MATLAB based Analytical Model for Short channel GaAs MESFET for the Distribution of potential and Threshold Voltage under dark and illuminated conditions

Sanjay.C.Patil
(Research Scholar at NMIMS MUMBAI)
Parshvanath College of Engineering,
THANE (W),
MUMBAI, 400601 INDIA
Mob+9109969634801,

B.K.Mishra
Thakur College of Engineering and Technology,
Kandivali (E) \
MUMBAI, 400101 INDIA
Mob+9109821285825,

ABSTRACT:-

Optoelectronic is one of the thrust areas for the recent research activity. One of the key components of the optoelectronic family is photo detector to be widely used in broadband communication, optical computing, optical transformer, optical control etc. Present paper includes the investigation carried on the basis of the 2 D (two dimensional) mathematical modeling for the potential distribution and threshold voltage of short –channel ion –implanted GaAs-MESFET operated in the sub threshold. Device is assumed to have the double –integrable Gaussian like function as the doping distribution profile in the vertical direction of the channel .The Schottky gate has been assumed to be semi-transparent through which optical radiation is coupled in to the device. Investigation shows the 2D potential distribution in the channel of the short channel device by using 2D Poisson's equation and suitable boundary conditions. It also shows that the effect of excess carrier generation due to the incident optical radiation in the channel, the potential function has been utilized to model the threshold voltage of the device under dark and illuminated conditions. Result's that theoretical predicted for device and using MATLAB.

Key word: - *Gaussian doping profile, Poisson's equation, ion Implantation, optical biasing, optically controlled GaAs MESFET*

I. INTRODUCTION:-

Optically controlled microwave devices and systems have some advantages such as size reduction, signal isolation, large bandwidth and immunity to electromagnetic interface. The incident illumination reduces the noise figure but increases the power gain of GaAs OPFET. The properties such as high speed, low cost monolithically integrated optically gated GaAs MESFET are presently in the high demand for optical communication in the range of low wavelength high frequency devices.

GaAs MESFET [metal Semiconductor Field Effect Transistor] have drawn considerable attention in the design of high speed digital/analog integrated circuits and microwave monolithic IC's [1]. The optical effects in MESFET have been studied by number of researchers because of its potential application in optoelectronic, optical communication and optical computing. The GaAs MESFET can be modified by coupling a fraction of optical power radiated by external source in to the channel of the device [2] The excess electron- hole pair generation due to optical generation in the channel is utilized to control the device characteristics. Since excess electron-hole pair can be controlled by the radiated power level of the external optical source, the radiated power level has direct control on device characteristics. A MESFET with transparent or semitransparent Schottky metal at the gate to the desired incident radiation is known as optically controlled field effect transistor (OPFET).GaAs MESFET with gate length values in the range of 0.2-0.5micrometer shows high drain –source current (output current) and large transconductance values at microwave frequencies .The one dimensional (1D) Poisson's equation will fail to provide potential distribution of such MESFET with channel length in above range. Since electrical characteristics of devices influenced by the two-dimensional potential distribution and high electric field effect, thus the 2D Poisson's equation is required to solve to obtain the channel potential and threshold voltage of short channel devices which can be utilized for the modeling of the electrical characteristics of the device [4-5].In general various techniques can be used for producing non uniform doping in the channel region of the device .ion –implantation is very effective for improved GaAs MESFET performance. Ion-implantation method produces a Gaussian doping profile which is an analytically non integrable function i.e. integration of the Gaussian function within the finite limit produces error function which is not analytical in nature. Thus 2D modeling of the potential distribution and threshold voltage of short channel ion –implanted GaAs MESFET is a difficult and challenging task. The complexity increased further If the modeling is carried out for short –gate length GaAs MESFET operating under illuminated condition .It is assumed that uniformly distributed channel for device and results are not validated by any experimental or numerical simulation data. To the best of our knowledge no work has been reported so far in the literature for two dimensional analytical model of an ion implanted GaAs MESFET under dark and illuminations [8-9].

