High efficiency multi-crystalline Inorganic Solar cell using Er^{+3} based Plano Convex lens

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Abstract: Photovoltaic cell PVC is semiconductor device generally called PN type semiconductor. PVC plays a vital role in electricity generation. There are various classes of PVC mainly Organic, inorganic and hybrid. Mostly consumers complain that their PVC is not producing electricity efficiently. Another problem which is associated with PVC is its less charging time or less visibility of the sun during winters and rainy season. The aim of this study is to address the aforementioned problems associated with PVC. Our team proposes the two main solutions in this regards one is use of erbium slit over solar cell to get the strong solar beam and second one is plano-convex lens over erbium slit that concentrate the sun light that will enhance the photon emission rate. Our study proves that proposed system is more efficient than the conventional PVC.

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Introduction

Although an immense amount of solar light energy is constantly coming from the sun to the earth, all that solar light energy is spread out over a very large area of the earth. This form of energy is free and environmental friendly. New possibilities are opened up if we convert concentrate solar energy into electrical signals. This is our area of research where large area sunlight is focused into much smaller area further this area will be used to generate electricity using PVC Photovoltaic cell. The process of conversion of sunlight into electricity through photovoltaic cell is known as Photovoltaic effect or solar cell. Light is a form of energy and comprises of photons and electromagnetic waves [1][2][3]. In the same way photovoltaic cell depends on frequency of electromagnetic waves and photons. Photon is just like an energy packet and depends on two major terms time and space. Photon is denoted by γ (the Greek letter gamma), it is massless, has no electric charge, and is stable [4]. Photons are usually symbolized by ($h\nu$), whereas ‘h’ is Planck's constant and the Greek letter ‘ν’ (nu) is the photon's frequency. There is another relationship between Photon and frequency which is symbolized by (hf)[5][6]. Double slit experiment is the well-known example of photons; solar spectrum possesses different wavelengths of light which causes different energy level of photons. One of the noble technique is to produce more electricity from PVC is the usage of concentrated sunlight which helps PVC to absorb more photons per unit area. In other words more electricity will be produced from a much smaller solar cell. The energy and momentum of a photon depend only on its frequency (ν) or inversely proportional to its wavelength (λ)[7][8]. So its good to filter larger electromagnetic waves to get better quality results. Plano convex lens is another technique to produce concentrated solar light. Lens collects the large area sunlight, focused it directly towards photovoltaic cell on the small face of the slab, resulting in a concentration effect and more photon emission from a single PVC. Photon cloning is possible or one photon will be converted into two Photons if incident photons absorbed in excited atom results hole and ground state atom with two photons[9][10].

A. Working of Photovoltaic cell (PVC)

The PVC is a solid state semiconductor that produces direct current or electricity. When incident photon is absorbed by the solar cell, it dislodges an electron from the atom and leaves the hole behind. The hole is like a bubble in the water and attracts other available free electrons. In terms of electronics free electrons will flow towards 'P' side of a PN junction. The result of PN junction is the flow of free electrons or flow of electricity will occur. Gallium arsenide (GaAs) are used in PVC on a commercial scale, its ultra-high efficiency is above 30% .Although both elements Gallium arsenide are electrically neutral, n-type (As) has excess electrons and p-type (Ga) has excess holes, by Sandwiching these elements together creates a PN junction at their interface, thereby creating an electric field. There are two major classes of Photovoltaic cell a) Organic (OPV) b) Inorganic (IPV).

An organic solar cell (OSC) or plastic solar cell is a type of organic electronics which deals with long chain polymer or conductive organic polymers .OSC is produced by special technique called molecule engineering it means creating a useful iso-polymer with appropriate energy gap, which enhances the absorption of photon in an organic molecule of OSC. The main disadvantage of OSC is low efficiency and less durable as compared to inorganic photovoltaic cells. There are few other types of photovoltaic cells that can convert infrared (IR) or ultraviolet (UV) radiation into electricity. When these polymers absorb a photon, an excited state is created where electron leaves its position, hole will be created which attract other free electrons. There are three types of PVC.

