IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

MODELING AND SIMULATION OF TIO2/GAAS SOLAR CELL USING SCAPS

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Abstract: To generate electricity, solar cells use either photovoltaic effects or chemical reactions to transform solar energy into heat or chemical power. Solar panels are made up of cell configurations that are used to create solar modules that gather energy from the sun. Processes for large-scale production that can be scaled up A flexible, semi-transparent, and low-cost organic solar cell (OSC) is a promising alternative to traditional photovoltaic cells. The effect of solar-cell thinness and doping concentration on the cell characteristics of TiO_2 and GaAs photovoltaic cells was investigated with the use of SCAPS. However, these cells' performance of power transmission remains modest. We ran simulations of n-TiO_2/p-GaAs using the SCAPS-1D software. Thin-film solar cells made of n-TiO_2/p-GaAs. We assessed a few certain n-TiO_2/p-GaAs thermal impact, phase density at the interface, metal work function and other heterojunction factors and Cross-section of electron and hole capture. Our findings demonstrate that raising the density of states of p-type GaAs layers and decreasing user's metal casting functionality can improve the performance of n-TiO_2/p-GaAs solar cells. Our findings also show that the best design includes TiO_2 as a buffer layer, GaAs as an absorber, and thicknesses of x = 2µm, 4µm, 6µm, 8µm, 10µm, 12µm, 14µm, 16µm and 18µm doped with a concentration of $1.00E^{+17}$ cm^{-3} for all compositions. These solar-cells have a performance of 24.99 %, which is potentially higher than what was previously achieved in the Solar-cell research.

