

A Review on Renewable Solar Energy Devices

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Abstract

Among each and every one of the remarkable trials, human beings would face in the next 50 years, the energy will be more discernible. The growing in energy applications, particularly from developing countries will make conditions more terrible. The reduction of petroleum derivatives temperature alteration around the world against the feasible advance of the world. The agreement is generally based on renewable energy resources only due to the high demand for energy, the development of new devices that can be used as an alternative to traditional energy resources and can illuminate the world in the future is extremely necessary. On the other hand, it has been openly demonstrated that the sun can offer a strong solution for energy crisis in the current situation of the world. Solar cells are the best devices to overcome the environmental problems caused by traditional energy resources, such as coal. These devices provide energy installations that are friendly with the environment.

Introduction

Energy

Energy is the capacity of any system to do work with the help of an external force that should be responsible for the change in the system as well. There are many types of energies by which world is fulfilling its requirements, for example, coal, fossil fuel, solar energy etc. However, the energy from the sun is reliable and pollution free which is environmentally friendly and cost-effective. Energy is a basic compulsory need for the human and socioeconomic progress of a country. Energy contribution per capita is the sign of expressing the growth of a country. Production of Electrical energy is key to the development of a country. Due to the low production of electricity from conventional resources, Pakistan is facing severe conditions of load shading nowadays. To overcome these serious issues of energy, renewable energy resources such as solar energy and wind energy should be included in energy production projects [1].

There are two main types of energy and both are important for human beings.

- I. Renewable energy
- II. Non-Renewable Energy

Non renewable Energy

This type of energy is limited and cannot be reproduced when once used. It does not show friendly behaviour with the environment and also has a high-cost factor with the high efficiency rate. This type of energy includes energy from fossil fuels and coal etc. In spite of many advantages the non renewable energy has many disadvantages, for example, these resources are the cause of pollution in the environment, have high cost factor and these are finite in existence may be in future world will face very intensive problems due to lack of traditional energy resources. So the scientists and researchers are now tending to introduce new energy resources that can overcome energy problems in the world and also these resources

can maintain the green environment in the society without emitting dangerous chemicals.

Renewable energy

This type of energy resources will not end in the future and will help forever to overcome the severe problems of the energy crisis. In all resources of renewable energy suns one of the best and reliable sources from which we can harness energy by many methods. The beauty of this source is that it is unlimited and sufficient to drive the conversion devices such as solar cells; these devices are very common nowadays like silicon solar cell and dye sensitized solar cells (DSSC) which are environmentally friendly and have a low-cost factor. There are many types of renewable energy resources some are listed below.

Solar Energy

The energy coming from the sun can be converted into electrical energy by using Photovoltaic devices. But this technology has challenges of cost factor and scalability problems. To provide continuous energy to the whole world solar energy should be stored, captured and converted with cost-effective designs. Fortunately, development in many disciplines like nanotechnology, physical sciences, material sciences, and biotechnology can help to overcome the high-cost effect of photovoltaic devices [2].



Figure 1: Pakistan solar power plant (Chinese company) 2015 100 MW [3]

Wind Energy

Worldwide power consumption is increasing due to which power costs are enhancing to their peak level. Also due to excess use of energy, the pollution problems in the environment are expanding. To minimize the cost factor and pollution problems renewable energy resources are best options and among these resources wind energy is dominant and reliable which has no harmful effects on human and environment. The renewable energy resources are rapidly increasing in both developing and developed countries [3,4]. In Malaysia and Pakistan, many researchers and scientists are working their best to utilize renewable energy resources so that they can help to meet the energy demand of their countries [5-7].



Figure 1.1: Wind power plant in Pakistan (Zorlu Turkish Company) 2012 [1]

Geothermal

This is not necessary that all renewable energy comes from the sun even we can get energy from the internal heat of the earth from specific areas that are called geothermal energy resources. Geothermal energy has been used for both productions of electricity and direct heating purpose. Commercially electricity from geothermal has been existing since 1913. Production of energy from geothermal is increasing day by day in the world, more than 58 countries are using this energy resource and in 80 countries options of this resource are available [8].

Hydrogen

Hydrogen is found in many organic compounds and water even scientists are doing work on getting energy from hydrogen on large scale to full fill the energy requirements of this globe.

Photovoltaic Devices

For the production of green energy which is better for all human beings renewable energy Resources are the best options and among them, solar energy is one of the best choices. The device which converts light energy into electricity via photovoltaic effect (PV) is known as a solar cell or photovoltaic cell [9].

Types of Photovoltaic cells

Photovoltaic (PV) Devices work on the principle of converting solar energy into electrical energy. In 1870 first time PV effect was observed on a solid material as on selenium. Photovoltaic cells based on selenium were fabricated in 1870 having only 1% to 2% efficiency of converting solar energy into electrical energy. To produce pure mono crystalline silicon, Czochralski method was observed in 1950. Silicon solar cell with 4% efficiency was prepared in 1954 by Bell Telephone Laboratories [10].

