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DESIGN OF HETEROJUNCTION PHOTOCELL FOR OPTIMIZE PERFORMANCE USING NUMERICAL SIMULATION

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ABSTRACT:

In our project work simulation study and analysis of n-ZnO/p-Si heterojunction photo detector are reported. In this project work we can use a program in AFROS-HET (Automat for simulation of hetero-structures) simulator and study of important quality parameters, their impacts and variation. AFROS-HET consists of one dimensional numerical program for model of multi layer homo or heterojunction solar cells We concluded that photo detector responsively increases with thickness of zno and decreases when donor and acceptor doping concentrations increases. Results of simulation have very good quantum efficiency and different impacts and variation.

KEYWORDS: photo detector, n-Zno /p-Si heterojunction, AFROS-HET simulator.

INTRODUCTION:

In recent years photocell applications are used rapidly. This technology is attracting a large industrial purposes and most useful for energy generation. Converting light energy in to electrical energy this device is called as photocell. There are three types of photocell, photo emissive cell, photovoltaic cell and photoconductive cell. Types of photocell have different characteristic function and uses. A hetero-junction occurs between dissimilar crystalline semiconductors regions. These heterojunction semiconductor materials have unequal bandgap compare to homojunction. Combinations of multiple heterostructures together in a device called as hetero structures .There are different modern definition of hetero-junction. When interface between two solid-state materials is called as heterojunction. The materials are amorphous and crystalline structures of insulating and semiconducting materials.

A Photodiode is a semiconductor device that converts light into current traditional solar cell used to generate electric solar power is large area diode. Photodiodes has large or small surface areas Current is generated when photons are absorbed in photodiode. When no light is present small amount of current is also produced The solar photovoltaic techniques are most useful in the energy global market. And it is very useful. Solar cell technology is very promising good work and their results.

We can use AFROS-HET (Automat for simulation of hetero-structures) simulator for simulation purposes. AFROS-HET provides a better way to create the role of various parameters present in fabrication process of HIT solar cells. AFROS-HET consists of one dimensional numerical program for model of multi layer homo or heterojunction solar cells and some common solar cells characterization method. Solar cell simulation consists of optical and electrical stimulation. In optical simulation the local generation rate G(x, t) with in solar cell is calculated. In electrical simulation the electron and hole particle densities n(x, t) , *p(x, t)* and the densities n(x, t) , *p(x, t)* and the local electric potential within the solar cell are calculated, the solar cell is also operated under a specified condition. I-V characteristic of solar cell is also evaluate with AFROS-HET simulator.

Many different technologies developed for photovoltaic cells production, and HET solar cells developing by SANYO Ltd 1994 [1, 2].

Research methodology is the important process for collecting information and data. The methodology consist interviews, surveys and other research techniques including present and historical data. Research is important different technical and non technical fields. Some researches on heterojunction for electrical and optical characteristics of n-zno/p-si heterojunction reported in past researches [6, 9]. Different searches on p types materials si, GaN, Nio2, n-Zno have been used to p-n

heterojunction [4, 5].AFROS-HET (Automat for simulation of hetero-structures) developed by a Berlin group [6]. This software provide better way to evaluate different quality parameters present in fabrication processing of HIT solar cells [7, 8].the thickness of different layers in heterojunction with intrinsic thin layers solar cells have strong performance[11,12].Some research work on numerical simulation of solar cells and different solar cell characteristics methods open source on demand program AFROS-HET[10].Investigation of a-si(N+)/c-Si(P) heterojunction solar cell through AFROS-HET surface and intersurface analysis[14]. Some researches on the buffer intrinsic layer resistivity of p type substrate of solar cells [12]. Computing modelling of heterojunction intrinsic thin layer of HET solar cells [17].so in this paper we can evaluate different parameters on AFROS-HET simulator and their better performance and efficiency. We can obtain the thickness of different layers of the solar cell and doping concentration.

DEVICE SIMULATION SETUP:

The proposed system Zno/p-Si heterojunction photodetector can be developed by using AFROS-HET simulator by using different quality parameters like acceptor concentration, donor concentration, and electron affinity, mobility effective density for valence and conduction band. The proposed system shows good performance of quality parameters and their impacts and variation of the ZnO/Si hetero-structure.