KEYWORDS: TiO_2/GaAs solar cells, Thin film solar cell, SCAPS-1D, Simulation

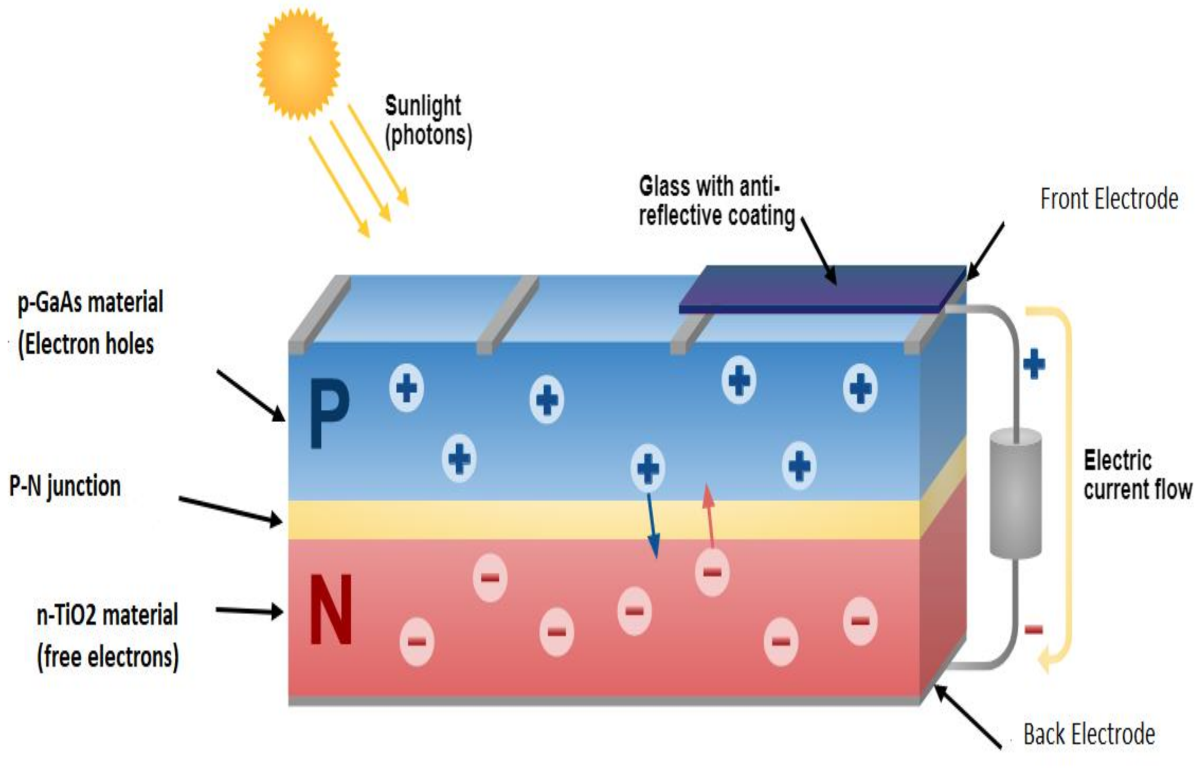
I. INTRODUCTION

Sunlight is a significant renewable energy source. Sources on the planet, with the potential to help alleviate a future global energy problem [1–2]. Over the last few years, photovoltaic (PV) module on a worldwide scale industry has exploded. Photovoltaic modules' global capacity grew from 6.1 GW to 6.2 GW. a rise from 6.1 GW in 2006 to 291 GW by the end of 2016; (IRENA, 2017a). In contrast to the crystalline wafers used to produce these PV devices, the semiconductor material layers used to make these devices are just a few micrometers thick.

The functionality of the multi junction solar cell was evaluated using the SCAPS1D simulation software. This software can calculate efficiency based on various solar cell parameters. The SCAPS-1D simulator software's main purpose is to find best solar cell structural with the highest efficiency.

OBJECTIVE OF MODELING AND SIMULATION:

Simulation solar cell's main goal is to see if the projected formation and performance are valid. Figure 2(a) and (b) depicts definition panel of SCAPS-1D. usually, typical cell has two layers: n type TIO2 of window layer and an absorber layer of p type GaAs as shown in figure-1. With back contact materials, GaAs thickness ranged from 2μm to 18μm in this simulation. All other parameters, as given in tables 1 and 2, remain unchanged.



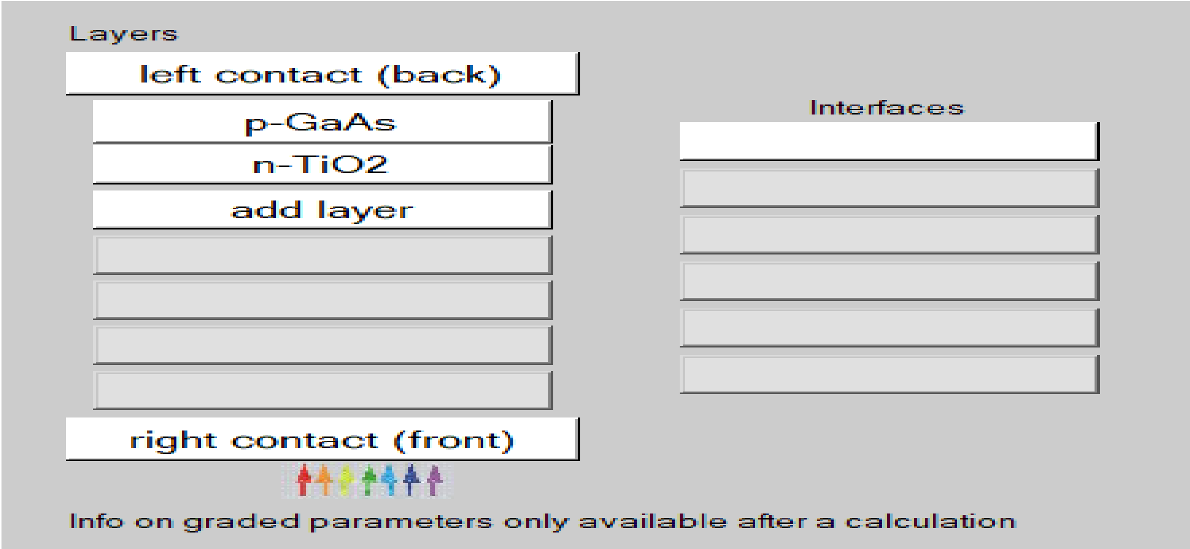
(Fig-1 Schematic diagram of solar cell)

