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A study of solar cells and different types of solar cells

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Abstract
The solar cell technology originates from the year 1839. A French physicist Antoine-César Becquerel while experimenting with a solid electrode in an electrolyte solution, discovered the photovoltaic effect. During his experiments, he studied that when light falls upon an electrode, it can generate an electrical voltage. Some years later it was Charles Fritts who developed the solar cells in their true sense by coating semiconductor selenium with a very thin and almost transparent layer of gold some 50 years later. Fritts's devices were not very efficient, as they could only transform less than 1 percent of absorbed sunlight into electricity. According to today's parameters, these early solar cells capacity can be considered inefficient, but they broadened a vision of a free, abundant, and clean source of energy among many others. In 1927 a different metal-semiconductor junction solar cell, made of copper and copper oxide semiconductor was demonstrated.

Keywords: different, originates, physicist, Becquerel

Introduction: Solar Cell

A solar cell is a device that transforms the incident light energy directly into electrical energy through the use of photovoltaic (PV). The development and idea of solar cell science dates back to the 1839 research of French physicist Antoine-César Becquerel. These early solar cells, however, had very low energy-conversion efficiency of less than 1 per cent. This deadlock got finally overcome with silicon solar cell developed by Russell Ohl in 1941. Thirteen years after, three other American researchers, G.L. Pearson, Daryl Chapin and Calvin Fuller, conceptualised a silicon solar cell capable of generating an efficiency of around 6 per cent energy conversion when exposed to direct sunlight [1, 2]. Today, silicon is widely used in fabrication of majority of solar cells, which are available in equally better efficiency and optimal cost as the materials differ from amorphous (non-crystalline form) to polycrystalline to crystalline (single crystal) silicon forms. The solar cells do not make use of any simulated chemical reactions as the case for batteries or fuel cells or consume fuel to generate electricity, and also unlike electric generators, they do not have any mobile parts.

Solar cells are placed in arrays, which is nothing but solar-cells present into large groups. Thousands of individual cells make up this array [3], can emulate electrical power stations, transforming sunlight into electrical energy for all commercial, industrial use and for residential power distribution. The advancements in technology has also enabled individual homeowners to deploy solar cells in much smaller configurations, widely referred to as solar cell panels or simply solar panels. These can be setup on their rooftops to fully replace or complement their conventional power supply. Solar cell panels can also be easily setup at remote terrestrial locations to provide electric supply where conventional sources of power are either unavailable or quite expensive to install. The solar power setups don't have any mobile components that would require extra maintenance or any exclusive fuels which require refilling. This enables solar cells generate power for most of the space installations, from communications and weather satellites to space stations. (For space probe mission's en-route to space or to other planets, solar power is still not sufficient. This is because of the incident energy gets diffused with distance from the Sun.) Solar cells have also been found to be extensively used in numerous consumer products, including electronic toys, portable calculators, and radios. Solar cells used in certain products may also try to utilize energy from other forms of lighting (e.g., from incandescent and fluorescent bulbs) in addition to sunlight, which is the primary intended source.

Solar Cell Structure and Operation

Solar cells, are found to have almost the same basic structure, even when used for different applications such as satellite, power plant or even a basic portable calculator. In a basic solar cell optical coating or antireflection layer makes way for the light to enter the cell, (this leads to reduction in loss by reflection). This layer in turn promotes below energy-conversion layers transmission, by effectively capturing light present on surface of solar cell. Spin coating helps in development of antireflection layer which is type of oxide of silicon, titanium or tantalum, it can also be developed by a method of vaccum decomposition on surface of cell [4].

