IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Recent Trends in Solar Cells

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Abstract**:** ***As most of the fossils will exhaust shortly, the hunger to explore renewable resources is getting worse. Renewable energy is sources of clean, inexhaustible and also increasingly competitive energy. Solar Photovoltaic energy is one of the important sources as it contains less noise, maintenance, and pollution-free. PV technology is still undergoing rapid evolution to achieve high efficiencies and to reduce the cost. New materials, concepts, and approaches in solar cell development have become the center of research in this field. This paper introduces the review of various recent generation technologies of solar cells. This addressed technology study is based on performance characteristics, efficiency, and cost of the solar cell.***

Keywords **:** ***Photovoltaic solar cell; perovskites; PV technology; generations of solar cell.***

I. INTRODUCTION

Nowadays, Solar energy has been considered the best option due to its enormous, inexhaustible and environmentally benign nature. The energy from the sun can be extracted in two major forms i.e. by photovoltaic or photo-electrochemical conversion and solar thermal technologies. [1] Among the solar energy harnessing technologies, photovoltaics is rapidly evolving with new materials being developed in search of more efficient, low cost and sustainable systems. So, based on light-absorbing materials PV technology has generally classified in various generations as shown in fig.

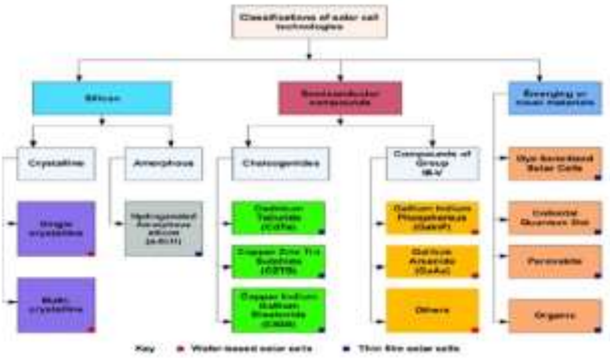

Figure.1: generation of PV technology solar cell

The first generation of the solar cell is crystalline silicon technology which is the most dominant used in market having the largest efficiency of 26.7 ± 0.5% and 22.3 ± 0.4 % for monocrystalline and poly-crystalline silicon solar cells respectively. They are more reliable and efficient having 25 years of life with limited degradation of performance.

The second generation of the solar cell is based on thin-film materials of various semiconducting compounds. These materials have high optical absorption coefficients compared to first-generation PV technology.

The third generation of the solar cell is based on emerging and novel materials. This solar cell technology is more efficient and low-cost solar cell technology. Development in nanotechnology has opened a leeway towards the realization of this vision with the use of cheaper Nano-structured materials.

A variety of technologies are invented for increasing the performance of solar PV generation with low cost and maintenance. Few of them are addressed in this paper.

II. LITERATURE REVIEW

Ghulam Ali et.al.(2018) investigates the solar cells, belonging to all three generations, concerning their recent challenges that limit the development of highly efficient and low-cost cells. They concluded that To acquire the maximum advantage of solar energy resources, the development of low cost and high-efficiency solar cells is inevitable. It was found that impediments such as carrier recombination, light management, stability, and other structural issues hinder the attainment of the maximum potential of these solar cells.[1]

Weiwei Deng et.al.(2016) presents the latest investigations on PERC sunlight based cells and uncovers the acknowledgment of a world record productivity of 20.8% PERC sun oriented cell manufactured with screen printing innovation on 156 mm × 156 mm multi-crystalline substrates. To build cell effectiveness, an optical misfortune investigation was led, which shows that the present misfortune due to the non-ideal light-catching rules the general optical misfortune. As per examination of the substrate productivity of 21.3% is reachable sooner rather than later with further advancement. The optical misfortune investigation of the victor cell presumed that the significant current misfortune happens from the non-ideal light-catching and front metal concealing. Further procedure streamlining would limit the force misfortune and raise cell proficiency to 21.3%. [2]