Parameters	p-GaAs	n-TiO_2
Thickness (µm)	18	0.3
Band gap (eV)	1.42	3.20
Electron Affinity (eV)	4.07	4.20
Dielectric Permittivity (relative)	13.18	10
CB Effective Density of States (cm^{-3})	4.70E+17	2.00E+17
VB Effective Density of States (cm^{-3})	7.00E+18	6.00E+17
Electron Thermal Velocity (cm/s)	1.00E+7	1.00E+7
Hole Thermal Velocity (cm/s)	1.00E+7	1.00E+7
Electron Mobility (cm^2 /Vs)	4600	1.00E+2
Hole Mobility (cm^2 /Vs)	239	2.50E+2
Shallow Uniform Donor Density N_D (1/cm^3)	0	1.00E+17
Shallow Uniform Acceptor Density N_A (1/cm^3)	1.00E+16	0

(Table-1)

	Parameter	Value
GaAs Defects 1	Defect Type	Single Donor
	Capture Cross Section Electrons (cm^2)	1.00E-15
	Capture Cross Section Holes (cm^2)	1.00E-17
	Energetic Distribution	Single
	Reference for Defect Energy Level E_t	Above Ev
	Energy Level with Respect to Reference (eV)	0.71
	Characteristic Energy (eV)	0.100

(Table-2)



(Fig.2 (a) definition panel of SCAPS-1)

(Fig.2 (b) definition panel structure of SCAPS-1D)

Research methodology:

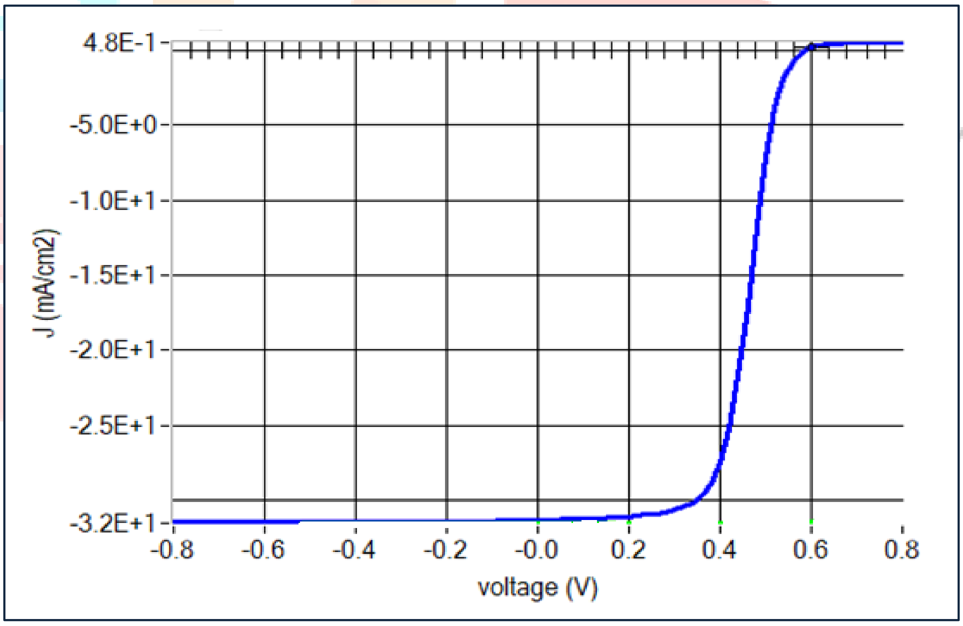
SCAPS1D is a unidimensional solar cell modeling developed an application by University of Gent Department of Electronics and Information Systems (ELIS), Belgium. This programme was created to study the structure of TiO2 and GaAs. Temperature has no effect on mobility or band gap with this software. Frequency, voltage, and temperature are used to calculate the working point. The user can also see the outcomes of prior calculations: I-V, C-V, C-F, and QE. For light conditions, each measurement should be estimated as a thermally. Wherever this simulation has ended, the analysis should be examined and contrasted to the analysis of other simulation. All simulations in this paper were done with the SCAPS-1D simulation programme.