In this paper the analytically model the channel potential and threshold voltage of short channel optically biased GaAs MESFET with vertical Gaussian profile to get faster and denser components for photonic IC's .The model uses a Gaussian like analytic function in place of actual non analytic Gaussian function for making the model purely analytical one .model is simplified by assuming that vertical channel doping is Gaussian in nature and it is uniform in lateral direction [10].

The 2D potential distribution function is obtained by solving the 2D Poisson's equation using superposition method in conjunction with appropriate boundary conditions. Modifications in the Poisson's equation to include the photo effect on the device characteristics of GaAs MESFETs under illuminated condition, Since threshold voltage is the key parameter in both dc and microwave circuit design using GaAs MESTFETs ,the effect of optical illumination on threshold voltage of GaAs OPFET has also been investigated[11].Theoretically predicted results are compared with MATLAB results.

II. DEVICE DETAILS:-

Optically biased GaAs MESFET used for modeling, Structure of fully doped GaAs MESFET shown schematically in the figure.1, where *a* and *L* are active layer thickness and gate length respectively

The substrate of device is assumed to be an un-doped high pure semi-insulating material .The active channel region of the device is an n-GaAs layer which can be obtained by ion implantation of silicon in to semi-insulating substrate .monochromatic light of energy greater than or equal to the band gap energy of GaAs is allowed to fall upon the gate area of the device (along y-axis).Indium tin oxide has been used as the Schottky –gate metal due to high optical transmittance of incident illumination on gate surface[12]. The un-doped substrate is assumed to have a uniform doping concentration of N_S The implantation is assumed from an infinitesimal beam that scanned uniformly across the substrate surface so that ion distribution profile become 1D Gaussian function described by equation(1)

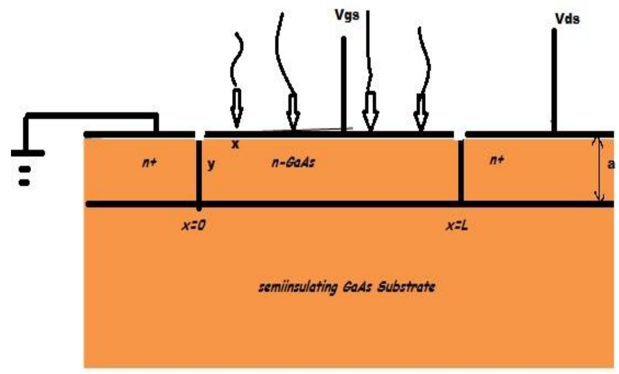

Fig.1 schematic of GaAs MESFET

The undoped substrate is assumed to have a uniform doping and implantation is assumed from an identical beam that scanned uniformly across the substrate, therefore the I D Gaussian Function described by[13].

$$N(y) = \frac{Q}{\sigma\sqrt{2\pi}} e^{\left[-\left[\frac{y-R_p}{\sigma\sqrt{2}}\right]^2\right]} = N_p e^{\left[-\left[\frac{y-R_p}{\sigma\sqrt{2}}\right]^2\right]} \quad --(1)$$

Where Q is the dose , R_p is the projected range, σ is the projected straggle and $N_p = \frac{Q}{\sigma\sqrt{2\pi}}$ is the peak ion concentration in the substrate

[2]The doping distribution in the channel can be approximately described by [considering N_S is the substrate doping concentration]

$$N_d(y) = N_s + (N_p - N_s) e^{\left[-\left[\frac{y-R_p}{\sigma\sqrt{2}}\right]^2\right]}$$

$$= N_s + (N_p - N_s) F(y) \quad --(2)$$

Where $F(y) = e^{\left[-\left[\frac{y-R_p}{\sigma\sqrt{2}}\right]^2\right]} \quad --(3)$

$N_d(y)$ is an analytically non-integrable function of y because of exponential function F(y)

[3] To remove this difficulty we have used an approximate analytic form of F(y) as

$$F(y) = C_c[\{a_c + \frac{2b_c\beta}{\sqrt{2\sigma}}(y - R_p)\}^2 - 2b_c]e^{[-\{\frac{a_c\beta}{\sqrt{2}\sigma^2}(y-R_p)^2\}]} \quad --(4)$$