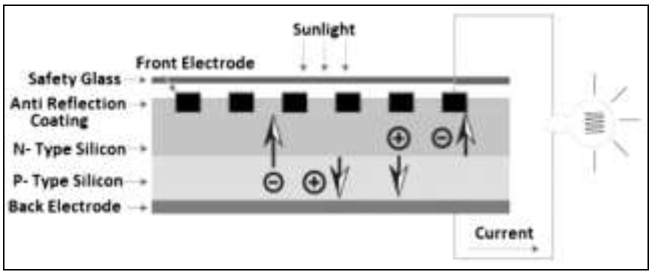

Fig 1: Solar cell structure

Under the antireflection layer the energy conversion layers present are top junction layer, absorber layer which constitutes device's core, and the junction layer present at back [5]. In addition, two more electrical contact layers are present, which completes the electric circuit by transporting the electric current out to an external load and back into the cell. The light entering location on cell's face is available in some grid pattern has electrical contact layer and is generally made up of metal which is a good conductor. As light is obstructed by metals, thin and widely spaced grid lines are created as without impairing collection of the cell current. There is no opposed restrictions on electrical contact layer present at back. It acts as an electrical contact and therfore covers the back surface of the cell completely. The layer present at back is made out of metal, due to requirement of good electrical conductivity.

A solar cell absorber should efficiently absorb radiation at wavelengths from the visible range of electromagnetic spectrum, as most of the energy in sunlight and artificial light falls in this bracket. A semiconductor-based multilayer stack should be able to exhibit absorption of solar light in increased manner and low thermal emission is required for solar thermal applications which are unconcentrated. The calculated absorption at solar wavelengths is 76%, whereas at thermal wavelengths the absorption measured is 5% when taken at room temperature [6]. Semiconductors are the class of substance which absorb visible radiation strongly. Semiconductors which are of thicknesses of about one-hundredth of a centimetre or less are found to absorb all incident visible light; since the junction-forming and contact layers are much thinner, the thickness of a solar cell is essentially that of the absorber. Solar cell are manufactured using semiconductor materials like Indium phosphide, silicon, gallium arsenide and copper indium selenide.

Common Types of Solar Cells

Hundreds of photovoltaic cells (or solar cells) form an array of solar photovoltaic (PV) cells called as PV array. Solar cells convert radiant light into electrical energy made up by solar arrays and this energy is then utilized in powering electrical devices and also to regulate temperature in businesses and homes. Solar cells have materials with semi–conducting characteristic whose electrons get excited upon getting strucked by sunlight and turn it into electrical current. Amidst all the various types of solar cells, crystalline silicon (including monocrystalline and polycrystalline) makes the two most commonly type of solar cells and they are made of what is known as thin film technology.

Silicon Solar Cells

In 1954, the first silicon photocell which produced electrical power from solar radiation was reported of having 6% efficiency [7] and lead to the development of this technology. The solar cells present in today's market are majorly made of some type of silicon, some estimates even show that silicon is used for making 90% of all solar cells [8]. However, there can be variety of form of silicon. The purity of the silicon mostly distinguishes the variations; purity here shows the alignment of silicon modules. The purity of the silicon modules is found to be directly proportional to the efficiency of solar cell at converting sunlight into electricity. Crystalline silicon make up 95% of silicon based solar cells currently present in the market [9, 10], which makes it the most commonly used solar cell. There are two types of crystalline silicon namely monocrystalline and polycrystalline.

Monocrystalline Silicon Solar Cells

Crystalline silicon of the monocrystalline type are easily recognized by their color, they are also called "single crystalline" cells. They are made up of very pure type of silicon, this property makes them most unique. In the silicon world, if the molecules are more pure then the material is more efficient at converting light energy into electricity. The most efficient of all solar cells are Monocrystalline solar cells, their efficiencies have been documented at increased level of 20%.

These cells last longest among all varieties with a warranty of up to 25 years. The % efficiency for the cells is usually 13-16% which is less than half of the limit of balance of around 33% for Si [11]. But quality occur with the price and the solar panels composed of monocrystalline cells are the most costly among all solar cells, hence polycrystalline cells and thin-film cells are more preferred by the consumers. Also, the cutting method (four-sided cutting) wastes too much of silicon which adds up to the cost.

Polycrystalline Solar Cells

The first solar cells to get an introduction to the solar-cell industry in 1981 were polycrystalline solar cells, also called polysilicon or multisilicon cells. They don't undergo the cutting method as for monocrystalline cells. The silicon is first melted and then it is poured in a squarish mold, which gives the square shape. Here there is no silicon wastage and the method is affordale. This makes them much more affordable since hardly any of the silicon is wasted during the manufacturing process.

