$In_{1-x}Ga_xAs$ a next generation material for photodetectors

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***Abstract*—Analytical results have been presented for an optically illuminated InGaAs MESFET with opaque gate. The excess carriers due to photo generation are obtained by solving the continuity equation. The energy levels are modified due to generation of carriers. The results of I–V characteristics under dark condition and under illumination have been compared and contrasted with the GaAs MESFET.**

***Index Terms*—Photodetectors, continuity equation, illumination, Schottky gate**

I. Introduction

With silicon VLSI technology approaching the limits of scaling and miniaturization, new material systems and device technologies are under investigation for improved speed and circuit compaction. Among the most promising of these are the resonant tunneling devices based on Gallium Arsenide (GaAs), Indium Phosphide (InP), and other III-V semiconductor materials alloys like $In_{1-x}Ga_xAs$.

The electrical performance of these devices is dominated by quantum effects. The devices contain quantum-well structures of nanometer dimensions comparable with the electron wavelength. Consequently, the wave nature of the electrons becomes important in determining the device electrical characteristics and these characteristics are very different from those of larger semiconductor devices such as the conventional MOSFET.

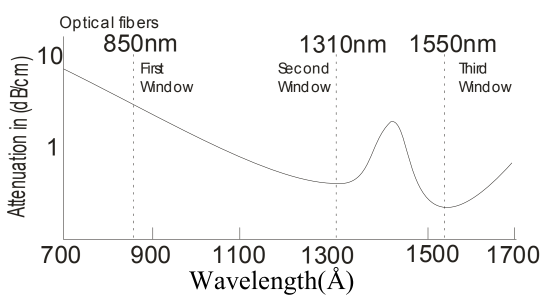

Figure 1.Attenuation Vs Wavelength[1]

A strong interest has been created in the study of optical effect in high-speed devices due to their potentiality in fiber-optical communication and optical device integration. Both experimental and analytical studies have been carried out by different investigators on the effect of illumination in GaAs MESFET as they show significant effect of incident light on the electrical parameters of the devices for applications in circuits for working in first window for optical communication. But as the rate of data transmission is increasing we require large bandwidth photodetector for working in second and the third window for optical communication as shown in Figure 1.

GaAs is a compound consisting of Ga atoms bonded to As atoms. An alloy which is made of two compounds can give required characteristics to the material according to the mole fraction of the compounds used. $In_{1-x}Ga_xAs$ is an alloy compound consisting of InAs and GaAs with a mole ratio of (1-x):(x). The bonds in GaAs and InAs have characteristics intermediate to those usually associated with the covalent and ionic terms. So according to the requirement we can set the composition of the components GaAs and InAs to have required characteristics [1].

Recently, $In_{1-x}Ga_xAs$ structures have been widely studied for ultra-high-speed device application especially for second and third window of operation for optical communication. $In_{1-x}Ga_xAs$ has high intrinsic carrier concentration with a high carrier mobility and saturated velocity. This material can detect and amplify radiation of wavelength within the range of 1.3–1.6 µm which is of recent interest in fiber-optic communication systems [1].

In this paper, we have calculated the effect of optical illumination on the ultra high speed $In_{0.57}Ga_{0.43}As$ MESFET. Previously, studies have been reported on the effect of illumination on GaAs MESFET considering opaque or transparent or semi-transparent Schottky gate. In this paper a comparative study of the $In_{0.57}Ga_{0.43}As$ and GaAs is also done to have a better understanding of the application of the device in different windows.

The photovoltage is developed across the Schottky junction which enhances the charge concentration of the channel region. The excess carriers are solved using the continuity equations for electrons and holes. The effect of radiation on I-V characteristics has been presented. The theory is presented below.

II. THEORY

The schematic structure of the MESFET under consideration is shown in Figure.2. It shows the $In_{0.57}Ga_{0.43}As$ MESFET with radiation falling within the gaps of source, gate and drain, the Schottky gate being opaque to the radiation. The active layer is of .15µm thick and channel length of 0.25µm.

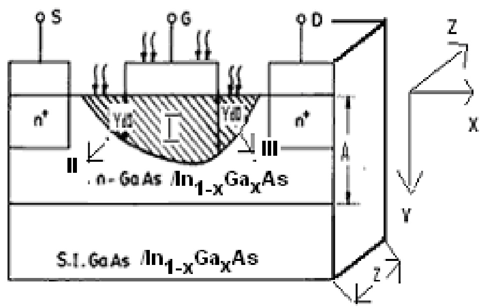

Figure 2. Schematic of MESFET under illumination [3]

The device is illuminated along the Y direction. The photovoltage is developed across the metal-semiconductor junction due to incident light and it reduces the depletion width below the gate in the active region. The Schottky metal gate is made with gold. Although it has been reported that the barrier potential at the barrier hardly changes with the change in the gate metal [4].

