical in a sense that it can store sunlight energy for a couple of days. The world’s first solar cell energy storage is introduced by Wu and his co-workers at Ohio State University. This device not only can store energy but can also reduce the costs of renewable energy by 25%, relying on a new aqueous, rechargeable lithium-oxygen battery used in sunlight.

4. CONCLUSION

There seems to be more of an interest in the forms of renewable energy these days than ever before. People from all walks of life are seeing the many benefits it can offer. What should be an indicator that we need to continue moving forward is that many of the underdeveloped countries out there use more renewable energy than the rest of us. While it is great that we have technology on our side, we need to always keep in mind what these products are doing to our environment. Global warming has always been a huge concern. The problem seems to continue to get worse though with the various types of pollution that are placed into the air. This is believed to be a key factor in the strange things that go on around us with the weather. Desert areas have seen rain and snow in recent years. Areas that get substantial rainfall are now in a drought. Several natural disasters including hurricanes, floods, and tornadoes continue to destroy everything in their path. As the governments out there as well as members of society continue to embrace what renewable energy has to offer it is likely that will start to come back into balance. There are plenty of major corporations out there leading the way as well. They want to set a very good example for others in the hopes that they will walk along the same path. As the cost of fuel for our vehicles continues to increase everyone is worried about it. As a result it makes searching for an alternative form of renewable energy that can be used in place of it. Some of the vehicles out there known as hybrids do all this to help. They use solar power the majority of the time and only switch to gasoline as a backup until more solar energy can be collected.

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