Solar Energy: In-depth review of solar cells

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Abstract

The Earth receives an incredible supply of solar energy. The sun, an average star, is a fusion reactor that has been burning over 4 billion years. It provides enough energy in one minute to supply the world's energy needs for one year. In a single day, it provides more energy than our current population would consume in 27 years. In fact, "The amount of solar radiation striking the earth over three days is equivalent to the energy stored in all fossil energy sources." Solar energy is a free, inexhaustible resource, yet harnessing it is a relatively new idea. Considering that the first practical solar cells were made less than 30 years ago, we have come a long way. A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. In this article, types of solar cells will be studied and their various applications.

Amorphous silicon (a-Si) solar cells.

Amorphous silicon (a-Si) is the non-crystalline form of silicon. It is the most improved type of thin-film technology that has been released in the last 15 years. The manufacture of amorphous silicon photovoltaic cells is based on plasma-enhanced chemical vapor deposition (PECVD), which can be used to produce silicon thin film. The substrate can be made of flexible and inexpensive material. It can also be at low temperature that allows the deposition on plastic as well.

"In its simplest form, the cell structure has a single sequence of p-i-n layers." Single layers could suffer from significant degradation in their power output. The mechanism of the degradation is called Staeble Wroski Effect that refers to the light-induced metastable changes in the properties of the hydrogenated amorphous silicon. As the defect in the density of hydrogenated amorphous silicon increases with high exposure causing an increase in recombination current and reducing the efficiency of the conversion of sunlight into electricity. In addition, to solve this problem, it is better to use multiple thin layers instead of one in order to increase the electric field strength across the material.

One of the pioneers of developing solar cells using amorphous silicon is Uni-Solar [1].

They use a triple layer system that is optimized to capture light from the full solar spectrum. The thickness of the solar cell is just 1 micron, or about 1/300th the size of mono-crystalline silicon solar cell because amorphous silicon features a high absorption capacity, the i-layer usually features a thickness of 0.2–0.5 μm. Its absorption frequency ranges between 1.1 and 1.7 eV, which is different from that of the silicon wafer, which has an absorption frequency of 1.1 eV. Unlike the crystal, the structural homogeneity of amorphous material is comparatively low.

Electrons and holes are conducted inside the material; therefore, within the case of long-distance conduction, there could also be a high composite probability of electricity. To avoid this phenomenon, the i-layer should not be too thick or too thin, because the latter problem can easily cause inadequate absorption. To overcome this predicament, a multilayer structured stack is usually utilized in the planning of amorphous silicon solar cells to realize a balance between the optical absorption and photoelectric efficiency. While crystalline silicon achieves a yield of about 18 percent, amorphous solar cells' yield remains at around 7% [2].

The low-efficiency rate is partly due to the Staebler-Wronski effect, which manifests itself in the first hours when the panels are exposed to sunlight, and results in a decrease in the energy yield of an amorphous silicon panel from 10 percent to around 7 percent. The principal advantage of amorphous silicon solar cells is their lower manufacturing costs, which makes these cells very cost-competitive [1].

Concentrated PV Cell (CVP and HCVP) following the sun.

A Concentrating electrical phenomenon (CPV) system converts light-weight energy into current within the same approach that typical electrical phenomenon technology well but uses a sophisticated optical system to focus an outsized space of sunlight onto every cell for optimum potency as shown in figure #1. Different CPV styles exist, generally differentiated by the concentration issue, like low-concentration (LCPV) and high concentration (HCPV). Concentrator photovoltaics' (CPV) could be an electrical phenomenon technology that generates electricity from daylight [3].

Contrary to standard electrical phenomenon systems, it uses lenses and mirrors to focus daylight, but extremely economical, multi-junction (MJ) star cells as shown in figure 1. Furthermore, CPV systems typically use star trackers and sometimes a cooling system to any increase their efficiency [4].

Current analysis and development are rapidly rising their fight within the utility-scale segment and in areas of high solar insulation. CPV technology has been around since the 70s. Recent technological advancements have enabled CPV to succeed in viability with ancient fuel plants, such as coal, gas, and oil, once put in regions of the world with sunny and dry climates. Concentrating photovoltaic systems work by changing sunlight into electricity past upside solar modules think about constant basic conception to come up with electricity [4].

Figure 1: representation of the structure of concentrated CPV.

CPV systems have utilized optical elements that concentrate important amounts of sunlight onto "multi-junction" solar cells. Particularly High concentrating electrical phenomenon (HCPV) systems have the potential to become competitive within the close to future. They possess the very best potency of all existing PV technologies, and a smaller electrical phenomenon array additionally reduces the balance of system prices. Currently, CPV is not utilized in the PV roof high segment and much less common than typical PV systems.

Concentrating electrical phenomenon (CPV) modules add abundant the same approach as past PV modules, except that they use optics to concentrate the sunlight onto solar cells that do not cover the whole module space. This concentration issue – in Semprius' case over one,100 times – dramatically reduces the amount of semiconductor required (<0.1 percent) and opens up the potential to cost-effectively use high-performance multi-junction cells efficiently levels greater than forty-one to figure properly, however, CPV modules should accurately face the sun.

Therefore, the CPV modules area unit utilized in conjunction with high-performance trackers that showing intelligence and mechanically follow the sun throughout the day. Aside from this, the CPV systems area unit designed and operate very like ancient PV systems [4].

References

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