The Schottky gate is made a semi-transparent medium. This transparent gate makes the photoeffect more meaningful in a MESFET. As this allows more of the incident optical flux be absorbed in the device. This allow the radiation to create electron-hole pairs in the depletion region. For making the gate semi-transparent the metal gate thickness should be less than 100Å. The major drawback of thin film fabrication is that they are not suitable for very high volume low cost applications. And the thin films are fabricated using sputtering technique, which is a slower, complicated and costly process as compared to vapor deposition used for thick film deposition.

With the advancement in technology there is a need of optical devices with reduced dimensions. It is because as the device dimensions reduce the photogenerated charges become significant and hence sensitivity is improved. The FET based devices being a potential candidate for photodetection can be used to fulfill the demand. However, it is well known that as the device dimensions reduce the short channel effects becomes prominent. Streetman [5] explains the various short channel effects of which saturation is predominant in short channel MESFET.

These effects deteriorate the device performance and sensitivity at higher frequency of operation. So with the reduction in the size of the device to get better sensitivity there is a requirement of a material which can give better sensitivity and improved performance at higher frequency of operation to be used as photodetector.

$In_{1-x}Ga_xAs$ is such material of choice for photodetector at higher frequency of operation in the second and the third window. This is because as we change the composition of its compound we can change energy band gap (E_g) and hence the corresponding wavelength of operation. Figure.3 shows the Eg Vs composition of Ga in $In_{1-x}Ga_xAs$ and shows the variation of Eg with the composition of Ga.

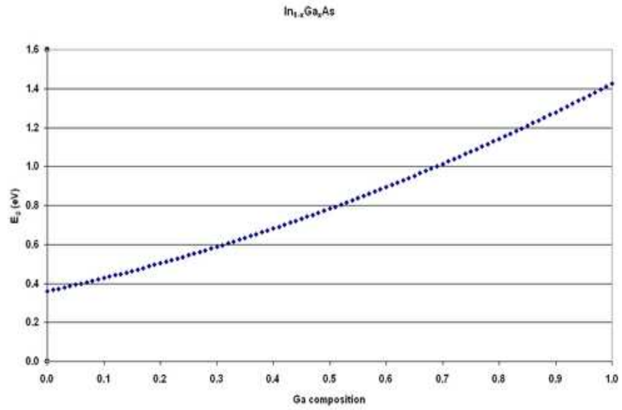

Figure 3. Energy gap versus gallium composition for InGaAs[6]

The second reason for choosing $In_{1-x}Ga_xAs$ is, it has higher saturation velocity as shown in Figure.4. This give the carriers higher mobility and therefore high current. Due to this they find application in higher speed detectors.

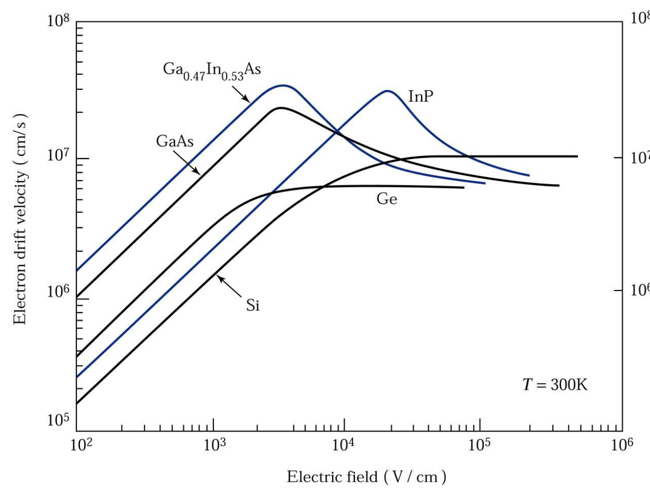

Figure 4. Drift velocity Vs electric field plot for various semiconductor materials[6]

