



## Improve the Efficiency and Open Circuit Voltage of Triple Junction GaAs Solar Cell with Anti Reflector Layer

Bitā Farhadi<sup>1</sup>, Tahereh Abasi<sup>1</sup>, Rozita Farhadi<sup>1\*</sup>, Niloofar Sadeghi<sup>2</sup>, Behnam Tahmasebi Esmati<sup>1</sup>, Saba Ebrahimpanah<sup>3</sup>

<sup>1</sup>Young Researchers and Elite Club, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran

<sup>2</sup>Zagros Institute of Higher Education, Kermanshah, Iran

<sup>3</sup>Electrical Engineering Department, Faculty of Engineering, Razi University, Tagh-E-Bostan, Kermanshah, Iran

**\*Corresponding Author:** Rozita Farhadi, Young Researchers and Elite Club, Kermanshah Branch, Islamic Azad University, Kermanshah, Iran

**Abstract:** In this paper, we first study the structure and operation of solar cells with three junctions based on GaAs, we then consider some important parameters like efficiency, Fill factor, short circuit current and open circuit voltage. Indeed, Solar cell or photovoltaic cell is a device which directly converts the photovoltaic effect to the electricity. Solar modules and photovoltaic arrays are used for constructing solar panels among all cells. Moreover, photovoltaic is a technology and research area that is related to the solar cells application in a electricity generation for practical using. In addition, the energy generation by using this method is an example of solar power.

**Keywords:** Photovoltaic, solar cells, Fill factor, GaAs, Anti reflector.

### 1. INTRODUCTION

Since solar cells are more applicable in electricity preparation (AC) using photovoltaic powerhouse and providing necessity energy for devices that need lower voltage, so operational improvement of them are more important. At first multi-junction solar cells with high efficiency are designed for specific applications like satellites and spatial discovering, but currently, they are the lowest cost selection for using in Terrestrial concentrator. These multi-junction solar cells consist of multi thin layers which are generated by Epitaxy method. Till now, GaAs multi-junction devices are more efficient solar cells.

### 2. OPTICAL LIGHT SOURCES IN ELECTRONICS AND TELECOMMUNICATIONS

Sets are both originally from the middle of the composition of aluminum, gallium, arsenic, germanium, phosphorus, antimony, Si with different proportions and the degree of concentration is obtained. understand the basic principles of light sources telecommunications, optical phenomena in absorbing the radiation we describe the spontaneous and stimulated emission. Atom or the semiconductor crystal, the absorption of certain wavelengths of light in the form of electromagnetic waves or will be free. Know that a semiconductor has three valence band and the conduction band energy of prohibited conduct are that if you call E1 and E2 and the valence band the electron energy band E2 is the energy of the conduction band energy band E2 to E1, light with a frequency proportional to the energy difference E2-E1 is absorbed or released by Ibn frequency from the following equation derived, Figure 1 illustrated the proposed structure.

