RESEARCH REVIEW JOURNALS

Volume-04
Issue-01
January -2019

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com[Peer Reviewed Journal]

Efficiency enhancement of solar cells with the use of photonic materials

Naveen Saini

Research Scholar, Dept. of Physics, MDU, Rohtak

ARTICLE DETAILS

Article History
Published Online: 20 January 2019

Keywords
photovoltaic, Solar cells Photonic crystals, silicon.

ABSTRACT

The potential of using photonic crystal structures for realizing highly efficient and reliable solar-cell devices is presented. The author thought about that due their ability to change the terribleand insolent characteristics of warm radiation, photonic crystals create as one of the primary chance for repeat and exact specific exuding segments in thermo photovoltaic contraptions. Furthermore it is viewed as that using photonic valuable stone based edge and repeat specific shields energizes a strong overhaul of the change viability of sun controlled cell devices without using concentrators.

INTRODUCTION

Photovoltaic (PV) solar energy conversion systems (or solar cells) are the most widely used power systems. Regardless, these contraptions suffer of low change adequacy. This is a direct result of the wavelength screw up between the constrained wavelength band related with the semiconductor essentialness opening and the wide band of the (blackbody) release curve of the Sun. The influence mishap is connected with both long-wavelength photons that need more essentialness to stimulate electron–hole coordinates over the imperativeness opening (inciting a 24% disaster in silicon, for instance) and short-wavelength photons that empower sets with imperativeness over the gap, which right now the extra dynamic imperativeness as warmth (giving a 32% incident in silicon). The profitability of the thermo photovoltaic (TPV) structure may be extended by reusing the photons with repeat greater than the sun controlled cell band-opening repeat, by using an unpleasantly subordinate coupling between the protect and the cell (Fig. 1).

However, any way to deal with sun based cell productivity change that does not address this major wavelength band confuse, can accomplish at most around 30% proficiency [1]. In addition, this can be accomplished just for concentrated radiation, which requires an extra optical gadget, which isn't alluring in applications where the mass is a basic concern. This article plots novel ways to deal with the plan of profoundly effective sunlight based cells utilizing photonic band-hole (PBG) materials [2,3]. These are another class of occasional materials that permit exact control of all electromagnetic wave properties [4,6]. A PBG happens in an occasional dielectric or metallic media, also to the electronic band hole in semiconductor precious stones. In the otherworldly scope of the PBG, the electromagnetic radiation light can't proliferate.

The capacity to tailor the properties of the electromagnetic radiation in a recommended way through the building of the photonic scattering connection empowers the plan of frameworks that precisely control the emanation and retention of light. This offers ascends to new wonders including the hindrance and upgrade of the unconstrained emanation [3], solid restriction of light [2], arrangement of atom– photon bound states [7], quantum obstruction impacts in unconstrained outflow [8], single molecule and aggregate nuclear exchanging conduct by cognizant full pumping, and nuclear reversal without variances [9]. These momentous marvels have pulled in a significant enthusiasm for essential mechanical applications, for example, low-limit smaller scale lasers [10,11], ultra-quick all-optical switches, and miniaturized scale transistors.