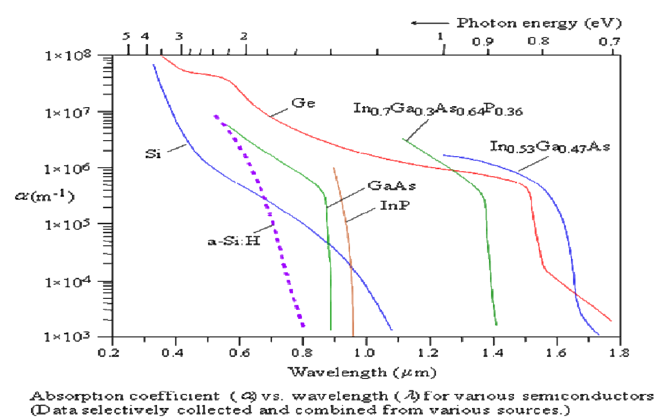

Figure 5. Absorption coefficient Vs Wavelength for various semiconductors[6]

Finally the most important reason for choosing $In_{1-x}Ga_xAs$ is a material of choice for photodetectors at higher frequency is it has higher absorption coefficient at higher wavelengths as shown in Figure.5. This make $In_{1-x}Ga_xAs$ photodetectors to have higher sensitivity for high data rate input.

Although it has been reported that the dark noise increases for $In_{1-x}Ga_xAs$ with the increase in composition of In as shown in Figure.6 it is still a material of choice of photodetectors for high data rate detection because dark noise is not able to deteriorate the performance of the detector at the high frequency of operation.

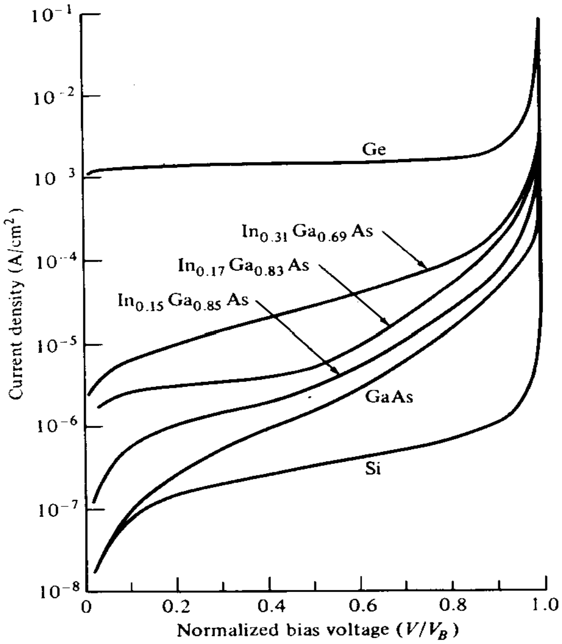

Figure 6. Dark current Vs Normalized bias voltage[6]

III. I-V MODEL

Here the material chosen for photodetector is $In_{0.57}Ga_{0.43}As$. Our interest is to calculate the excess carriers generated in the active region by solving the continuity equations for electrons and holes for plotting I-V curves under D.C. and A.C. condition and this done as in [3,8].The results for the simulated model are discussed in the next section.

For non-uniform doping (Gaussian Profile)[7]

$$N(y)=\frac{Q}{\sigma\sqrt{2\pi}}\exp\left(-\left(\frac{y-Rp}{\sigma\sqrt{2}}\right)^2\right) \quad (1)$$

Where N_D constant doping concentration in the active region:

Q implanted dose;

σ straggle parameter;

Rp projected range.

The drain-source current flows along the X direction and the device is illuminated along the Y direction. The gate being opaque, the excess carriers are generated in the extended gate depletion region (side walls) and the neutral region of the channel .The optically generated electrons flow toward the drain and contributes to the drain-source current when a drain source voltage is applied.

The number of photogenerated electrons and holes are obtained by solving the continuity equations for respective doping profiles as, for electrons [7]:

$$\frac{\partial n(y,t)}{\partial t}=\frac{1}{q}\frac{\partial J_n(y,t)}{\partial y}+G-\frac{n(y,t)}{\tau_n}-\frac{R_s\tau_n}{S_n} \quad (2)$$

for holes,

$$\frac{\partial p(y,t)}{\partial t}=\frac{1}{q}\frac{\partial J_p(y,t)}{\partial y}+G-\frac{p(y,t)}{\tau_p}-\frac{R_s\tau_p}{S_p} \quad (3)$$

where τ_n lifetime for electrons;

τ_p lifetime for holes;

J_n electron current densities;

J_p hole current densities;

and electron and hole current densities are represented as[7]

$$Jn = qv_y n + qD_n\frac{\partial n}{\partial y} \quad (4)$$

$$Jp = qv_y p - qD_p\frac{\partial p}{\partial y} \quad (5)$$

where G volume generation rate;

Dn and Dp diffusion coefficients for electrons and holes;

n and p excess electron and hole concentrations;

Vy carrier velocity along the vertical –direction perpendicular to the surface of the device and is assumed same as the scattering limited velocity;

Sn and Sp surface recombination velocities for electrons and holes;

Rs surface recombination rate.