$$F = e2 - e1 / h. \quad (1)$$

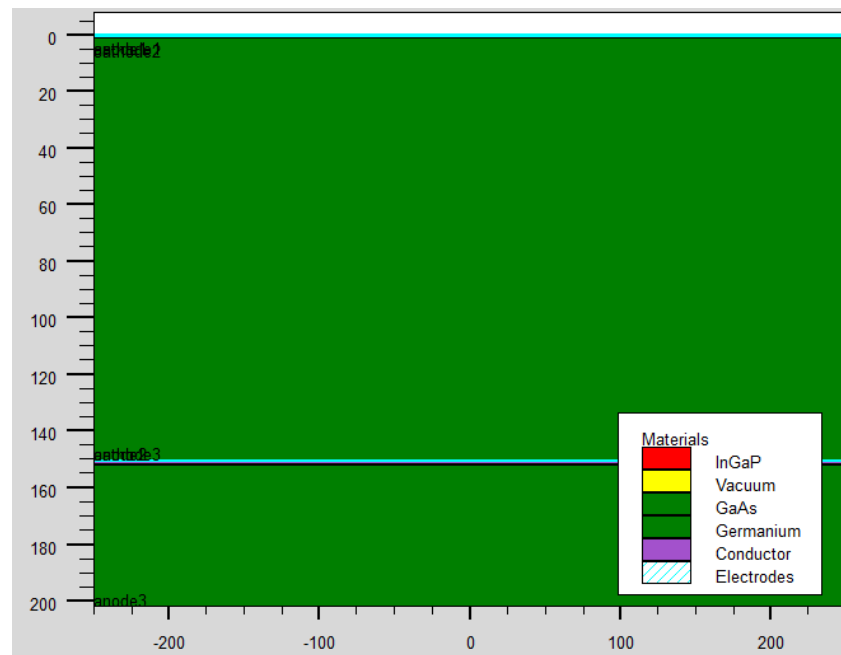


Figure1. Proposed structure

### 3. PROPOSED SOLARCELL STRUCTURE

Solar cell that LED can also say, like typical diode, connecting two semiconductor p-type and n are constructed with different junction semiconductor materials wearing black is, but because it light junction semiconductors will usually " it by the glass or transparent plastic cover. Be installed on most photo diode a very small lens to focus light into the area and can link to the site. photo diode a light detector that may be required depending on the light energy is converted into electrical current. photo diodes very similar to the diodes semiconductor usual, with the difference that the diodes in photon could also be exposed to light energy ( x-ray or uv) be and can be optical fiber connections shall be mounted to light the areas of critical is entered, it should be noted that the structure of the photon diode diode that is built into the pin connection used to link the pn. N -type silicon is the basic material. A thin layer of P, using thermal diffusion or ion implantation doping with suitable material (typically boron) on the upper surface of the tool is installed. The thickness of this layer must be represented by the wavelength of the radiation is determined. P and N silicon boundary layer is known as the PN bond. Small metal fitting on the upper level and all the instruments are mounted on the back is coated with a metallic connection. Back connection, cathode and connectivity front, the anode. Active surface of the silicon nitride or silicon monoxide or silicon dioxide is coated for protection and to prevent reflections. The thickness of the cladding layer is specific for a particular emission wavelength. PN link capacity depends on the thickness of the depletion region. Reverse bias voltage increases, the thickness of this region increases, the capacity is reduced (as long as it does not create conditions for full discharge). Link capacity, as well as the specific resistance of the silicon active area. Photo diodes basis is actually a link PN or PIN structure .the area is called sweeping .Thus holes move toward the anode, and electrons toward the cathode, and a stream of light (photo current) is created. Photovoltaic mode, the diode at zero bias or photovoltaic mode, go to work, the luminous flux (photo current ) is restricted and a voltage builds . In this case, the diode is forward biased and" dark current" (currents this is that in the absence of light photons diode) light in the opposite direction of the flow will begin to flow. This mode is induced photovoltaic effect is the basis for solar cells. Indeed Cell a diode with a large area of solar panels. photo conductive mode or optical semiconductor diode is reverse biased in this fashion usually quickly reduces the response time will increase the noise. This, in turn, increase the width of the depletion region, which in turn reduces the link capacity and the response speed is faster. Reverse bias induces only a small amount of current for a while during constant light (figuratively, of course). Linearly with the light intensity is proportional. Although it is faster, more electronic noise shows photo conductive mode. In figure 2 and table 1 show the J-V curve and output parameters of proposed structure, respectively.

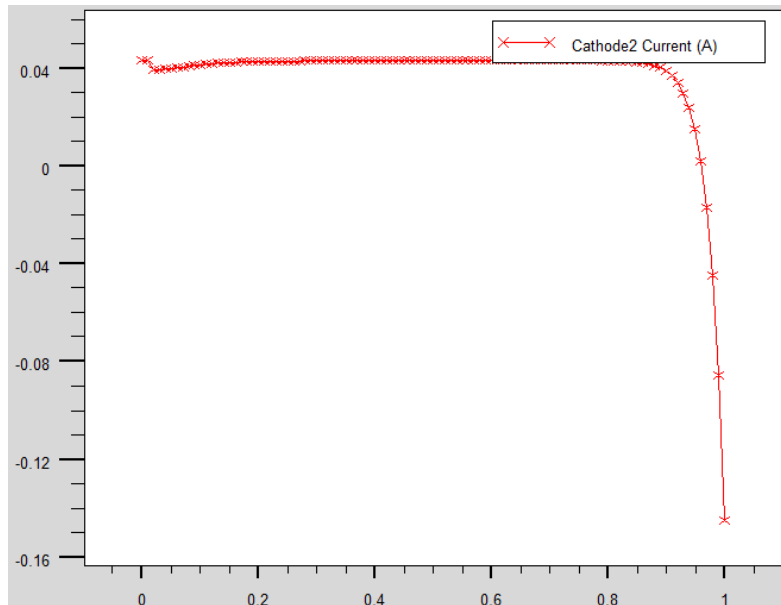


Figure2. The J-V curve of proposed structure

Table1. The output parameters of proposed structure

$J_{sc}(mA/cm^2)$	41.305
$V_{oc}(V)$	1.0002
FF(%)	88.2489
$\eta(\%)$	26.670

#### 4. PHOTOVOLTAIC MODE

When the diode at zero bias or photovoltaic mode, go to work, the luminous flux (photo current) is restricted and a voltage is created. In this case, the diode is forward biased and "dark current" begins to flow in the opposite direction of the flow of light. These materials, photovoltaic effect.

