DEVELOPMENT OF SOLAR PHOTOVOLTAIC TECHNOLOGY: A REVIEW

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Abstract

Energy plays a vital role for the development of society and its demand is continuously increasing. Conventional sources of energy which are being used impose adverse effect on the environment. So renewable energy resources based on biomass energy, water energy, nuclear energy, geothermal energy, tidal energy, wind energy, solar energy etc are best alternatives. Among these, solar energy is available abundantly around us. The PV system converts sunlight into electrical power whenever light falls on PV cell.

Keywords: Energy, renewable energy, solar cell, silicon, photovoltaic.

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1. Introduction

Energy is fundamental need for our society along with food, clothes and shelter. Energy play crucial role in economic growth and development [1]. The demand of energy in various fields is increasing day by day. With an increase in demand for energy due to a growing population and expanding economy, there is a need to use renewable energy sources as their counterparts can be detrimental to our environment [2]. All over the world, using conventional energy sources from many decades which are based on fossil fuels but it affect the environment in respect of global warming. Greenhouse gases (GHGs) emissions etc [3,4]. The fossil fuel is fast depleting and the need for alternative sources of energy. To overcome these factors, the renewable energy is alternate best solutions [5]. The available renewable energy resources are based on biomass energy, water energy, nuclear energy, geothermal energy, tidal energy, wind energy and solar energy [6]. Solar energy is infinite and available in all over the world. Here are two ways to make use of the solar energy i.e. photothermal and photovoltaic [7]. In photothermal system solar radiation is either directly used for applications or is converted into electricity [8] while in photovoltaic conversion (PV system), known as solar cell devices directly convert the solar radiation into electricity [9]. The solar cells should be highly efficient with low cost. This review acquaint with the growth of solar cell technologies and efficiencies.

Different types of photovoltaic solar cell and other efficiencies

Solar cell technologies can be generally divided as first generation solar cell (solar cells based on silicon), second generation solar cell (thin film solar cells), third generation solar cell (multijunction solar cells) and next generation solar cells [10].

A. First Generation Solar Cell (Crystalline Silicon Solar Cells)

Monocrystalline and multi-crystalline solar panels are used for a long time due to durability [11]. Single-monocrystalline solar panel uses a single and pure crystal of silicon [11]. The efficiency of Single-monocrystalline PV panel is 14-17.5% [12]. One of the scientists had investigated a model by using single-monocrystalline silicon producing an efficiency of 19.2% by combining selective emitter (SE) with metal wrap through (MWT) cells technology. Multifaceted crystalline material is used in multi-crystalline solar cell and the efficiency is 12-14% [12-14] which is lower than monocrystalline cells. Both the single & multi crystalline solar panels, are extensively admired because silicon is abundant and non-toxic [11].

B. Second Generation Solar Cells (Thin Film Solar Cells)

Thin film solar cells are prepared by using single / multiple layers of photovoltaic materials on the base glass, metal or plastic [15]. Second generation solar cells are classified as, amorphous Silicon (a-Si), Cadmium Telluride (CdTe) and Copper Indium Gallium Selenide (CIGS) [15]. CIGS is a direct band gap type semiconductor. Compared to the cadmium Telluride (CdTe) thin film solar cell, CIGS showed greater efficiency 10-12% [12] rather than CdTe. Higher efficiency with low cost made the CIGS better solar cell technology [16,17] but the CIGS solar cells are not as efficient as silicon solar cells.

C. Third Generation Solar Cells

Third generation cells are the new solar cell technology and their types are o*rganic cells,* dye sensitized solar cells, nano crystal based solar cells and polymer based solar cells,

Organic cells

Organic molecules or polymers are used in this solar cell and have the competence to absorb photon and generate electrical power [11]. This is also known as plastic solar cell and mainly made of polymer material [11]. OPV cells have various advantages like low weight, low cost, flexibility and fabrication is simple [18-21].

Dye sensitized solar cell (DSSC)

DSSC are photoelectrochemical cells which consists of photoanode, sensitizer, electrolyte and counter electrode [22]. The sensitizer is a dye material (organic dye, inorganic dye or metal-organic dye) in between the electrodes [23]. 11-15% efficiencies of this cell obtained with single junction and tandem cells, respectively (24). This technique is inexpensive [25] but have low conversion efficiency and also causes stability problems [26].

Nanocrystal solar cell

This type of cell is developed by depositing a layer of nanocrystals on silicon or organic materials [27]. Nanocrystal solar cells alter the field of renewable energy with the reduction of cost, pollution free power creation and higher efficiency rather than silicon based solar cells [28]. Optical properties of hybrid nanocomposites is fabricated [29] in which hybrid nanocomposites were prepared by using ZnO with natural dyes and synthetic dyes and observations recorded that natural dye used nanocomposites shows a superior absorption and optical properties than synthetic dye.

Polymer solar cell

Polymer material based solar cell has higher flexibility, processing ability and low material cost but has low efficiency rather than traditional solar cells [30]. A scientist [31] formulated a poly(3-hexylthiophene) (P3HT)/C-70 photoactive layer by using heptanes and o-dichlorobenzene (ODCB) mixture with 2.24% power conversion efficiency. In [32], an integration of a Ni nanoparticle in Indium tin oxide electrode in poly (3-hexylthiophene) or [6, 6]-pheny-C71-butyric acid methylester based organic optoelectronic devices was performed and obtained result showed that Ni layer with 3 nm thickness increased the current.

D. Next Generation Solar Cells:

The next generation solar cells include: Perovskite solar cells, kesterite solar cells and quantum dot solar cells.

Pervoskites

Molecules having crystal structure analogous to a mineral called perovskite which is composed of $CaTiO_3$ [11]. Perovskite solar cells are based on organometallic halides and reported with high efficiency 25.50% in single-junction and 29.10% in silicon based tandem cells [11]. Perovskite solar cell is one of the advanced solar technology with high efficiencies at low costs of production but this technique have some issues like stability against air moisture and O_2 [33], heating [34], mechanical frailty [35] and environmental pollution owing to toxicity of lead halides.

Kesterite Solar Cells

This cell is based on two compounds viz. copper zinc tin sulphide (CZTS) and copper zinc tin selenide (CZTSe) [36]. The properties with reference to optical and electronic of CZTS & CZTSe are alike to CdTe & CIGS and have 7.60% & 9.80% efficiency respectively [37]. However, CZTS and CZTSe do not contain toxic or rare earth elements like Cd and In respectively [38].

Quantum Dots (QD)

Quantum dots are a unique class of semiconductors, which are nanocrystals, composed of periodic groups of II-VI, III-V or IV- VI materials [39]. QD are structures with coordinate gap of band to match the spectral distribution of solar spectrum, which reduces cost of solar electricity [40]. QD can be molded into various types and processed to create junctions on inexpensive substrates such as plastics, glass or metal sheets; they can easily be combined with organic polymers and dyes [41].

2. Conclusion

In this paper, a detailed review is made on the development of solar photovoltaic cells with materials used for the manufacturing of photovoltaic cell. It is observed that, Silicon material is broadly used due to its abundant availability and lower cost but cell which are made by using silicon material showed low efficiency. Research in the field of solar photovoltaic is providing new materials to explore the solar energy with high efficiency. Design of the cell and material used play important role to acquire high efficiency and low environmental impact.

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Conflict of Interest: No

3. References

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