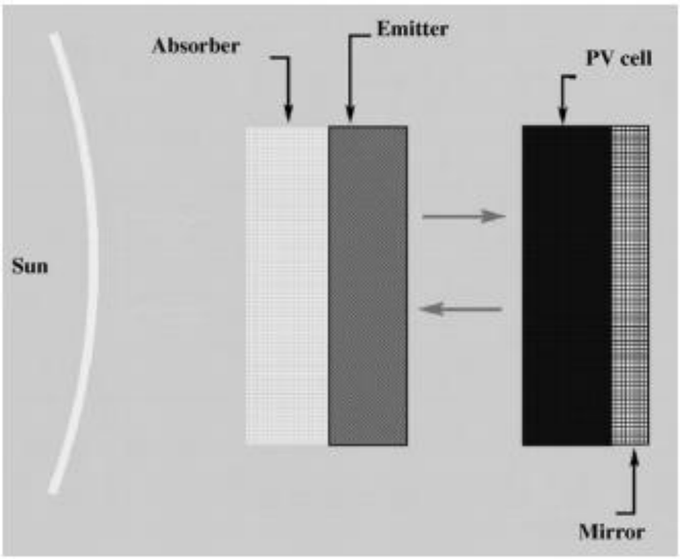

Fig. 1: Schematic of a TPV energy conversion scheme

Photonic crystals

The essential thought of photonic crystals is a similarity of the scattering of an electron in a strong state precious stone and a photon in a photonic crystal. In a solid state crystal, the atom backsides outline an irregular potential. Because of the discontinuous potential, the dispersing of the electron in the valuable stone may be given in a band layout which shows forbidden and allowed imperativeness states for the electron depending upon the orientation of development of the electron in the pearl [9]. Commonly, band structures are connected with solid state valuable stones, anyway semi crystalline and vague materials may moreover have a band structure. A basic condition may be recognized for a photon in a photonic crystal. Here the photon accept the piece of the electron and the ability of the molecule backsides is subbed by a spatial assortment of the refractive rundown. In such a material, thoughts of solid state physical science may be associated with photons, like the band structure. A first specifying of this idea is found as exactly on schedule as 1972 by Bykov [Byk72]; in any case, the field of research started with two free creations of Eli Yablonovitch [7] and Sajeev John [8] who at first determined the optical properties of photonic pearls. Photonic valuable stones are gathered by their dimensionality. 1D, 2D and 3D photonic valuable stones are perceived depending upon the amount of headings in space wherein the structure is periodical (see Figure 2.). 1D photonic valuable stones identify with multilayer stacks. The least unpredictable case here is the Bragg stack, an optical segment, which has been for a long while known. In any case, the implications of photonic crystals outperform the edges of customary optics and a photonic valuable stone is in excess of a multidimensional Bragg stack.

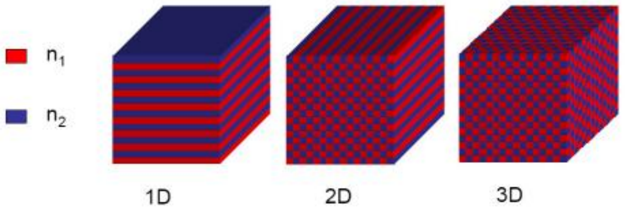

Figure 2: Schematic diagram of the different kinds of photonic crystals.

While the period length in a strong state precious stone is characterized by the separation of the molecules in the crystal grid (for example NaCl has a cross section consistent of Λ = 560 10-12 m), the period length of photonic precious stones is identified with the wavelength of the thought about light. In the wavelength system pertinent for PV applications, ordinarily cross section constants are in the scope of a few 100nm and are along these lines three sets of extents bigger than strong state precious stones. All the more definitely, a structure will go about as a photonic structure if the period length of the refractive list profile is in a similar range as the thought about light wavelength. Such structures are found in nature for example in wings of butterflies [Zha09], in the plumes of peacocks [Zi03], in opal crystals [San64] and in the stinger of the ocean mouse [Par01] (Figure 3).

Figure 3: Examples for photonic structures in nature. Butterfly wing, peacock feathers, opal, sea mouse

On the other hand it is additionally conceivable to acknowledge manufactured 3D photonic structures. One of the chief phony photonic structures was the "Yablonovite" [9], a structure where openings were exhausted in a 120° evenness. The Yablonovite and near photonic structures, like the "store of wood" structure [Lin98], were used to recognize photonic impacts in the infrared bit of the range. It was, regardless, hard to convey these structures for an application in the recognizable bit of the range as no fitting creation procedures existed. Despite for the correspondingly tremendous periods these structures included, the creation methodologies were moderate and to an incredible degree exhausting with the objective that no valuable stones could be conveyed on sweeping zones.

To get photonic structures in the undeniable range, a couple of techniques exist. One incorporates lithography systems like holography [10] or two photon lithography. Exchange utilizes the self-relationship of monodisperse roundabout particles. The most popular illustrative of these sorts of photonic valuable stones is the opal [Xia00]. This photonic valuable stone is named opal, since it has an indistinct structure from the precious stone. In the pearl, the refractive record profile is surrounded by silica zones with different water content (and as needs be unprecedented refractive rundown), while in the phony opal, the refractive document separate is the one of circle/an including area. Opals expect a basic part, since they may be conveyed on broad zones with comparably little effort [12].