The effect of impurity thickness and density on various physical and electrical parameters of the solar cell was investigated. We will now examine the results of the simulation with respect to changes in the geometric characteristics of the solar cell. Tables 2 and 3 show the results of numerical analysis.

Table2. Parameters extracted from the simulation due to the change in emitter layer thickness.

Emitter thickness	0.1	0.2	0.4	0.8
$J_{sc}(mA/cm^2)$	42.7701	35.2002	43.008	27.6004
$V_{oc}(V)$	1	1	1	1
FF (%)	86.2754	83.0965	87.8906	81.5217
$\eta(\%)$	26.9993	21.4019	27.6578	16.4630

Table3. Parameters extracted from the simulation due to the change in the thickness of the base layer.

Base thickness	100	120	140	150
$J_{sc}(mA/cm^2)$	28.865	3.6875	5.984	42.77
$V_{oc}(V)$	1	1	1	1
FF(%)	89.8908	87.8644	89.7292	86.2754
$\eta(\%)$	18.9851	2.3706	3.9287	26.9993

According to the table 4, The best doping concentration is  $1e17$  for Emitter and  $1e18$  for Base.

Table4. Parameters extracted from the simulation due to the change in impurity density of the base layer

Base doping concentration	$1e15$	$1e16$	$1e17$	$1e18$
$J_{sc}(mA/cm^2)$	40/9175	42/351	43/025	43/1
$V_{oc}(v)$	1	1	1	1
FF(%)	88/8617	87/9790	89/4248	89/6868
$\eta(\%)$	26.6042	27.2627	28.1517	28.2834

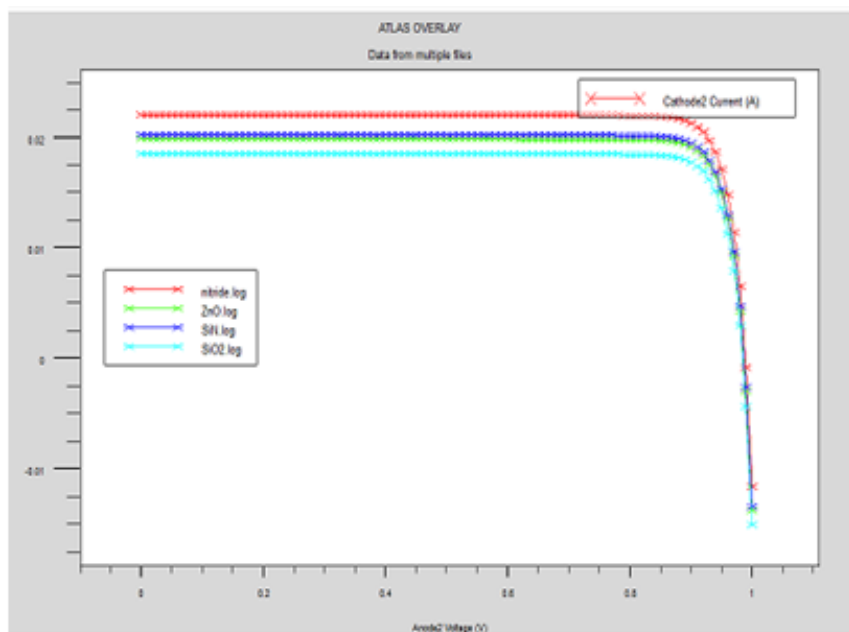
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Then we investigation the effect of adding different anti-reflective coatings on InGaP / GaAs / Ge three-junction solar cells. The results of this simulation are shown in the table 5.