Elisa Antolín et.al. (2019) proposed the heterojunction bipolar transistor solar cell idea (HBTSC)which is a basic, reduced and savvy multi-terminal cell structure that permits free current extraction. Right now, I utilized a float dissemination model to investigate significant viewpoints in the plan of an HBTSC structure dependent on commonplace III-V semiconductor materials. It was reasoned that expanding the band hole vitality, the doping focus, as well as the minority transporter dispersion length in the base decreases bearer infusion and improves the general execution.[3]

Z. Sahwee et.al (2019)proposed an epitome procedure to expand the toughness and unwavering quality was investigated by playing out a progression of tests. The goal of this investigation is to investigate the sun oriented embodiment process while intending to keep up its change proficiency. Change effectiveness and weight punishment of every strategy were recorded and were estimated under sun irradiance. This examination gives an exhibition correlation between crude solar cells and embodied sun oriented cells. [4]

F. Javier Ramos et.al.(2014) introduced and examined the creation and exemplification of perovskite-based solar cells. Perovskite-based solar cells are rising as a financially suitable option for productive photovoltaic vitality collecting. Utilizing arrangement based preparing courses alone, devices with power transformation efficiencies surpassing 15% can be created, on a fundamental level at a small number of costs detailed for other photovoltaic innovations. In these excitonic solar cells, the perovskites multifunctional nature permit these layers to act as a light safeguard, electron conductor and gap shipping material, contingent upon the device design. Fruitful exemplification causing scarcely any device harm is the initial step to accomplish attractive device long haul dependability and subsequently mechanical reasonableness. The second advance embodiment approach has the potential to be an excellent barrier to protecting devices from environmental conditions.[5]

Sergey Malyukov et.al.(2018) performed Numerical simulation of laser annealing to obtain the temperature distribution in perovskite precursor / TiO2 / FTO / glass substrate structure and determine the energy density of the laser radiation, which is necessary for perovskite crystallization. They concluded that the optimum energy density of laser annealing is 50-140 mJ/cm2, at which the crystal grains of the perovskite film vary in the range from 110 to 490 nm. This research can be used for perovskite solar cells technological processes automatization. Laser annealing of perovskite leads to the formation of a homogeneous crystalline film with large grain size (490 nm) compared to annealing in a furnace (300 nm), which can increase carrier mobility, reduce recombination in the perovskite film, and increase the efficiency of these solar cells.[6]

T Prasanti et.al.(2018) fabricated Hysteresis free p-i-n Perovskite solar cells using NiOx (p-type) and PCBM (n-type) as transport layers. The device's presentation is improved by pre-molding both the NiOx/perovskite and perovskite interfaces. NiOx is presented to ozone before perovskite testimony and that improves charge extraction and diminishes device fluctuation. PCBM/perovskite interface is improved by a maturing procedure after PCBM statement that lessens hysteresis and improves charge assortment. Devices with altered interfaces and upgraded perovskite thickness with improved lifetimes show 13.3% productivity, 76% fill-factor and fantastic device-to-device consistency.[7]

Jeffrey A. Christians et.al. (2018) planned perovskite solar cells with low misfortunes and the proper band holes, which vary from the perfect band hole for single intersection perovskite sun based cells. Right now, unimaginably low voltage misfortune and tunable band hole of CsPbI3 quantum specks make them unmistakably appropriate for all-perovskite pair solar cell applications. the way that these materials are handled from non-polar natural solvents, for example, octane and methyl acetic acid derivation, could encourage 2-terminal pair solar cell preparation and maybe expel the requirement for a TCO obstruction layer between the two subcells. [8]

Nji Raden Poespawati et.al. (2018) examined the economical creation of perovskite solar cells utilizing turn covering testimony strategies and are likewise generally minimal effort materials for the perovskite solar cells structure themselves. They had portrayed the presentation of perovskite solar cells depends on a natural metal halide perovskite material by improving the rotational speed of turn covering. They accomplished perovskite solar cells with the 1000 rpm rotational speed of turn covering of the natural metal halide layer and the 2000 rpm CuSCN. This PSC device has steadiness for about fourteen days, after that the productivity is decreased by 50%.[9]