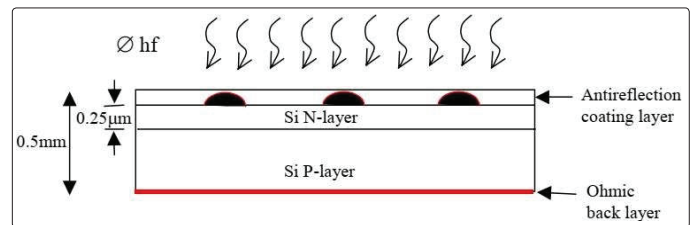


Figure 1.2: Silicon solar cell schematic representation [10]

Amorphous Silicon Solar Cell (A-Si)

It is an on-crystalline form of silicon material. It is the most prominent thin film technology which is being imported into the market for more than fifteen years.

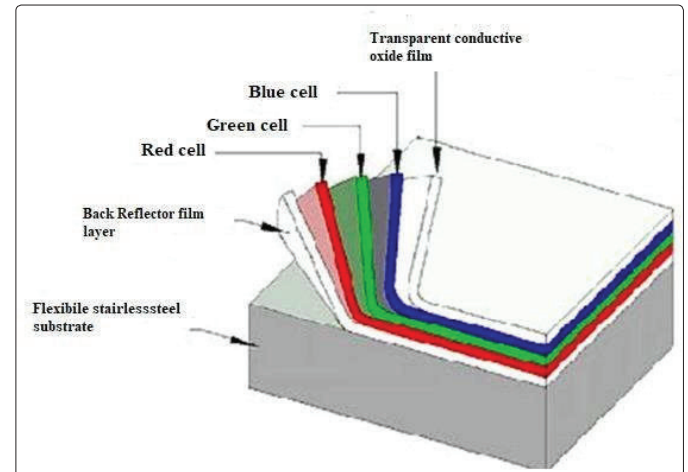


Figure 1.3: Structure of the Amorphous Silicon Solar Cell [9]

The applications of this type are in pocket calculators also in some buildings and homes for private use. Vapour deposition technique is used for the fabrication of amorphous silicon panels. The thin film is grown on a glass or metal substrate even at a low temperature such as 75°C. Due to this unique property, it can also be produced on a plastic substrate [9].

Biohybrid solarcell

By the combination of organic matter and nonorganic matter bio hybrid cell is made. These cells were made at Vanderbilt University by a team of Researcher. To obtain the higher efficiency researcher used photo system to regenerate the process of photosynthesis which occurs naturally, these are considered as a new type of the renewable energy and provides its contribution in the renewable energy resources which are necessary and harmless for the environment and society also have low cost factor which help in the solutions of economic problems of a country.

This PV device can help in the production of green energy to overcome the problems of energy in the world however still efficiency of the cell is under consideration and researchers are working to improve the efficiencies [11].

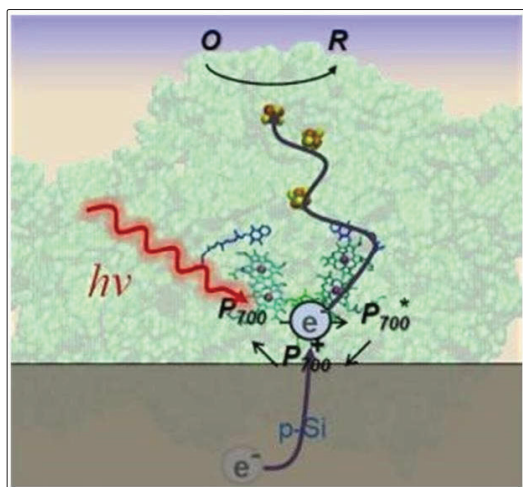


Figure 1.4: The working process of the hybrid solar cell [9]

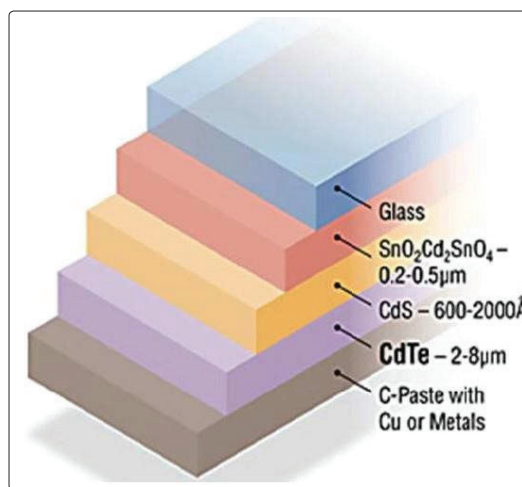


Figure 1.6: Schematic diagram of Cadmium Telluride Solar cell [9]

Buried Contact solar cell

The buried contact solar cell is commercially available solar cell technology having high efficiency. It is based on a plated metal contact with the laser-formed groove inside it. This technology solved many problems which were associated with screen printed contacts as it can deliver 25% better than that of screen-printed solar cells. There as one of having higher efficiency is that metal is buried into a laser-formed groove inside the semiconductor solar cell. Buried contact technology has cost-effective benefits also its hows better performance [12].