The term Rs is calculated using the expression (6).Assuming that only negative trap centers are present and that the traps close to the surface are important, Rs may be approximated as[7]

$$R_s = N_t k_p p_s \quad (6)$$

Where p_s αΦτn

N_t trap density

k_p capture factor for holes

The Φ optical flux density being assumed to be modulated by the signal frequency, under small signal condition we write it as:

$\Phi=\Phi_0+\Phi_1 e^{jwt}$ (7a)

$n=n_0+n_1e^{jwt}$ (7b)

$p=p_0+p_1e^{jwt}$ (7c)

where "zero" indicates the dc value and "one" indicates the ac value. Substitution of (3.9) in above equation will give sets of differential equations under dc and ac conditions. The process of illumination generates excess carriers in the channel .These excess carrier generated effect the minority carrier lifetime of the carriers which is discussed in the next section.

A. Calculation of minority carrier lifetime

Due to the excess charges generated in the channel there is reduction in the minority carrier lifetime due to the increase in recombination. The minority carrier dependence on illumination is given by [8]

$$\frac{\tau_L}{\tau} = \frac{ni}{\Delta n + ni} \quad (8)$$

where τ_L minority carrier lifetime under illumination
τ minority carrier lifetime at thermal equilibrium
ni intrinsic carrier concentration.
Δn excess charges generated in the channel due to illumination and is calculated as in[8]

$$\Delta n = \frac{(1-R_m)(1-R_s)P_{op}\tau_L(1-\exp(-\alpha a))}{ah\nu} \quad (9)$$

where R_m and R_s are the reflection coefficients of the metal and the semiconductor surfaces respectively
a Width of the active channel
h Plank's constant
P_{op} Optical power density
ν Operating Frequency
α Optical absorption coefficient

In equation (9) as the illumination increases the excess carrier generated will increase. Hence minority carrier lifetime decreases with increase in illumination.
These excess generated carrier results in the change of barrier potential at the Schottky gate. This change in barrier potential is taken into account as development of photovoltage at the gate which forward bias the metal semiconductor junction. The next section describes the method to calculate the photovoltage developed at the Schottky junction.

B. Calculation of the Photovoltage

Due to illumination, the voltage developed across the Schottky junction (V_{op}) is called the photovoltage. This voltage id developed because of the transport mechanism in the depletion region (which is drift) and recombination.

To calculate the photovoltage we start with first order continuity equation which describes the transport phenomenon for the carriers in the semiconductor. For holes it is written as [7]

$$\frac{\partial p}{\partial t} = -\frac{\partial p}{\partial y} - \frac{p}{V_y \tau_p} + \frac{\alpha\phi}{V_y} e^{-\alpha y} - \frac{Rs\tau_p}{S_p V_y} \quad (10)$$

Equation (10) is solved under ac condition resulting in a solution for hole density as [7]

$$p(y) = \frac{\alpha\phi_1\tau_{wp}}{(1-\alpha V_y \tau_{wp})} e^{-\alpha y} - \frac{N_T K_p \tau_p \tau_{wp} \phi_1 \alpha}{S_p} + C\exp\left(-\frac{y}{V_y \tau_{wp}}\right) \quad (11)$$

$$1/\tau_{wp} \rightarrow 1/\tau_p + jw \quad (12)$$

where
τ_{wp} lifetime of holes under ac condition
τ_p lifetime of holes under dark and d.c. condition
τ_{wp} is independent of w if $1/\tau_{wp}$ >>w .
K_p capturte rate of holes

The constant C of (12) is evaluated using the boundary condition at y=Y_{dg},

$$p = \alpha\phi_1\tau_{wp} e^{-\alpha y_{dg}} \quad (13)$$

where Y_{dg} is the extension of the gate depletion region in the channel measured from the surface.