However the monocrystalline cell is more efficient than the polycrystalline cell because the latter has lesser purity, example: polycrystalline solar cells in a PV system operates at an efficiency of 13-16% [12]. It is less efficient in terms of space as well. Also, it doesn't perform better than monocrystalline cell when the temperature is high.

Thin Film Solar Cells

The thin film solar cell is another upcoming solar cell with growth rate of 60% since 2002 to 2007, representing 5% of all market cells by 2011. The typical efficiency is 7-13% [13]. Much R&D is carried out with the hope that the efficiency would shoot up to 16% in upcoming devices [14].

Many varieties of semiconducting materials are placed on top of each other to create a thin series of films. The price of mass production of thin films is much less than crystalline-based models. Flexibility of the product is also very high which has many advantages. One more advantage is that high temperature and shading has lesser negative effects on the thin films.

Amorphous Silicon Solar Cells

A-Si or a-Si: H solar cells are in the category of thin-film silicon, in which some layers of photovoltaic substance are deposited on a surface substrate. This technology may progress swiftly in the future, it accounted for 4% of the market. Many varieties of silicon-based solar cells are structured (crystalized) on a molecular level but the silicon material is not. In this the principal carrier transport process occurs by either diffusion current or the drift current due to a huge electric field.

The power source of most of the portable calculators are amorphous silicon based thin film solar cell. For quite a long span of time, the low power output of amorphous silicon solar cells had their usefulness for small applications only. This problem is solved to some extent by "stacking" of multiple solar cells one upon another like a stack of books, this enhances their performance and increases their efficiency in terms of space.

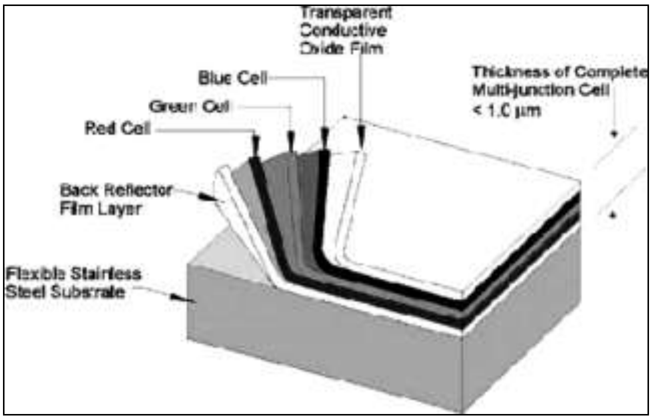

Fig 2: a-Si solar cell

Thin film amorphous silicon solar cells are generally used for powering small portable devices like pocket calculators, travel lights, and camping gear used in trekking. Stacking is an costly process in which multiple layers of amorphous silicon cells have improved the efficiency to 8%.

Fabrication of Amorphous Silicon Cell

Solar panels comprising amorphous silicon are formed on a substrate like glass or metal by depositing vapour of a thin layer of around 1µm thick of silicon material. Plastics can also be used for deposition at 75^0C. The cell consists of single sequence of p-i-n layers. However, power output falls down to 15-35% under exposure to sunlight. This degradation mechanism has its name after their discoverers, the Staebler-Wronski Effect.

For improved stability, the use of a thinner layers is recommended in order to increase strength of electric field around the material. This, however, reduces light absorption, hence the effectiveness of the cells. This lead to the development of triple layer devices containing p-i-n cells stacked one upon another. Uni-Solar is one of the pioneers in the development of amorphous silicon cells. They use a triple layer system to absorb the light coming from the entire solar spectrum.

Conclusion

I was doing research for this article. I found more than one article (in mining publications) that suggested that the capacity for manufacturing thin–film photovoltaic solar cells from cadmium telluride is very close to a maximum supply of tellurium available, or that may become available and that a ability of companies like First solar to continue to expand at the rates they have been going to over the past several years will become increasingly difficult to maintain because of lack of available tellurium.

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