1. Mono-crystalline it the slice from single crystal (expensive)
2. Poly-crystalline or Multi-crystalline it is a slice cut from a block of silicon (Moderate)
3. Amorphous cell it is manufactured by placing a thin film of amorphous (non-crystalline) on to white choice of surfaces (least expensive)

Methodology

Aim of this study is to develop an efficient inorganic solar panel using two different technologies one is Erbium and other one is Plano-convex lens. There two layer above PVC which is erbium and plano-convex lens. Erbium strengthens the light signal whereas lens collects the light from its coverage area. In other words it is concentrated source of energy, which enhances the photon rate of emission. Our study proves it enhances the photon rate of emission up-to 35%. Experiments are conducted on 32 inorganic cells. The mathematical relationship of open circuit voltage is as follows.

$$V_{oc} = \frac{KT}{q} \ln\left(\frac{I_L}{I_0}\right) \text{------1}$$

Where as

K is Boltzmann constant which is K=1.38e-23

T is total temperature which is T=300K

I_L is Current supplied by solar cell, our readings

I_0 = the reverse saturation current, our readings

The second relationship a fill factor which means power of PVC divided by Voc open circuit voltage.

$$ff = \frac{P_{Max}}{V_{oc}} \text{------2}$$

Our study compares the regular PVC and proposed PVC energy level which depicts the exact difference between two systems, results are as follows.

Aforementioned graph shows the comparative efficiency of the two systems. The proposed PVC efficiency from 11a.m to 4p.m is maximum current but the regular PVC does not. Further this study proves the proposed PVC in different environment.

Table 1.

S.NO	Day time	Regular PVC η	Our Research η
1	7.00A.M	30%	50%
2	8.00A.M	40%	70%
3	9.00A.M	50%	80%
4	10.00A.M	60%	95%
5	11.00A.M	80%	100%
6	12.00P.M	100%	100%
7	1.00P.M	90%	100%
8	2.00P.M	80%	100%
9	3.00P.M	70%	100%
10	4.00P.M	60%	100%
11	5.00P.M	50%	95%
12	6.00P.M	40%	80%
13	7.00A.M	30%	40%
14	8.00A.M	0%	0%

Related comparative Graph is as follows.

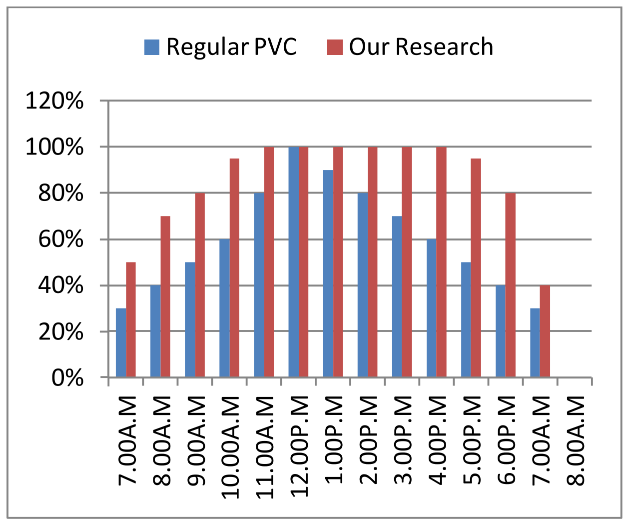
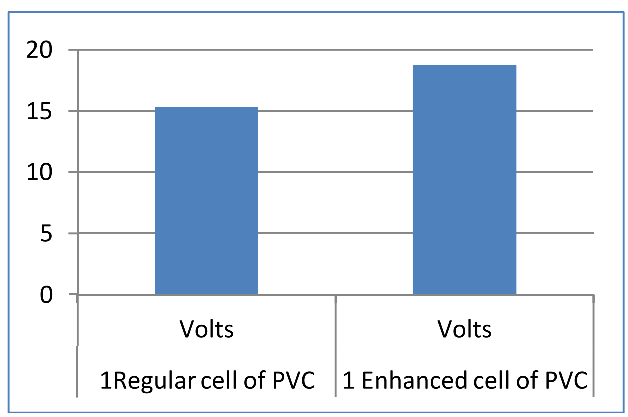


Fig. 1. Inorganic PVC vs Plano-Convex Er+3 PVC



The graph shows the difference in potential difference which is 15.33V and 18.75V respectively. More over our study proves the enhancement of current over all day long. The graph is as follows.