**Table5.** Parameters derived from simulation due to the addition of various anti-reflective coatings.

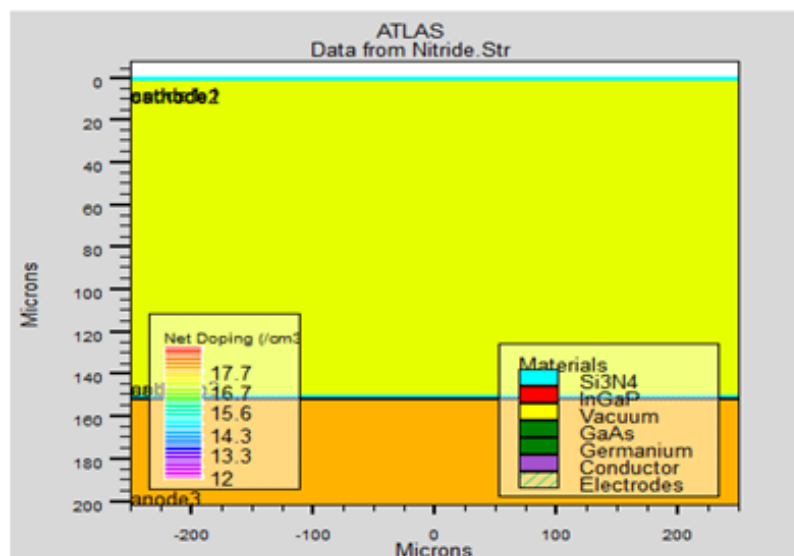
Anti-reflector materials	SiO <sub>2</sub>	SiN	ZnO	Si <sub>3</sub> N <sub>4</sub>
<b>J<sub>sc</sub>(mA/cm<sup>2</sup>)</b>	<b>40.746</b>	<b>41.081</b>	<b>41.644</b>	43.095
<b>V<sub>oc</sub>(V)</b>	<b>1</b>	<b>1</b>	<b>1</b>	1.006
<b>FF(%)</b>	<b>90.4137</b>	<b>90.7974</b>	<b>91.249</b>	89.3699
<b>η(%)</b>	<b>26.9554</b>	<b>27.2923</b>	<b>27.804</b>	28.3493

Figure 3 and Table 5 compares the IV diagram of the cell with different reflective coatings, By adding Si<sub>3</sub>N<sub>4</sub> anti-reflective coating, we were able to return the efficiency to 28.3493% That has increased compared to single-link mode and other covers.



**Figure3.** Comparison of the performance of different anti-reflective coatings

The figure 4 shows the proposed cell structure by adding the Si<sub>3</sub>N<sub>4</sub> anti-reflective coating, and figure 5 shows the I-V curve of proposed structure with Si<sub>3</sub>N<sub>4</sub> anti-reflective coating.



**Figure4.** The InGaP / GaAs / Ge solar cell structure by adding Si<sub>3</sub>N<sub>4</sub> reflective coating.

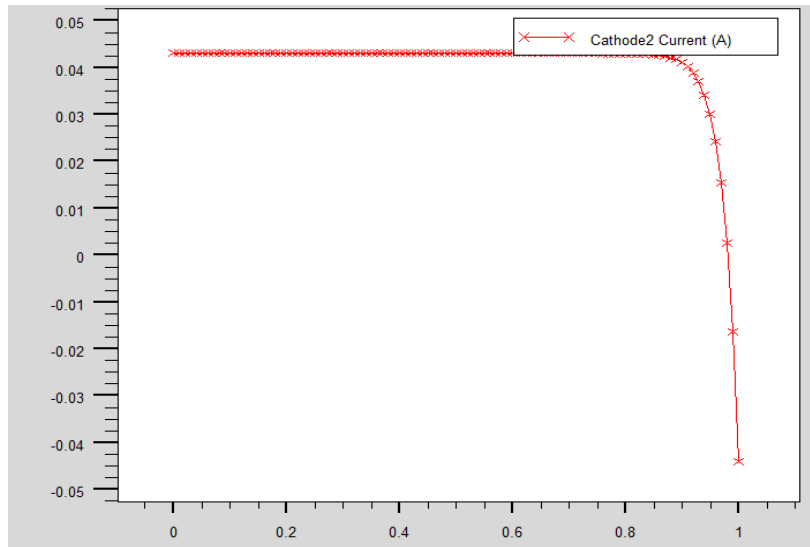


Figure 5. The I-V curve of InGaP / GaAs / Ge solar cell with Si<sub>3</sub>N<sub>4</sub> anti-reflective coating

## 5. CONCLUSION

In this paper, we examined and analyzed the structure and function of InGaP / GaAs / Ge solar cells. We have shown that GaAs single-link solar cells have a conversion efficiency of 21.97%, which we were able to increase by 26.67% by adding the number of layers.

We also showed that changing the thickness and contamination of solar cell layers, like other electrical devices, has a significant effect on cell output, and with proper selection of these two factors, many parameters of the solar cell can be optimized.

Then we showed that by adding Anti Reflect Coating (ARC) the cell parameters were affected and we examined the effect of adding different anti-reflective coatings such as Si<sub>3</sub>N<sub>4</sub>, SiN, ZnO and SiO<sub>2</sub> and we came to this conclusion. By placing the Si<sub>3</sub>N<sub>4</sub> as an anti-reflective coating, we were able to achieve higher efficiency and filler coefficient.

Finally, we examined the effect of changing the impurity level of the layers along with adding the Si<sub>3</sub>N<sub>4</sub> anti-reflective layer on the cell function and concluded that if we increase the impurity level of the middle layer of the cell and put a layer of Si<sub>3</sub>N<sub>4</sub> anti-reflective coating on the cell. The yield will increase by 34.0788% and we will reach a shorter connection current and a higher open circuit voltage.

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