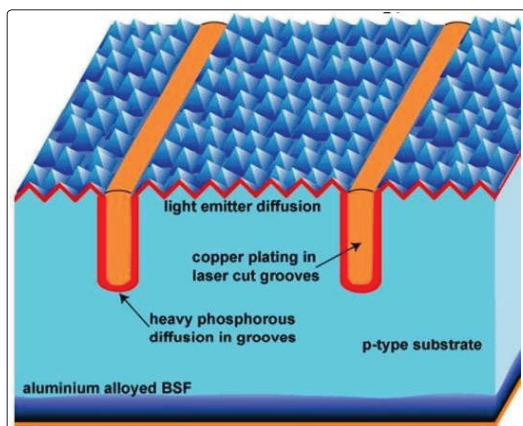


Figure 1.5: Schematic diagram of Buried Contact Solar cell [9]

Cadmium Telluride solar cell

Cadmium telluride photo voltaic illustrates a PV technology that relies on uses of Cadmium telluride a thin layer of semiconductor architect to absorb and convert solar energy into electrical energy [13]. As compared to the conventional solar cells which are made crystalline silicon Cadmium telluride PV is cost effective having cheaper cost [14]. For the purpose of lifecycle cadmium telluride solar cells has the property of lowest carbon footprint and water used also it has shortest energy payback time as compare to all solar technologies [14, 16, 17]. The cadmium telluride solar cell has less than a year energy payback time which permits for quick carbon consumptions by ignoring short-term energy discrepancies. At the end of its lifetime recycling of cadmium, molecules reduce the toxic effect on the environment [17].

Introduction to Dye-sensitized Solarcell

Extreme use of petroleum derivatives has driven the world to move from the traditional power sources to a sustainable power source to meet the increasing demand for energy. Despite the fact that the procedure is progressive the capability of the sustainable power source has been all around discussed in the past decades. There are many energy resources like wind energy but they are less efficient as compared to solar energy. Photovoltaic devices convert heat energy from the sun into electrical energy, these devices work on the principle of charge separation at the interface of two different materials which have Different conduction methodology according to their properties. Silicon-based solar cells have been most important for this mechanism as they reconsider reads solid-stated devices. The third generation of solar cell has been introduced that is dye-sensitized solar cell (DSSC). This technology has much importance for the conversion of solar energy into electrical energy [18]. Dye-sensitized solar cells (DSSCs) are getting impressive attention as contrasting to semiconductor-based thin film solar cells. O'Regan and Gratzel in 1991 showed dye-sensitized solar cells (DSSC) are not expensive and can be used as an alternative to silicon solar cells [19]. The dye-sensitized solar cell is a semiconductor photovoltaic device which is used to convert solar energy into electrical energy [20]. This has been confirmed that the efficient work of Organ and Gratzel is the most cited article in the field of energy in the world [21]. According to the latest research, more than 17000 papers have been presented to fabricate the new material, characterization techniques for the launching of DSSC on large scale in the world [22]. During the past decades, the dye sensitized solar cell is considered one of the best photovoltaic devices for the conversion of solar energy into electrical energy. This is due to the uniqueness of the DSSC as its fabrication process is very simple and materials required for construction are low cost and easily available. Moreover, the instruments used in the fabrication process are also less expensive and easily available. It has a high light to electricity transformation efficiency. Currently, it has archived sufficient efficiency to light up [23]. DSSC has fabricated on the conductive polymer which interestingly is lightweight, flexible, environmentally friendly and low cost. This unique manufacturing has led roll to roll function of dye-sensitized solar cell for the installation on curved and flat surfaces. However, the thermal instability of the polymer is still challenged for better efficiency. Polymer-based electrodes show less efficiency rate as compared to the DSSCs which have a glass

substrate. However, many research groups have worked on the alternative of the polymer substrate to sustain the flexibility factor along with better conversion efficiency [24]. For the fabrication of flexible DSSC many techniques have been implemented such as Yamaguchi et.al introduced the compression technique for the purpose of constructing titanium dioxide (TiO₂) film on polymer substrate which constitutes flexible properties with better efficiency. In this method, the particle size of TiO₂ was large which showed a light confinement effect and the 7.4% conversion efficiency was achieved through this mechanism [25].

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