Where

$$a_c = 1.78571, b_c = 0.6460835, c_c = 0.28\sqrt{\pi}$$

and

$$\beta = \{+1 \text{for } y > R_p, -1 \text{ for } y < R_p$$

III.THEORETICAL MODEL:

1. Modeling of 2D channel function:-

$\phi(x, y)$ is potential distribution of the channel and it can be determined by solving the following 2D

Poisson's equation in the fully depleted rectangular channel region

$$\frac{d^2\phi(x,y)}{dx^2} + \frac{d^2\phi(x,y)}{dy^2} = -\frac{qN_D(y)}{\varepsilon_s} \quad --(5)$$

Where ε_s is dielectric permittivity of GaAs semiconductor, q- is the electron charge

$N_D(y)$ is the net doping concentration in the active channel region under illuminated condition which can be expressed as

$$N_D(y) = N_d(y) + G(y)\tau_n - \frac{R\tau_p}{\alpha} \quad --(6)$$

Where $N_d(y)$ is the doping profile defined by equation (2)

R is the surface recombination rate

α is the absorption coefficient of GaAs material τ_n and τ_p are the life time of electrons and holes respectively

And G(y) is photo-generation rate given by

$$G(y) = \Phi_0\alpha e^{(-\alpha y)} \quad --(7)$$

where Φ_0 is the photon flux density expressed as

$$\Phi_0 = \frac{P_{in}T_m}{h\nu ZL} \quad --(8)$$

Where P_{in} is the incident optical power , Z is the width of the gate –material ,L is the gate length ,

T_m is the optical transmission coefficient for the gate metal,

h- is the planks constant and ν is the frequency of the incident light

we can use following boundary conditions for solving equation (5) :

$$\phi(x,0) = V_{bi} - V_{gs} - V_{op} \quad --(9)$$

$$\phi(0, y) = V_{bi} \quad --(10)$$

$$\phi(L, y) = V_{bi} + V_{ds} \quad --(11)$$

$$\frac{\partial\phi(x,y)}{\partial y} \vdots\, y = \alpha \quad = 0 \quad --(12)$$

Where V_{bi} is Schottky –barrier potential , V_{gs} is the applied gate bias and V_{op} is the photo voltage developed at the Schottky junction due to illumination which can be described by

$$V_{op} = \frac{nkT}{q} \ln(1 + \frac{J_p(0)}{J_s}) --(13)$$

Where J_s - is reverse saturation current density at the gate depletion layer interface, k- is the Boltzman Constant, T- is the room temperature (i.e. 300k) , n -is the ideality factor of Schottky junction

q- is the charge of the electron and $J_p(0)$ - is the hole current density crossing the gate –channel

Interface is given by

$$J_p(0) = qv_p p_d(y) \vdots y = 0 \quad ---(14)$$

Where v_p is the saturation velocity of hole and $p_d(y)$ is the photo-generated hole density in the depletion region and $p_d(y) \vdots y = 0$ is described by

$$p_d(y) \vdots y = 0 = \left(\frac{\Phi_0 \alpha \tau_p}{1 - \alpha\beta\tau_p v_p}\right)\left[1 - e^{(-\alpha a)}\right] --(15)$$

Applying superposition technique to solve the 2D Poisson's equation described by(5), $\phi(x, y)$ can be expressed as

$$\phi(x, y) = \varphi_{1D}(y) + \varphi_{2D}(x, y) --(16)$$

Where $\varphi_{1D}(y)$ is the 1D potential function of the long –channel MESFET and $\varphi_{2D}(x, y)$ is the 2D potential function responsible for the short channel effects