The sidewalls of the gate depletion region are assumed quarter arcs. Considering the arcs at the source and drain ends to have radii r1 and r2, respectively, where
r1=Y_{dg} at V(x)=0.
r2=Y_{dg} at V(x)=$V_{ds.}$
The number of holes crossing the junction at y=0 is given by [7]

$$p(0) = \frac{\pi}{4} Z(p_1 r_1^2 + p_2 r_2^2) \quad (14)$$

Where $p1 = \alpha\phi_1\tau_{wp} e^{-\alpha r1}$ (15a)

$$p2 = \alpha\phi_1\tau_{wp} e^{-\alpha r2} \quad (15b)$$

The photovoltage across the Schottky junction is obtained using the relation as in [7]

$$V_{op1} = \frac{kT}{q} 1n\left(\frac{J_p}{J_s}\right) = \frac{kT}{q} 1n\left(\frac{qv_y p(0)}{J_{s1}}\right) \quad (16a)$$

Where Js1 is the minority carrier current density of the Schottky junction and is given by

$$J_{s1} = A^* T^2 \exp(-qV_{bi}/kT) \quad (16b)$$

$$A^* = \frac{4\Pi q m_n^* k^2}{h^3} \quad (16c)$$

m_n^* Effective mass of the electron
k Boltzman constant
T Room temperature in Kelvin
q charge of an electron
V_{bi} Built in voltage across the n–p junction,

The calculation of the photovoltage is important because they modify the depletion width Y_{dg} .Using the abrupt junction approximation and under dark and illumination Y_{dg} are calculated as given below[7]

$$Y_{dg} = \left[\frac{2\in}{qN_D}\left(\phi_B - \Delta + v(x) - V_{gs}\right)\right]^{1/2} \quad (17a)$$

Under illumination due to the photovoltage developed at the gate the gate voltage changes and Y_{dg} is modified to Y_{dg}' given by[7]

$$Y'_{dg} = \left[\frac{2\varepsilon}{qN_D}\left(\phi_B - \Delta + V(x) - V_{gs} - V_{op}\right)\right]^{1/2} \quad (17b)$$

where V(x) channel voltage,
Φ_B Schottky barrier height,
Δ position of fermi level at the neutral region below the conduction band,

V_{gs} Gate to source potential and
N_D substrate concentration.

Thus, the drain-source current changes as the photovoltage get modified by the signal frequency because of the change in the charges in the channel. Next section calculates the charges in the channel.

C. Calculation of Channel Charge

Under illuminated condition the total channel charge (Q_{total}) is due to the carriers present because of ion-implantation(Q_{ion}) and optical generation($Q_{illumination}$), i.e[7]

$$Q_{total} = Q_{ion} + Q_{illu\min ation} \quad (18)$$

Charges due to ion-implantation are due to doping profile and the charges due optical generation condition are because of the generated carriers in the depletion and the neutral region. So we considered each section separately to calculate the charge contribution because of them for total charge in the channel.

C1. Charge Due to Ion-Implantation: The channel charge due to ion-implantation which is because of doping profile is given by[7]:

$$Q_{ion} = q \int_{y_{dg}}^{a} N(y)dy \quad (19)$$

C2. Charge Due to Carriers Generated in the Neutral Channel Region: When the frequency modulated optical signal is incident on the device, the number of generated electrons in neutral region is obtained by solving (3.4). Since the transport mechanism is diffusion and recombination for the neutral region in absence of any drain-source voltage, the continuity equation is a second order differential equation and is given by [7]

$$\frac{d^2 n_1}{dy^2} - \frac{n_1}{D_n T_{wn}} = -\frac{\alpha\phi_1 e^{-\alpha y}}{D_n} \quad (20a)$$

in which $1/\tau_{wn} \rightarrow 1/\tau_n + jw$.

τ_{wn} is the lifetime of electrons under ac condition.

τ_n lifetime of electrons under dark and d.c. condition

τ_{wn} is independent of w if $1/\tau_{wn}$ >>w.

Since the presence of negative traps have been assumed at or close to the surface, the surface recombination term is absent in the continuity equation for electrons.

The solution to the above equation is [7],

$$n_1 = \alpha\phi_1 \left[T_{wn} + \frac{1}{D_n\left(\alpha^2 - \frac{1}{L_{nw}^2}\right)} \right] \exp\left(-\frac{y}{L_{nw}}\right) - \frac{\alpha\phi_1 e^{-\alpha y}}{D_n\left(\alpha^2 - \frac{1}{L_{nw}^2}\right)} \quad (20b)$$

where the boundary condition applied is at y=0 , $n = \alpha\phi_1 \tau_{wn}$.

$L_{nw} = \sqrt{D_n \tau_{wn}}$ called the ac diffusion length of electrons.