Figure 1 shows the Device simulation setup. Light of UV wavelength falls on the Zno/p-Si heterojunction photo detector due to electron hole pair generation in neutral p and n region of Zno layer. Separation of electron-holes also done in depletion region of Zno, electric field also contributes in photocurrent. In this system the ZnO layer behaves as a complete transparent layer and due to electron hole pair photocurrent is generated in Si layer. In this way n-ZnO/p-Si hetero-junction detects UV-Visible wavelengths over a single frame work and behaves as a dual detector.

The energy band diagram for n-Zno/p-Si heterostructures is shown in Figure 2. ZnO and Si consist of 500nm and 380um thickness respectively. Light is falling from the top of the heterojunction, then Material properties of the Zno and Si also been defined. For simulation different quality factor required like as conduction band discontinuity, valence band discontinuity, effective density of states for in the conduction band, effective density of states for in the valence band and intrinsic carrier concentration calculated by following formulas.

$$\Delta Ec = X_{zno} - X_{si} \quad (1)$$

$$\Delta Ev = (E_{g,zno} - E_{g,si}) + \Delta E_c \quad (2)$$

$$N_c = 2(2\pi m_e^* kT / h^2)^{3/2} \quad (3)$$

$$N_v = 2(2\pi m_h^* kT / h^2)^{3/2} \quad (4)$$

$$ni = (Nc\ Nv)\ 1/2 \exp(-(Ec-Ev))/2kT \quad (5)$$

Where,
X ZnO- Electron affinity for ZnO
X Si - Electron affinity for Si
h - Planck constant
k - Boltzmann constant
T - Lattice temperature,
q - Charge of electron,
me- effective mass of electron and mh- is effective mass of holes.

Different properties required for simulation consist of values electron affinity, band gap, conduction and valence band densities, electron and hole mobilities and dielectric constant. AFROS-HET consists of one dimensional numerical program for model of multi layer homo or heterojunction solar cells.

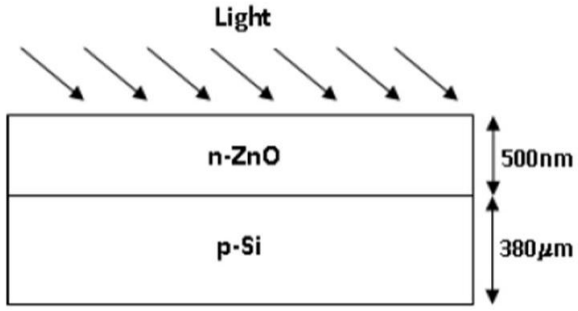

Figure 1: Structure of n-ZnO/p-Si heterojunction photodetector

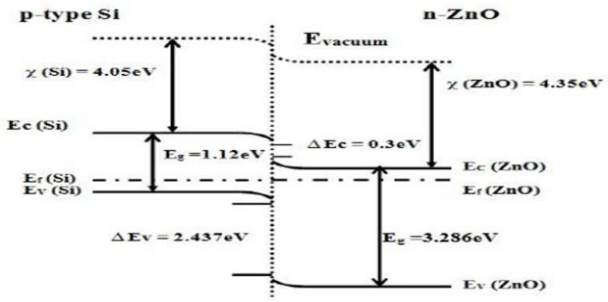

Figure 2: n-ZnO/p-Si heterojunction photodetector Energy band diagram.

The different parameters used for simulation of heterojunction photo detector showing in table 1.

For improving the efficiency of parameters use newton-richardson iteration and SRH model of recombination mechanism also used.

Table 1: Values of parameters used for the simulation of n-ZnO/p-Si hetero- junction photodetector

SR. .NO.	QUALITY PARAMETERS	PARAMETERS VALUE
1	Donor concentration (N_D)	$1*10^{19}$ cm^{-3}
2	Acceptor Concentration(N_A)	$1*10^{15}$ cm^{-3}
3	Electron affinity(x)	4.35 (ZnO), 4.05 (Si)
4	Effective density of states in the conduction band (N_c)[cm^{-3}]	$6.0*10^{19}$(Si), $4.4*10^{18}$ (ZnO)
5	Effective density of states in the valance band (N_v)[cm^{-3}]	$2.2*10^{19}$(Si), $7.1*10^{19}$ (ZnO)
6	τ_h and τ_n (sec)	$1*10^{-9}$(ZnO), $1*10^{-3}$ (Si)
7	Dielectric constants (ε)	8.5 (ZnO), 11.9(Si)
8	μ_n (cm^2 / V.s)	60 (ZnO), 1000(Si)
9	μ_p (cm^2 / V.s)	10 (ZnO), 500(Si)
10	Surface recombination velocity (S)	10m/s (electrons) 1000 m/s (holes)
11	Effective mass of electron (m_e*)	$0.19*m_0$ (ZnO), $1.08*m_0$ (Si)
12	Effective mass of electron (m_h*)	$1.21*m_0$ (ZnO), $0.56*m_0$ (Si)