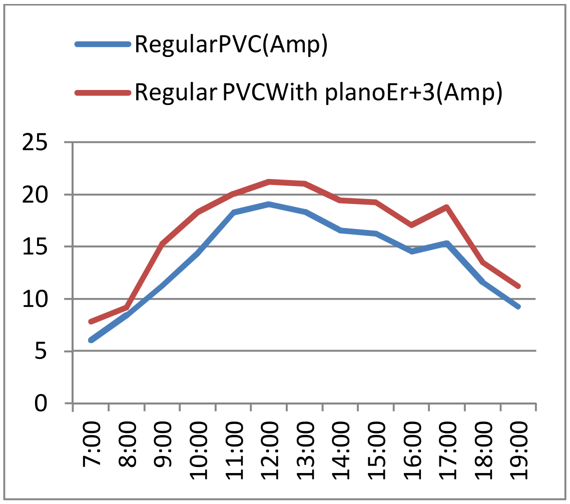


Fig. 3. Daily chart in amperes.

This study compares the two systems, develops its interpolation. Photovoltaic cell efficiency can be increase if the concentrated sun light is high and focused, the photon absorption will be high if its reflection rate is low and sun light is concentrated. Basically PVC is a semi-conductor or PN junction where two types of electron flows one is electron and other is holes. When photon absorb by the PN layer the fixed electron reacts with it, dislodge its position leaving a hole behind. So, electrons flow from P side to N side. Thus flow of electrons takes place. The chemistry in this process is band gap in PVC and frequency of light not its wavelength. Interpolation of the two systems is as follows.

Time		Amp	∇	∇2	∇3	∇4	∇5	∇6	∇7	∇8	∇9	∇10	∇11	∇12
7:00	1	7.84												
			1.36											
8:00	2	9.2		4.67										
			6.03		-7.67									
9:00	3	15.23		-3		9.4								
			3.03		1.73		-10.42							
10:00	4	18.26		-1.27		-1.02		9.92						
			1.76		0.71		-0.5		-7.18					
11:00	5	20.02		-0.56		-1.52		2.74		4.47				
			1.2		-0.81		2.24		-2.71		-13.37			
12:00	6	21.22		-1.37		0.72		0.03		-8.9		70.35		
			-0.17		-0.09		2.27		-11.61		56.98		-278.2	
1:00	7	21.05		-1.46		2.99		-11.58		48.08		-207.9		910.8
			-1.63		2.9		-9.31		36.47		-150.9		632.5	
2:00	8	19.42		1.44		-6.32		24.89		-102.8		424.6		
			-0.19		-3.42		15.58		-66.35		273.7			
3:00	9	19.23		-1.98		9.26		-41.46		170.9				
			-2.17		5.84		-25.88		104.6					
4:00	10	17.06		3.86		-16.62		63.11						
			1.69		-10.78		37.23							
5:00	11	18.75		-6.92		20.61								
			-5.23		9.83									
6:00	12	13.52		2.91										
			-2.32											
7:00	13	11.2												