The charge developed due to the electrons generated in this region is given by,

$$Q_{neutral} = q \int_{y_{dg}}^{y_{ds}} n_1 dy \quad (20c)$$

C3. Charge Due to Carriers Generated in the Depletion Region: The number of carriers generated in the depletion region is obtained by solving the continuity equation for electrons which is similar to (3.13), except that the surface recombination term is absent. The solution is given by [7]

$$n_{1dep} = \frac{\alpha\phi_1 T_{wn}}{\left(1 + \alpha v_y T_{wn}\right)} e^{-xy} \quad (21a)$$

The generation of carriers in the depletion region will take place in the extended depletion region on the source side and the drain side which is considered as quarter arcs. The charge developed due to electrons contributed from the side walls of the gate depletion region (arc regions) is given by,

$$Q_{dep1} = qZ\frac{\pi}{4}\left[\int_0^{r1} n_{1dep}dy + \int_0^{r2} n_{1dep}dy\right] \quad (21b)$$

Due to these change in the charge concentration under illuminated condition the drain to source current will change and its calculation is dealt in detail in the next section.

D. Calculation of Drain-Source Current

The drain-source current is calculated from gradual channel approximation using the relation [7],

$$I_{ds} = \frac{\mu Z}{L} \int_0^{V_{ds}} Q_{total} dV \quad (22)$$

where Qtotal is given by (18).

Thus, substituting above equations into (3.24) and integrating we obtain the total drain-source current of the opaque gate OPFET.

D1. The contribution to the drain-source current due to ion-implantation is given by [7]

$$I_{ion} = \frac{q\mu Z}{L}\left[-\frac{Q}{2} I_1\right] \quad (23a)$$

where $I_1 = \int_0^{V_{DS}} erf\left(\frac{Y_{dg}{}^{l} - R_p}{\sigma\sqrt{2}}\right) dV \quad (23b)$

D2. In the neutral channel region, the ac drain-source current is obtained as [7]

$$I_{neutral} = \frac{\mu Z}{L} \int_0^{V_{ds}} Q_{neutral} dV \quad (24)$$

D3. The current contribution due to generation in the sidewalls of the gate depletion layer is given by [7],

$$I_{dsdep1} = q v_d Z \frac{\pi}{4} \int_0^{r1} n_{1dep} dy \quad (25a)$$

$$I_{dsdep2} = qv_s Z \frac{\pi}{4} \int_0^{r2} n_{1dep} dy \qquad (25b)$$

where v_d drift velocity of carriers at the source end and $v_d = \mu E$

μ low field mobility

E applied field

v_s saturated velocity at the drain end.

$$I_{dsdep} = I_{dsdep1} + I_{dsdep2} \qquad (25c)$$

So the total drain-source current (Ids) is obtained by summing up the above current equations [7]

$$I_{ds} = I_{ion} + I_{neutral} + I_{dsdep} \qquad (26)$$

The dependence of frequency of Ids through different components arises due to the ac lifetime and ac diffusion length of electrons and holes which are dependent on the frequency. The frequency limitation depends on the conditions that $1/\tau_{wp}$, $1/\tau_{wn}$ >>w.

When w is larger than or comparable with $1/\tau_{wp}$ or $1/\tau_{wn}$ the frequency effect dominates. Equation (26) represents the current for an opaque gate OPFET.

E. Sensitivity

Sensitivity is an important parameter and gives a measure of the ability of the device to detect the variations of the input optical signal.

$$\text{Sensitivity} = \frac{I_{Popt2} - I_{Popt1}}{I_{Popt1}} \text{x}100\% \qquad (27)$$

where I_{Popt1}, I_{Popt2} are the current at a fixed Vds for optical flux density Popt1 and Popt2 respectively.

V. Result and Discussion

Numerical calculations have been carried out for $In_{0.57}Ga_{0.43}As$ MESFET considering optical effect. The basic parameters used in the calculations are given in Table 1.

It has been presented in this paper that the device sensitivity improves as the device dimensions reduce with the help of simulation in Figure.7. It shows a comparison of I-V characteristics of GaAs MESFET with a channel length of 1.3μm and 0.25μm under D.C. condition. It shows that as the device dimensions reduce the device current increases and the photosensitivity increases.The photosensitivity is checked for (Popt1 (Flux density)=$0.5\text{x}10^{15}$ $1/m^2s$, Popt2(Flux density)=1x 10^{16} $1/m^2s$). Table 2 gives a comparison of sensitivity of small channel devices and large channel devices .It shows that the sensitivity of the device with 0.25μm channel length is more and about double than the sensitivity of the device with 1.3μm channel length.