The long -channel potential function $\varphi_{1D}(y)$ can be obtained by solving following 1D Poisson's equation

$$\frac{d^2 \varphi_{1D}(y)}{dx^2} = -\frac{qN_D(y)}{\varepsilon_s} --(17)$$

With following boundary conditions

$$\varphi_{1D}(y) \vdots y = 0 = V_{bi} - V_{gs} - V_{op} --(18)$$

$$\frac{\partial \varphi_{1D}(y)}{\partial y} \vdots y = a = 0 --(19)$$

The function $\varphi_{1D}(y)$ can be obtained by integrating equation (17) twice and can be written as

$$\varphi_{1D}(y) = \frac{q(\sigma\sqrt{2})^2}{\varepsilon_s}[C_c(N_p - N_s)e^{[-[a_c[\frac{y-R_p}{\sqrt{2}\sigma}] + b_c[\frac{y-R_p}{\sqrt{2}\sigma}]^2]]}$$

$$- \frac{R\tau_p}{a}(\frac{y-R_p}{\sqrt{2}\sigma})^2 + \frac{\Phi_0 \tau_n e^{(-\alpha R_p)} e^{(-\alpha(y-R_p))}}{\alpha^2(\sigma\sqrt{2})^2} +$$

$$\frac{N_s}{2}(\frac{y-R_p}{\sqrt{2}\sigma})^2 + A(\frac{y-R_p}{\sqrt{2}\sigma})^2 + B] --(20)$$

Where A, B are the arbitrary constants expressed as

ISSN: 2278-0181
Vol. 1 Issue 7, September - 2012

$$A = -\frac{q\sigma\sqrt{2}}{\varepsilon_s}[-C_c(N_p - N_s)[a_c + 2b_c[\frac{a-R_p}{\sqrt{2\sigma}}]]e^{[-[a_c[\frac{a-R_p}{\sqrt{2\sigma}}]+b_c[\frac{a-R_p}{\sqrt{2\sigma}}]^2]]}$$

$$+N_s[\frac{a-R_p}{\sqrt{2\sigma}}]$$

$$-\frac{R_p\tau}{a}[\frac{a-R_p}{\sqrt{2\sigma}}] - \frac{(\Phi_0\tau_n e^{(-aR_p)}e^{(-\alpha(a-R_p))}}{\sqrt{2\sigma\alpha}}] - (21)$$

$$B = -[C_c(N_p - N_s)e^{[-[a_c[\frac{-R_p}{\sqrt{2\sigma}}]+b_c[\frac{-R_p}{\sqrt{2\sigma}}]^2]]} + \frac{N_s}{4}[\frac{-R_p}{\sigma}]^2 -$$

$$+\frac{\Phi_0\tau_n e^{(-\alpha R_p)}e^{(\alpha R_p)}}{\alpha^2(\sigma\sqrt{2})^2}$$

$$+A[\frac{-R_p}{\sqrt{2\sigma}}] - \frac{\varepsilon_s(V_{bi} - V_{gs} - V_{op})}{q(\sigma\sqrt{2})^2}] - -(22)$$

Now, $\varphi_{2D}(x,y)$ the can be obtained by 2D Laplace equation

$$\frac{\partial^2\varphi_{2D}(x,y)}{\partial x^2} + \frac{\partial^2\varphi_{2D}(x,y)}{\partial y^2} = 0 - -(23)$$

by using the following boundary conditions derived from equation(9)-(12) in conjunction with equation (18)-(19)

$$\varphi_{2D}(x,0) = 0 - -(24)$$

$$\varphi_{2D}(0,y) = V_{bi} - \varphi_{1D}(y) - -(25)$$

$$\varphi_{2D}(L,y) = V_{bi} + V_{ds} - \varphi_{1D}(y) - -(26)$$

$$\frac{d\varphi_{2D}(x,y)}{dy} \vdots\, y = a = 0 - -(27)$$

Appling the standard technique of separation of variables and using the boundary conditions described by equations(24)-(27), $\varphi_{2D}(x,y)$ can be expressed as

$$\varphi_{2D}(x,y) = \sum_{n=1}^{\infty}\frac{\sin(k_n y)}{\sinh(k_n L)}\{A_n \sinh[k_n(L-x)] + B_n \sinh(k_n x)\} - -(28)$$