Improving solar cells efficiency

In this section, it is exhibited tentatively that a back reflector structure with Ag plasmonic particles inserted between a dielectric and diffuse reflector can bolster great light catching execution in monocrystalline silicon sunlight based cells which is practically identical with the customary reversed pyramid finishing structure. We utilize frightfully settled photoluminescence to measure the absorptance, which empowers parasitic osmosis to be dismissed and gives a quick technique to assessing light getting. Photo conductance based estimations of the amazing conveyor lifetime at noteworthy implantation levels furthermore show that surface passivation isn't degraded. Plasmonic structures have a couple of central focuses over customary geometrical surfaces as they can be used for dainty crystalline silicon and multi-crystalline silicon where pyramid completing isn't possible. They can moreover be associated with a planar semiconductor layer, keeping up a key good ways from the need to scratch the dynamic zone of the device, consequently avoid the damage to the surface passivation of the sun arranged cell.

Diffuse coatings delivered utilizing dielectric particles have been used as back surface reflectors (BSR) in photovoltaic applications for more than 10 years. In 1998, Cotter at first associated dielectric particles as diffuse reflectors on daylight based cells. Berger et al. extended the short out current thickness by 41% for a flimsy cell with a mechanically available TiO2 white paint as diffuse reflector, and probably displayed that the white paint is better than anything Al, air, TCO/Al stack and withdrew reflect as a BSR. Starting late, Basch et al. achieved an improvement of 35% in hamper by applying TiO2 particles as BSR on a poly-Si meager film sun fueled cells, and extended this to 100% update by joining plasmonic particles with the TiO2 reflector [13].

A total review on the improvement of dielectric based diffuse reflector has been presented in Paper 2. This part discusses the preliminary show of an extraordinary light getting practiced by mix of diffuse reflector and scattering plasmonic nanoparticles on crystalline silicon wafers. And furthermore metallic reflectors, dielectric reflectors are moreover promising for joining with plasmonic structures as a result of their high reflectance over a sweeping powerful range, insignificant exertion and compound quality.

Here, C is a consistent of proportionality, eF.C − eF.V is the qualification of the quasi Fermi energies, ABB is absorptivity for band-to-band propels, k is the Boltzmann predictable, T is the temperature in Kelvin, ¯hω is photon essentialness (¯h is the reduced Planck steady, and ω is the jaunty repeat of the photon). Fig 4. is authentic for conditions where the differentiation in semi Fermi energies is consistent over the device, which is the circumstance for the high gauge, passivated, silicon wafers we use right now. The procedure for removing absorptance from radiance was first made and used by Trupke et al., using electroluminescence [14].

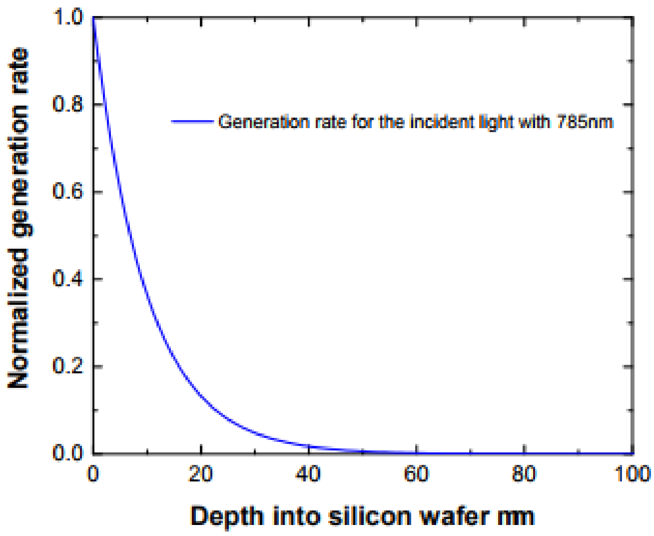

Figure 4: Normalized generation rate at 785nm in silicon wafer

The absorptance that we separate here are just relative esteems since the PL forces we measure are in self- assertive units. These should be changed over into total esteems by being standardized to 1 − R at the high vitality extend, where R is the front surface reflectance. The examples we consider here have light catching structures on the back of the gadget, and we enlighten with a laser with photon vitality well over the band-hole of silicon.