Table 1: Basic Parameters values [9]

Pop	Id (LD)	Id (SD)	%Change (LD)	%Change (SD)
Popt1	.004609	0.03494	3.8%	8.9%
Popt2	.004868	0.03805		
Popt3	.005025	0.03993	3.2%	4.9%

Table 2. Comparison of Small channel devices and large channel devices for sensitivity at Vds =0.75V

Sr.No.	Parameter	GaAs	$In_{0.57}Ga_{0.43}As$
1.	Low-frequency dielectric constant	12.90	13.85
2.	High-frequency dielectric constant	10.92	11.09
3.	Energy bandgap (eV)	1.425	0.75
4.	Intrinsic carrier concentration (cm^{-3})	$2.1\text{x}10^6$	$9.4\text{x}10^{11}$
5.	Electron mobility at 300 K (cm^2V/s)	8500	10000
6.	Hole mobility at 300 K (cm^2V/s)	400	400
7.	Effective mass at ¡ (m*=m0)	0.067	0.0463
8.	Saturation Velocity (m/s)	$1.2\text{x}10^5$	$2\text{x}10^5$
9.	Saturation Field (V/m)	$5\text{x}10^5$	$7\text{x}10^5$

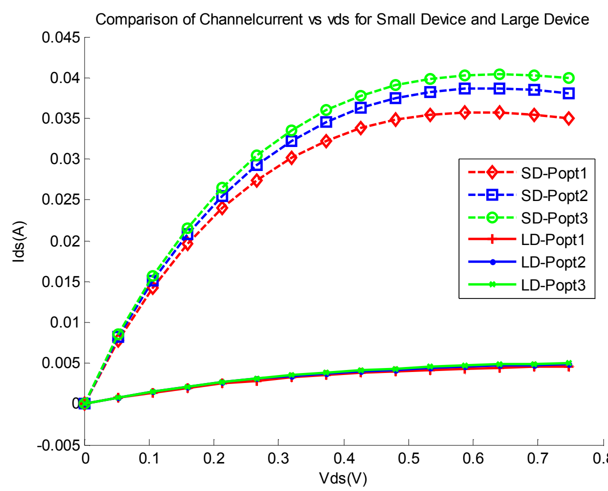

Figure 7. I-V curves SD (short channel devices with L=0.25μm) and LD (Long channel devices with L=1.3μm)

Due to fabrication limitations we cannot reduce the size of the device below a certain limit. So there is a need of material which can give better sensitivity at higher frequency of operation.Figure.8 shows a comparison of minority carrier life time under illuminated condition (τ_L) Vs frequency of GaAs and $In_{0.57}Ga_{0.43}As$ MESFET under different illumination. It shows that there is negligible change in minority carrier lifetime of the $In_{0.57}Ga_{0.43}As$ MESFET and there is prominent change in GaAs MESFET. This is because the intrinsic carrier concentration of $In_{0.57}Ga_{0.43}As$ MESFET is very high.

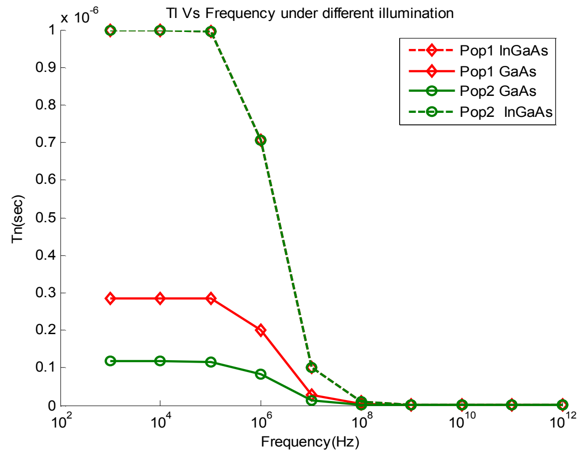

Figure 8. Minority carrier lifetime under illuminated condition Vs Frequency for GaAs and $In_{0.57}Ga_{0.43}As$ MESFET.