Where

$$k_n = \frac{(2n+1)\pi}{2a} - -(29)$$

$$A_n = \frac{C_{1n} - C_{2n} - C_{3n} + C_{4n} - C_{5n} + C_{6n} + C_{7n}}{M_n} - -(30)$$

$$B_n = \frac{C_{1n} + C_{11n} - C_{2n} - C_{3n} - +C_{4n} - C_{5n} + C_{6n} + C_{7n}}{M_n} - -(31)$$

$$C_{1n} = -\frac{q(\sigma\sqrt{2})^3 C_c(N_p - N_s)}{\varepsilon_s K_n^{13}}[2b_c + k_n^2 + (-2b_c + (-1 + a(a_c + b_c a))k^2 + n(-2b_c + (-1 + a(a_c + b_c a))k_n^2 \cos(k_n a) - (a_c + 2b_c a)k_n)\sin(k_n a)] - -(32)$$

$$C_{11n} = \frac{V_{ds}}{k_n} = -\frac{V_{ds}\cos k_n a}{k_n} - -(33)$$

$$C_{2n} = \frac{q(\sigma\sqrt{2})^3 N_s}{2\varepsilon_s k_n^3}[-2 + (2 - a^2 k_n^2)\cos(ak_n) + 2ak_n \cos(ak_n) - -(34)$$

$$C_{3n} = \frac{q(\sigma\sqrt{2})\Phi_0\tau_n}{\alpha} e^{(-\alpha R_p - \alpha\sigma\sqrt{2}a)} X\left[\frac{k_n e^{(\alpha\sigma\sqrt{2}a)} - k_n\cos(ak_n) - \alpha\sigma\sqrt{2}\sin(ak_n)}{\alpha(\sigma\sqrt{2})^2 + k_n^2}\right]$$

$$-\left[\frac{V_{bi}}{k_n} - \frac{V_{bi}\cos(ak_n)}{k_n}\right] - -(35)$$

$$C_{4n} = \frac{q(\sigma\sqrt{2})^3 R\tau_p}{2a\varepsilon_s k_n^3}[-2 + (2 - a^2k_n^2)\cos(ak_n) + 2ak_n\cos(ak_n)] - -(36)$$

$$C_{5n} = \frac{Aq^2(\sigma\sqrt{2})^4(-ak_n)\cos(ak_n) + \sin(ak_n)}{k_n^2\varepsilon_s^2}$$

$$-\frac{R_p Aq^2(\sigma\sqrt{2})^3(-1 + \cos(ak_n))}{K_n^1\varepsilon_s^2} - -(37)$$

$$C_{6n} = \frac{q^2(\sigma\sqrt{2})^6 C_c(N_p - N_s)(-1 + \cos(ak_n))}{\varepsilon_s^2 k_n^1} X[[a_c$$

$$+ 2b_c\left(\frac{a - R_p}{\sigma\sqrt{2}}\right)]^2 - 2b_c]e^{[-a_c\left(\frac{a - R_p}{\sigma\sqrt{2}}\right) - b_c\left(\frac{a - R_p}{\sigma\sqrt{2}}\right)^2]} - -(38)$$

$$C_{7n} = \frac{q(\sigma\sqrt{2})^2(1 - \cos ak_n)}{\varepsilon_s^2 k}[C_c(N_p - N_s)e^{[-a_c\left(\frac{-R_p}{\sigma\sqrt{2}}\right) + b_c\left(\frac{-R_p}{\sigma\sqrt{2}}\right)^2]}$$

$$+\frac{N_s}{2}\left(\frac{-R_p}{\sigma\sqrt{2}}\right)^2 - \frac{R\tau_p}{a}\left(\frac{-R_p}{\sigma\sqrt{2}}\right)^2 + \frac{\Phi_0\tau_n e^{(-\alpha R_p)}e^{(\alpha R_p)}}{\alpha(\sigma\sqrt{2})^2}]$$

$$-\frac{(V_{bi} - V_{gs} - V_{op})(1 - \cos k_n a)}{k_n} - -(39)$$

$$M_n = \frac{2ak_n - \sin(2ak_n)}{4k_n} - -(40)$$

Thus from resultant expression $\phi(x, y)$ can be obtained by using the expression $\varphi_{1D}(y)$ and $\varphi_{2D}(x, y)$ from equation (20) and equation (28) in equation (16) respectively