The standardized age rate of silicon wafer at 785nm episode laser is appeared in Figure 5 where all the light age occur at the initial 60 microns of the wafer. Along these lines assimilation of the enlightening laser by an example is the same whether the light catching structure is available or not.

Conclusion

In this paper, author contemplated the significant revelations and key studies of the topic. In view of the outcomes displayed here, a viewpoint for future bearings is examined. The primary focal point of this paper is to contemplate enhancing the transformation effectiveness of silicon Solar based cells by advancing light administration advancements. An epic procedure is concentrated to evaluate the light getting structures on silicon wafers. Considering the summarized Planck's law, the procedure uses band-to-band absorptance expelled from the horribly settled photoluminescence of tests. By standing out the band-from band absorptance of silicon wafers with and without light getting structures, the possible most prominent photocurrent improvement due to the light getting is figured. Not in the slightest degree like other depiction methodology, this system can decisively evaluate the veritable photocurrent thickness inside the dynamic layer without twistings in the intentional ingestion in light of parasitic disasters. Meanwhile, it allows brisk relationship of a wide collection of light getting structures on silicon wafers without the necessity for surrounding a p-n convergence, which can quicken the cell upgrade process.

References

[1]. A. Luque and S. Hegedus, Handpaper of photovoltaic science and engineering. John Wiley & Sons, 2011.

[2]. A. W. Blakers, A. Wang, A. M. Milne, J. Zhao, and M. A. Green, “22.8% efficient silicon solar cell,” Applied Physics Letters, vol. 55, no. 13, pp. 1363–1365, 1989.

[3]. R. M. Swanson, “Approaching the 29% limit efficiency of silicon solar cells,” in Photovoltaic Specialists Conference, 2005. Conference Record of the Thirty-first IEEE, pp. 889–894, IEEE, 2005.

[4]. M. Campbell, P. Aschenbrenner, J. Blunden, E. Smeloff, and S. Wright, “The drivers of the levelized cost of electricity for utility-scale photovoltaics,” White Paper: SunPower Corporation, 2008.

[5]. N.P. Harder, P. Wu¨rfel, Semicond. Sci. Technol. 18 (2003) S151.

[6]. S. John, Phys. Rev. Lett. 58 (1987) 2486.

[7]. M. A. Green and M. Keevers, “Optical properties of intrinsic silicon at 300 K,” Prog. Photovoltaics 3, 189–192 (1995).

[8]. A. Deinega and S. John, “Effective optical response of silicon to sunlight in the finite-difference time-domain method,” Opt. Lett. 37, 112–114 (2012).

[9]. R. R. LaPierre, “Numerical model of current-voltage characteristics and efficiency of GaAs nanowire solar cells,” J. Appl. Phys. 109, 034311 (2011).

[10]. 22D. Zhou and R. Biswas, “Photonic crystal enhanced light-trapping in thin film solar cells,” J. Appl. Phys. 103, 093102 (2008).

[11]. B. Rech, J. Müller, T.s Repmann, O. Kluth, T. Roschek, J. Hüpkes, H. Stiebig, and W. Appenzeller, “Amorphous and Microcrystalline Silicon Based Solar Cells and Modules on Textured Zinc Oxide Coated Glass Substrates”, Materials Research Society Symposium proceedings, 762 (2003).

[12]. G. L. Araujo, A. Marti “Absolute limiting efficiencies for photovoltaic energy conversion, “Solar Energy Materials and Solar Cells, 33 (1994), 213-240.

[13]. Y. P. Varshni, “Band to Band Radiative Recombination in Groups IV, VI and III-V Semiconductors”, phys. Stat. sol. 19 (1967) , 459

[14]. P. Würfel and U. Würfel, Physics of solar cells: from basic principles to advanced concepts. John Wiley & Sons, 2009.