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Original research article

The realization of the intermediate layer (IML) in a tandem solar cell using silicon-based photonic ribbon structure

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Highlights

- One dimensional photonic ribbon structure is disclosed to enhance an efficiency of Solar cell.
- Band gap of photonic structure is lucidly explained at all visible colours.
- Principle of intrinsic mechanism in tandem solar cell is divulged.

Abstract

The silicon-based 1D photonic structure is proposed in this research to realize an intermediate layer, which could be used in tandem solar cell, where 1 D photonic structure deals with a silicon ribbon with having 10 number of circular periodic air

hole on it. Further, the principle of realization of the present intermediate layer is based on the generation of photonic band gap with respect to the visible light, which is evaluated with the help of the plane wave expansion method. Finally, photonic band gap analysis confirms that the proposed one-dimensional photonic ribbon structure can be a suitable layer to introduce in a tandem solar cell to envisage better efficiency.

Introduction

Nevertheless, the world is taking interest in a renewable energy source, the efficiency of these sources is a matter of concern now a day's pertaining to the present. For example; the efficiency of the solar cell is a big challenge with respect to current technology. The present research indicates that the efficiency of the solar cell is about 22–25 and 40–50% pertaining to theory and experiment respectively. Researchers around the globe are being carried out research for increasing overall efficiency of the same through individual components of the cell. Further, considering the type of solar cell, it is realized that a single cell or multiple cell junction belongs to solar cell category [1]. Out of which two cells separated by an intermediate layer is called a tandem solar cell (multi-junction cell) which bestows high efficiency as compared to a single junction cell. Though each element of the tandem solar cell is responsible for increasing the cell's efficiency, an intermediate layer in the same is also an onus for enhancing intrinsic properties of the tandem cell such that all the signals of visible spectrum would be absorbed by two cells. As a result of which an overall efficiency of the tandem cell increases. As far as the focus of this work is concerned, it deals with α-silicon and μ-silicon cells such that it is separated by a photonic ribbon structure whose length and breadth controls the signals. This paper organized as follows Section 2 mentioned a brief of a literature review on the IML which has been disclosed in different works for realizing tandem solar cell. Section 3 discusses an operational mechanism of the present works including structure, where result and analysis are stated in Section 4, and finally, the conclusion is indicated in Section 5.

Section snippets

A brief literature review

Before going to focus on previous works related to the intermediate layer, let us define a tandem solar cell as follows;

It is the simplest solar cell which is the stacking of two absorbers. For example; the combination of two cells leads to high and low bandgap material, which gives rise to control all the illumination inside it. Further realizing a couple of benefits over solar cells we can say that photons having less energy as compared to bandgap do not contribute all to produce

Structure and mechanism

Before going to discuss the mechanism of operation, let us concentrate on the tandem cell structure, which is shown in Fig. 1.

Fig. 1 represents α- silicon /μ- silicon stack cell with having an intermediate layer of the one-dimensional photonic structure. From the above figure, it is understood that the top layer would be a lower band gap regime as compared to the bottom layer. Though the different band gap regime is considered in this cell, the efficiency is not up to mark due to the junction

Basic mathematics to create a photonic bandgap

The reflectance and transmittance of a signal with respect to the one-dimensional photonic structure are studied with the help of photonic band gap analysis which is carried out using the plane wave expansion method [8]. Before going to discuss the outcomes of this research, let us summarise mathematics to calculate of photonic bandgap of the proposed structure which is mentioned in Fig. 3.

The above periodic arrangement of air holes on a silicon substrate has the following properties such as$\varepsilon(r + a)$

Result and interpretation

With the help of numerical techniques from Eq. (6), the photonic band gap of one-dimensional silicon strip with 10 numbers of periodic air holes is investigated for all visible spectrum. As far as visible spectrum is concerned, the present communication deals with seven colors such as violet, indigo, blue, green, yellow, orange and red having the wavelength range of 400 nm–450 nm,450 nm-485 nm,485 nm–

500 nm,500 nm-565 nm,565 nm–590 nm,590 nm-625 nm and625nm-700 nm respectively. Again reminding

Conclusion

Silicon-based an intermediate layer is envisaged in this paper with the help of one-dimensional photonic structure. The same realization is made through photonic band gap analysis, which is carried out a plane-wave expansion technique. Finally, outcomes of present research divulge that silicon-based one-dimensional photonic structure could be a promising candidate to design an intermediate layer and it would help to increase the overall efficiency of tandem solar cell.

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References (8)

G. Palai *et al.*
Efficient silicon grating for SOI applications
Opt. – Int. J. Light Electron Opt. (2013)

S. Ikhmayies
Advances in Silicon Solar Cells
(2018)

D.W. Zhao *et al.*
Efficient tandem organic solar cells with an Al/MoO3 intermediate layer
Appl. Phys. Lett. (2008)

Y. Yuan *et al.*
Intermediate layers in tandem organic solar cells
Green (2011)

There are more references available in the full text version of this article.

Cited by (4)

Enhancement of optical visible wavelength region selective reflector for photovoltaic cell applications using a ternary photonic crystal

2021, Optik

> *Citation Excerpt :*
>
> ...The light propagation in these structures is controlled by using variant materials and geometrical arrangements. As a result of this feature, employing photonic crystals in photovoltaic applications has grown in recent years [2–6]. Photonic crystals have been proposed for many other applications [7–14]....

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Realization of graphene based quantum dot solar cell through the principle of photonics

2020, Optik

> *Citation Excerpt :*
>
> ...Nevertheless different types of solar cells [1] have been envisaged now a days to achieve maximum throughput of the cells, the quantum dot based solar is a promising research throughout the globe because it deals with the quality performance with respect to the current research scenario. Even though researchers around the world designing different new type of devices, the efficiency of solar cell is a matter of concerned owing to it restricts with 21–23 % [2–7]. Keeping the importance of the same, the present research deals with the photonic based solar cell where graphene based quantum dot layer have been used as active layer....

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Realization of antireflection elements using glass-based photonic crystal structures

2019, Optik

> *Citation Excerpt :*
>
> ...For examples, the antireflection coating is used in solar cell, where 100% visible signal can be absorbed by it. Apart from this, recently a paper is published in OPTIK [11] which realizes antireflection elements, where the entire structure is based on artificial materials, which claims that the proposed structure would be used in solar cell as antireflection elements. Since this paper claims a novel notion, it deals with plasmonic-based metamaterial structure which is difficult to design it....

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