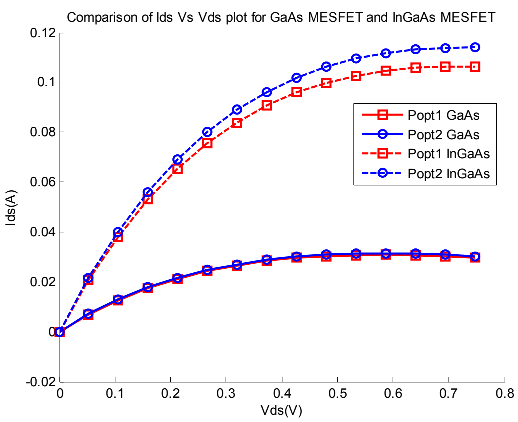

Figure 9:Id Vs Vds for GaAs and $In_{0.57}Ga_{0.43}As$ MESFET

Figure 9 shows a comparison of Ids-Vds characteristics of GaAs MESFET with $In_{0.57}Ga_{0.43}As$ MESFET under D.C. condition. It shows that the $In_{0.57}Ga_{0.43}As$ MESFET gives higher current and higher sensitivity. Table 3 gives a comparison of sensitivity of GaAs MESFET with $In_{0.57}Ga_{0.43}As$ MESFET. It shows that the sensitivity of the GaAs MESFET is less than that of $In_{0.57}Ga_{0.43}As$ MESFET for same dimensions and similar biasing conditions.

TABLE 3. COMPARISON OF SENSITIVITY OF GAAS MESFET AND $IN_{0.57}GA_{0.43}AS$ MESFET AT VDS =0.75V

Pop	Id (A) GaAs	Id (A) $In_{0.57}Ga_{0.43}As$	Sensitivity GaAs	Sensitivity $In_{0.57}Ga_{0.43}As$
Popt1	.0303	0.1139	2%	7.35%
Popt2	.02968	0.1061		

Figure 10 shows a comparison of Ids-frequency curves of GaAs MESFET with $In_{0.57}Ga_{0.43}As$ MESFET. It shows that the $In_{0.57}Ga_{0.43}As$ MESFET gives higher current, higher sensitivity and higher bandwidth. It also shows that its bandwidth does not change under illuminated condition because there is no change in minority carrier lifetime of the $In_{0.57}Ga_{0.43}As$ MESFET.It shows that the bandwidth of $In_{0.57}Ga_{0.43}As$ MESFET is 70GHz.

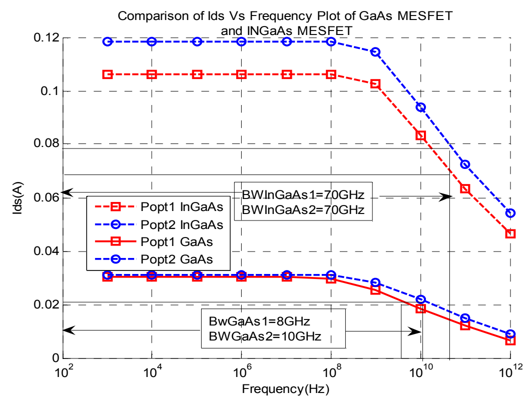

Figure 10. I-V curves for GaAs MESFET and $In_{0.57}Ga_{0.43}As$ MESFET

Table 4 gives a comparison of sensitivity of GaAs MESFET with $In_{0.57}Ga_{0.43}As$ MESFET under A.C. condition. It shows that the sensitivity of the GaAs MESFET is less than that of $In_{0.57}Ga_{0.43}As$ MESFET under similar conditions of operation.

TABLE 4. COMPARISON OF SENSITIVITY OF GAAS AND $IN_{0.57}GA_{0.43}AS$ MESFET UNDER A.C. AT V_{DS} =0.75V

w(Hz)	Id (A) GaAs		Id (A) $In_{0.57}Ga_{0.43}As$		Sensitivit y GaAs	Sensitivity $In_{0.57}Ga_{0.43}As$
	Popt2	Popt1	Popt2	Popt1		
10^8	.03091	.02982	0.1184	0.1062	3.6%	11.48%
10^9	.02828	0.02546	0.1145	0.1026	11%	11.6%
10^{10}	.02182	0.01844	0.0938	0.08326	18.3%	12.7%
10^{11}	0.01492	0.01194	0.07255	0.06348	25%	14.28

V. CONCLUSION

$In_{0.57}Ga_{0.43}As$ MESFET has been analyzed under the condition of optical illumination. The Current characteristics under d.c. and a.c. conditions have been plotted and discussed. These results of $In_{0.57}Ga_{0.43}As$ MESFET are compared with GaAs MESFET under dark and under illumination. The results show that $In_{0.57}Ga_{0.43}As$ MESFET is a better photodetector as it has higher sensitivity.

The results also show that the minority carrier life time in InGaAs is independent of illumination. It has a wider bandwidth as compared with GaAs MESFET. Therefore $In_{0.57}Ga_{0.43}As$ MESFET will work as a high-speed photodetector and amplifier in MMIC and communication systems.

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