Time		Amp	∇	∇2	∇3	∇4	∇5	∇6	∇7	∇8	∇9	∇10	∇11	∇12
7:00	1	6.04												
			2.38											
8:00	2	8.42		0.4										
			2.78		-0.05									
9:00	3	11.2		0.35		0.53								
			3.13		0.48		-5.05							
10:00	4	14.33		0.83		-4.52		15.36						
			3.96		-4.04		10.31		-32.83					
11:00	5	18.29		-3.21		5.79		-17.47		61.05				
			0.75		1.75		-7.16		28.22		-111.4			
12:00	6	19.04		-1.46		-1.37		10.75		-50.37		215.7		
			-0.71		0.38		3.59		-22.15		104.3		-456.9	
1:00	7	18.33		-1.08		2.22		-11.4		53.95		-241.1		1042
			-1.79		2.6		-7.81		31.8		-136.8		584.7	
2:00	8	16.54		1.52		-5.59		20.4		-82.87		343.6		
			-0.27		-2.99		12.59		-51.07		206.8			
3:00	9	16.27		-1.47		7		-30.67		123.9				
			-1.74		4.01		-18.08		72.82					
4:00	10	14.53		2.54		-11.08		42.15						
			0.8		-7.07		24.07							
5:00	11	15.33		-4.53		12.99								
			-3.73		5.92									
6:00	12	11.6		1.39										
			-2.34											
7:00	13	9.26												

Fig. 4. Regular PVC vs Proposed PVC.

The interpolation difference of these systems is 130.85. The mathematical relationship is as follows. Conventional PVC minus proposed PVC.

I= 1042 - 910.8 =130.85

B. Mathematical Relationship of proposed system.

Lagrange approximation helps us to develop its relationship the proposed equations are as follows.

P(x)=

<table>
<tr><td colspan="5">(x-16.745)(x-20.62)(x-20.235)(x-18.145)(x-16.135)(0.21325)+</td></tr>
<tr><td></td><td></td><td>-85454</td><td></td><td></td></tr>
<tr><td colspan="5">(x)(x-20.62)(x-20.235)(x-18.145)(x-16.135)(0.23055)+</td></tr>
<tr><td></td><td></td><td>-193.393</td><td></td><td></td></tr>
<tr><td colspan="5">(x)(x-16.745)(x-20.235)(x-18.145)(x-16.135)(0.23605)+</td></tr>
<tr><td></td><td></td><td></td><td>341.4749</td><td></td></tr>
<tr><td colspan="5">(x)(x-16.745)(x-20.62)(x-18.145)(x-16.135)(0.2355)+</td></tr>
<tr><td></td><td></td><td>-232.981</td><td></td><td></td></tr>
<tr><td colspan="5">(x)(x-16.745)(x-20.62)(x-20.235)(x-16.135)(0.23265)+</td></tr>
<tr><td></td><td></td><td>264.1208</td><td></td><td></td></tr>
<tr><td colspan="5">(x)(x-16.745)(x-20.62)(x-20.235)(x-18.145)(0.2294)</td></tr>
<tr><td></td><td></td><td>363.782</td><td></td><td></td></tr>
</table>

Mathematical expression gives the exact relationship of the charge conduction in proposed PVC but it is efficiency is based on solar visibility.

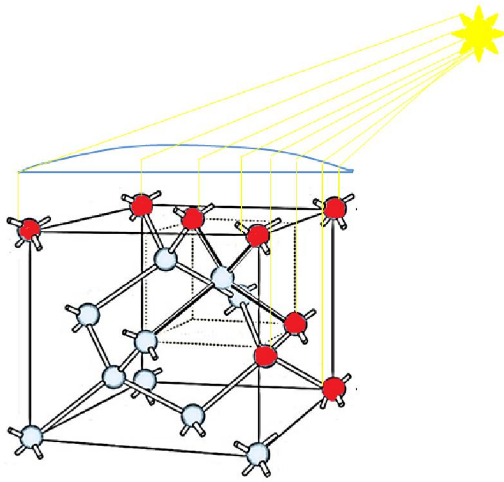


Fig. 5. Demonstration

Conclusions

This study explores the importance of concentrated sunlight and Erbium over Photovoltaic cell PVC. It helps PVC to absorb more photons in unit time and produce more electric current. Our proposed system is cheap and easy to install on any other solar cell, it will be one of the success factor of our research. By comparing the results of regular PVC with proposed PVC we have found that the photon emission ratio is 1:1.6. The experiment shows its interpolation result is 130.85 units better than the conventional one. The logic behind this performance is concentrated sun light, technically more photon absorption through erbium slit result more free electrons or electricity. More experiments are underway soon our team will develop efficient inorganic photovoltaic cell, it result will be better than our proposed PVC.

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