RESULTS:

In results we can shows that different quality parameters and their impacts and variation. We can use AFORS-HET simulator for simulation results.

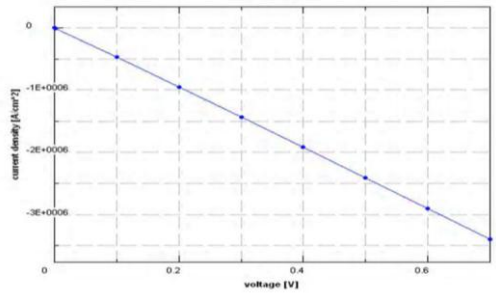

Figure 3: I-V Diagram

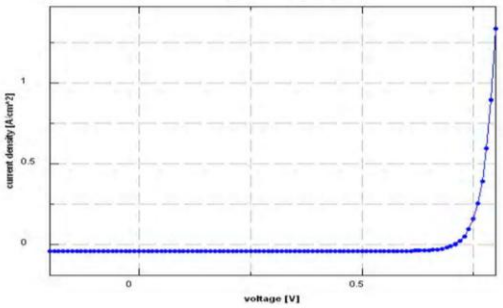

Figure 4: 1D DIAGRAM

Fig.7 shows the photocurrent variation when temperature is varied. It also shows in graph, photocurrent of photodetector increases when temperature increases. For this process responsivity is most important parameter for a photodetector and can be described as follows

$$R = \frac{q\eta\lambda}{hc} \qquad (6)$$

For this responsively

q - Charge of electron,
η - Quantum efficiency
λ - Wavelength,
h - Planck's constant
c - Velocity of light.

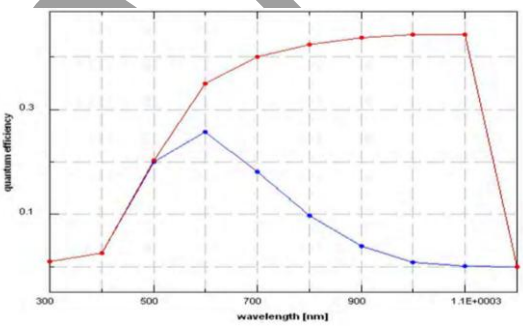

Figure 5: Quantum Efficiency

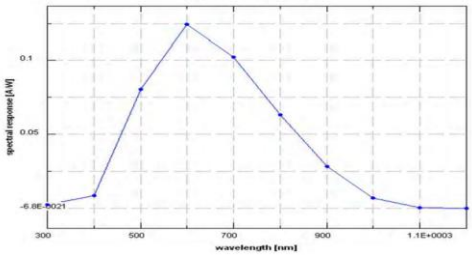

Figure 6: Spectral response

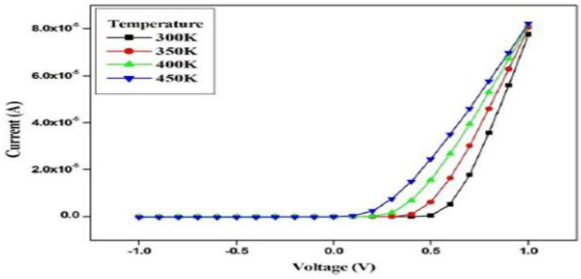

Figure 7: photocurrent vs biasing voltage plot with temperature variations (wavelength= 600nm optical intensity=0.2W/cm-2)

CONCLUSION:

We came to conclusion that using simulation software we can do performance analysis of hetero-junction photo-detector. To show performance analysis we can choose different parameters like responsively,

Quantum efficiency, current and voltage of hetero-junction photo-detector. Result shows Zno/si heterojunction has very good efficiency .So we can study heterojunction photo detector of different quality parameters and their impacts.

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