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## Photovoltaic Cells: Present Scenario and Future Prospects

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### Abstract

The increasing pollution every second due to extreme use of fossil fuels for energy generation is of high concern. It affects adversely the ecological cycles of biosphere. It is of much concern to look for new sources of sustainable and green energy. One of the countless stars in our universe i.e. Sun which has about 4.5-5.5 billion years remaining of its lifespan is a continual source of energy. It is an abundant source of non conventional energy. The solar energy is directly converted into electrical energy by photovoltaic systems. A review of solar photovoltaic technologies is presented in this paper including its various applications and future prospects. The various materials used for absorbing light in photovoltaic systems have also been discussed.

**Keywords:** Fossil fuels, green energy, electrical energy, photovoltaic.

### 1. Introduction

The global energy consumption is increasing exponentially; hence the need of sustainable, harmless and renewable energy resources has attracted the attention of researchers. Due to the growing industrialisation, population and the increasing comfort level in humans life, the energy demand is increasing at a rate of 3 % per year [1]. Solar energy that falls on the surface of earth at a rate of 120 petawatts, can satisfy the huge and steadily increasing demand of energy. Solar energy and its conversion to electric energy has wide applications and deep impact to our society. In Photovoltaic cells, the solar energy can be converted directly to electricity or in photo electrochemical cells the solar energy can be converted to chemical energy [2-4]. In 2010, the International Energy Agency (IEA) presented a report according to which about 30 % of the total energy produced is consumed by electricity generation sectors with an efficiency rate of 42.6%. The lack of electricity has become a major issue worldwide. Energy generation using Photovoltaic technology which utilizes

sunlight to generate energy, is an attractive alternate energy source. The basic component of PV technology i.e. PV cell produces less than three watts on average. These cells are connected in series/parallel configurations, known as PV modules or solar cells and they achieve high powered tasks. A photovoltaic cell aims to produce useable energy, from the solar spectrum by absorbing radiation emitted by sun [5]. Carbon dioxide or other pollutants are not emitted in its operation. Hence it is environmentally safe. Due to the vast array of applications, the demand for photovoltaics is increasing every year.

## 2. Power generation in PV cells

Some materials, on absorbing photons, generate free electrons via the photovoltaic effect, which is the conversion of light to electricity. This effect forms the basis of solar cells. Semiconductors are perfect insulators at absolute zero but as the temperature increases sufficient amount of energy is transferred to electrons which causes them to move from valence band to the conduction band. This increase in temperature is due to the photons incident by illumination in case of PV systems [6-8]. The material used is most commonly a pn junction diode of Silicon. When the material absorbs a photon, it imparts energy to the electron and if this energy is greater than the electrons work function, the electron is liberated and the electron is the free to move around the semiconductor material. Hence the electron – hole pairs may be created at the junction of pn diode under the photoelectric effect and a potential difference across the junction is established. An electric field is hence created at the cell junction which causes the electrons to drift back into the n region and holes into p region, and the electron hole pair is separated. The energy created by this bidirectional current path is harnessed. A single photovoltaic cell may be used in low energy consuming appliances like watches and calculators. While a PV module is made by connecting a number of PV cells in series, for utilizing it in solar lighting system [9]. Also these PV modules are connected in large numbers serially or in parallel to make PV array for large grid connected power generation

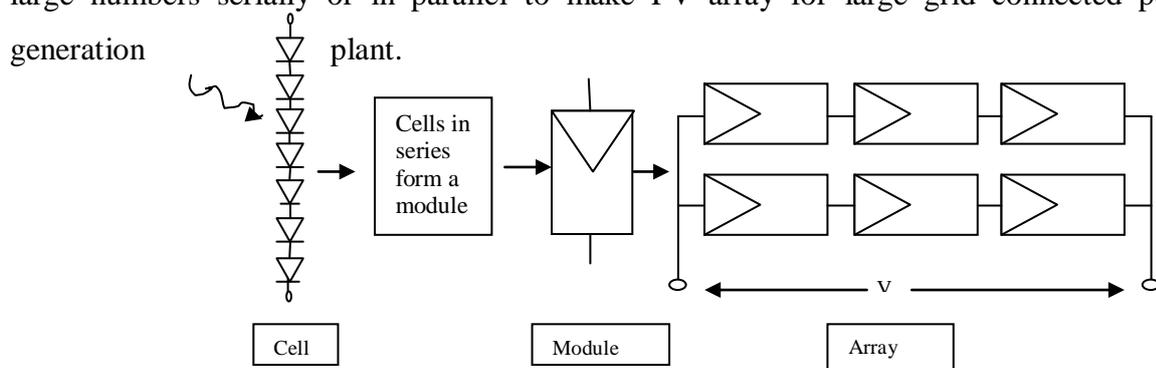


Figure 1: Cell modules and arrays.