Lee was person who initially uses a one-dimensional solar cell simulation program to simulate a solar cell. This analysis of simulation too looked at the effect of a narrow layer between the TiO_2 and GaAs regions. J-V graphs were obtained by simulation. S. Fonash and colleagues from Pennsylvania State University also employed AMPS. Currently, various applications of solar cell simulations are available. Many solar cells modeling software includes TFSSP (thin film semiconductor simulation program), SCAPS-1D (Unidirectional program of solar cell analysis), SCAPS-2D (two dimensional program of solar cell analysis), PUPHS, and PUPHS2D (two dimensional program of solar cell analysis). SCAPS-1D is used to simulate thin film solar cells in this research, which is based on one-dimensional simulation.

CDTE solar cell design and control:

Various parameters should be added in SCAPS-1D simulation program which are mentioned below in table number 1 & 2.

- **Effect of layer thickness:**



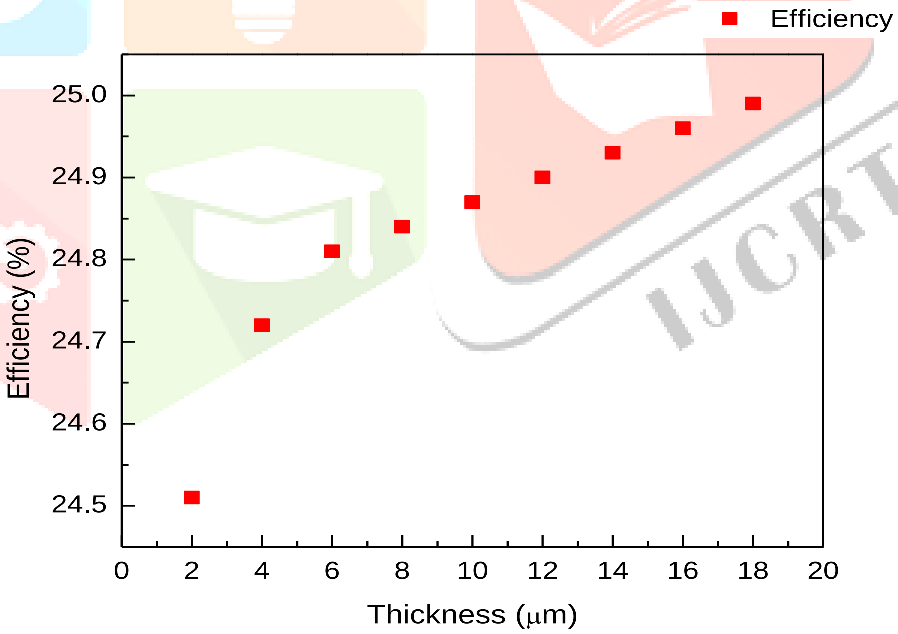
(Fig.3 J-V curves for solar cell)

The effects of GaAs thickness on solar cell efficiency were investigated. Using SCAPS-1D simulation software, the thickness of the GaAs layer was changed from 2.00 μm to 18.00 μm to test the efficiency of the solar cell. The results revealed that the 18.00 μm cell has the highest efficiency. Table 3 shows how the cell's efficiency drops dramatically below 16.00μm. The figure -3 shows J-V curves for 300K temperature.

Thickness	V_{oc}(V)	J_{sc}(mA/cm^2)	FF%	Efficiency%
2.00	5.52	31.19	14.22	24.51
4.00	6.21	31.39	12.67	24.72
6.00	6.88	31.45	11.46	24.81
8.00	7.53	31.45	10.48	24.84
10.00	8.17	31.46	09.66	24.87
12.00	8.81	31.46	08.97	24.90
14.00	9.44	31.48	08.38	24.93
16.00		31.49		24.96
18.00		31.51		24.99

(Table-3)

The figure -4 shows when thickness is increases efficiency of solar cell also increases.



(Fig.4 Efficiency of solar cell)

Conclusion: The goal of this study is to study performance of solar cell (TiO_2/GaAs) and has been studied accordingly. High efficiency 24.99% has been obtained with 18 μm of GaAs and 0.3 μm of TiO_2 when temperature is fixed at 300 K.

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