L.J. Geerligs et.al.(2011) reviewed recent progress in the development of high-efficiency cells on n-type monocrystalline Si wafers. They conclude recent results of processing with reduced front contact area and improved BSF and improved rear surface passivation, which are key parameters that limit the cell efficiency. The improvement leads to an efficiency of 20%. The improvements of front metallization and BSF, that were described above, have not yet been incorporated in the n-MWT technology.[10]

R.K Koech et.al. (2019) reviewed the progress of PV technology with a keen interest in the emerging PV materials that hold the prospects for achieving high efficiencies at low costs. They concluded that the PV technology based on PSCs can lead to the achievement of the goals of the PV industry if the challenge of stability can be addressed. Further prospects for research in PSCs include the development of low cost, efficient and non-toxic materials, improvement in device fabrication and a better understanding of material properties, charge transport kinetics and performance degradation mechanisms to establish new routes for further performance improvement. Furthermore, there is a need to develop light and flexible.[11]

Deepti Dhuriya et.al. emphasized some focus on the output parameters of the organic solar cells such as open-circuit voltage, short circuit current, fill factor and efficiency. Compared to the single-layer and bi-layer solar cells, the heterojunction solar cell a multilayer device. The bi-layer devices, which were better than the single-layer devices, have not achieved the efficiency as they were deemed to achieve. They discovered a new type of device structure to enhance the reliability and efficiency of OPV cells. The single layer, bilayer and bulk heterojunction structure is simulated using 2D device TCAD.[12]

C. Chu et.al. (1991) described recent advances in technology for producing large area, thin gallium arsenide solar cells grown on germanium substrates. This work has also provided a realistic basis for estimating the area, weight and cost tradeoffs available for cells for advanced space missions. The results reported were obtained using typical production methods, and thus allow firm projections of production yields and throughout.[13]

Kamaruzzaman Sopian et.al.(2015) focuses on recent achievement on flexible dye-sensitized solar cells with titanium dioxide as the best material that is used as photoanode material. They concluded that some of the flexible dye-sensitized solar cell achievements in the past few years. The highest power conversion efficiency for flexible dye-sensitized solar cell technology still cannot compete with the standard rigid substrate which is a glass substrate. However, the efficiency that was obtained was not quite high compared to the performance of DSSC using a rigid substrate. This is due to the low annealing temperature process that produces poor adhesion of TiO2 particles on the substrate and also poor inter contact with TiO2 particles. Therefore, there is new generation technology that has been proposed to compete with standard rigid DSSC such perovskite and flexible perovskite solar cell which offer more compact and high power conversion efficiency (PCE).[14]

A. Abbreviations and Acronyms

HBTSC- Heterojunction Bipolar Transistor Solar Cell
PERC –Passivated Emitter & Rear Solar Cell
PCBM- (Phenyl-C61-Butyric acid Methyl ester)
TCO- Transparent Conductive Oxide
OPV- organic photovoltaic cell
PSC- Perovskites Solar Cell
BSF- Back Surface Field
MWT – Metal Wrap Through
TCAD- Technology Computer Aided Design
DSSC- Dye synthesized solar cell
PCE- Power conversion efficiency

III. RESULT AND DISCUSSION

In this paper, we have studied various recent technologies of solar cell materials to improve the performance of solar PV technology. The technologies are studied based on implementation feasibility, performance characteristics and efficiency of the solar cell. By studying these technologies, we can conclude that nowadays the emerging and novel materials containing third-generation PV technology can achieve high efficiency with low cost compared to other generations. Also, there is a new generation technology that competes the recent generation devices offering more flexible operation and high efficiency of the solar cell in PV technology.

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