Other parts of a PV system are battery, a PCU (Power Conditioning Unit which includes converter, inverter and maximum power point tracking), dump load and data logger [10]. The maximum power point tracking extracts maximum power from PV module. The converter is for the battery charging and the inverter is for AC load. As per the land and area available, these systems are designed properly for the load required along with the environmental and economic considerations. So that the available resources are utilized efficiently [11,12].

### **3. Materials used for absorbing light**

A light absorbing material is required in all solar cells for the photoelectric effect to take place. The most dominant technique for the supply of power modules in photovoltaic applications has been the silicon technology [13]. The review of Braga et al on recent advances in chemical and metallurgical routes for PV silicon production revealed that the production of solar grade silicon can be five times more energy efficient than the conventional process [14]. Then there is amorphous silicon which is the most popular thin film technology having efficiencies of 5-7%, while the double and triple junction designs raise it to 8-10%. A 13% stable cell efficiency achieved by the advances made in amorphous Silicon PV technology has been discussed by Yang et al [15]. An efficiency of 14-19% is also achieved by commercially available multicrystalline silicon solar cell. The efficiency in crystalline silicon is greater than amorphous silicon that too using a very small amount of material. A crystalline silicon on glass solar cell technology that aims to combine benefits of silicon wafer based technology with that of thin films was developed by Green et al [16]. Cadmium Telluride and Cadmium Sulphide are also used as light absorbing materials. Feredricks et al presented a work in which he used CdTe/CdS solar cells fabricated by the close space sublimation process, having attractive features for large area applications like high deposition rates and efficient material utilization [17]. There are some strategies towards improved photovoltaic performance using organic and polymer materials, including double cable polymers, regioregular polymers and low bandgap polymers. These strategies were presented by Mozer et al, which demonstrated that bulk heterojunction concept is a viable approach of developing photovoltaic systems by low cost solution based fabrication technologies [18]. Wu et al. came up with a new technique through which the PV system could adopt amorphous Si solar cell together with crystalline Si solar cell to make a PV system with higher ratio of efficiency to cost [19]. Another technique for solar cells is thin film technology in which thin layers of semiconductor materials are applied to solid backing material. It reduces greatly the amount of semiconductor material required for each cell as

compared to silicon wafers, also it lowers the cost of production of PV cells. According to Barnett et al solar cells utilizing thin film polycrystalline silicon can achieve efficiencies greater than 19% as a result of light trapping and back surface passivation with optimum silicon thickness [20]. A dye-sensitized nanocrystalline electrochemical photovoltaic system, that was proposed by Gratzel became a reasonable competitor to solid state junction devices for converting solar energy into electricity and is the prototype of many energy technology devices taking advantage of the characteristics of these innovative oxide and ceramic semiconductor films [21].

#### **4. Applications**

PV cells are clean and environment friendly power source. They may serve as good energy providers where electric grid extensions cannot be used. Roof-top residential or commercial systems, remote water pumping stations, traffic lights, garden lights, water heaters, satellites, shuttles are some common examples of PV devices. Photons that are absorbed by the PV cells are sent to an inverter in the form of DC, which transforms it to 240V AC, to be used by the household appliances. This AC power is then distributed to the equipments throughout the house. Unused electricity if any, may be recycled and used in other requirements [22, 23]. In a building design proposed by Yoo et al has the shade of PV modules to reduce cooling loads in summer [24]. A pump for drip irrigation system operated by solar photovoltaic cells was designed by Pande et al in order to irrigate orchards in arid region. The variation in the pressure of the pump by changing the irradiance was also studied by him [25].

In an application of PV cells in nanotechnology, a plastic spray is created on PV cells, which utilizes sun's infrared rays. Since, it utilizes infrared rays of spectrum they can be used to produce electricity even in cloudy days. It can be sprayed on any material to serve as portable electricity [26].

#### **5. Advancements**

Most of the photovoltaic cells are designed with the semiconductor approach, which are the first generation cells. Second and third generation cells are made by thin film deposits and electron confined nanoparticles. Though the thin film technologies reduce the mass of material used for absorbing light and the cost of processing, but it results in decrease in efficiency. Being almost mass less these thin films are stacked to form multilayer cells to increase the efficiency. The average energy then is 30% while the standard efficiency of semiconductor cell is 14% [27]. If these thin film light absorbing materials are coated by an

extremely thin coating of mesoporous metal oxide then the efficiency of these nanocrystalline solar cells increases to 40% [28, 29].

## 6. Conclusion

Various light absorbing materials used in photovoltaic cells are amorphous and crystalline silicon. The efficiency of crystalline silicon is more than amorphous silicon. Cadmium Telluride and Cadmium Sulphide are also used as light absorbing materials as they have high deposition rates. The attractive characteristics will continue further research in photovoltaic cells as environmentally benign power source. Current PV systems are not highly efficient and commonly used as their cost is not comparable with fossil fuel based sources.

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