Note that equation (28) is an infinite series and hence impossible to use for computation of the values of $\varphi_{2D}(x, y)$ by taking all the terms in to consideration .it may be mentioned that any hyperbolic sine function ,say sinh(z) ,decreases exponentially with the increase in z ,Thus both $\sin(k_n(L - x))$ and $\sin(k_n L)$ In equation (28) decreases very rapidly with increase in *n* since k_n is increased with *n*

Further it may be verified that both A_n and B_n are also decreased with the increase in n

Therefore it maybe a quite reasonable assumption to consider only the fundamental term for *n=1*

Of the series to approximately express as

$$\phi(x, y) = \varphi_{1D}(y) + \frac{\sin(k_1 y)}{\sin(k_1 L)}\{A_1\sinh[k_1(L - x)] + B_1\sinh(k_1 x)\} - -(41)$$

Where k_1, A_1 and B_1 can be determined by using *n=1* in equations (29)-(31) respectively.

2. Modeling of Threshold Voltage:-

The Threshold voltage V_{th} of a short channel optically biased MESFET can be obtained as

$$V_{th} = V_{tho} - \sec\left(\frac{k_1 L}{2}\right)A_1 - -(42)$$

Where k_1 and A_1 are obtained from equation (29) and equation(30) with *n=1* respectively, and V_{tho} is the threshold voltage of the long –channel MESFET which can be obtained as

$$V_{tho} = V_{bi} - V_{po} - V_{op} - -(43)$$

Where V_{po} is the pinch -off voltage defined as

$$V_{po} = \frac{q}{\varepsilon_s}\int_0^a N_D(y)y\,dy --(44)$$

$$V_{po} = \frac{q[C_1 + (N_p - N_s)\sigma\sqrt{2}(C_2 + C_3 + C_4)]}{\varepsilon_s} --(45)$$

$$C_1 = \frac{N_s a^2}{2} - \frac{R_p \tau a}{2} + [\frac{(1-(1+a\alpha)e^{(-a\alpha)}\Phi_0 \tau_n}{\alpha}] --(46)$$

$$C_2 = -\sigma\sqrt{2}C_c\,[e^{[\frac{a_c(a-R_p)}{\sigma\sqrt{2}} - b_c(\frac{(a-R_p)}{\sigma\sqrt{2}})^2]} - e^{[\frac{a_c(-R_p)}{\sigma\sqrt{2}} - b_c(\frac{(-R_p)}{\sigma\sqrt{2}})^2]}] --(47)$$

$$C_3 = C_c(a-R_p)[a_c + 2b_c\frac{(a-R_p)}{\sigma\sqrt{2}}]e^{[\frac{a_c(a-R_p)}{\sigma\sqrt{2}} - b_c(\frac{(a-R_p)}{\sigma\sqrt{2}})^2]} - C_c(-R_p)[a_c + 2b_c\frac{(-R_p)}{\sigma\sqrt{2}}]e^{[\frac{a_c(-R_p)}{\sigma\sqrt{2}} - b_c(\frac{(-R_p)}{\sigma\sqrt{2}})^2]} --(48)$$

$$C_4 = -R_p C_c[[a_c + 2b_c\frac{(a-R_p)}{\sigma\sqrt{2}}]e^{[\frac{a_c(a-R_p)}{\sigma\sqrt{2}} - b_c[\frac{(a-R_p)}{\sigma\sqrt{2}}]^2]} - [a_c + 2b_c\frac{(-R_p)}{\sigma\sqrt{2}}]e^{[\frac{a_c(-R_p)}{\sigma\sqrt{2}} - b_c[\frac{(-R_p)}{\sigma\sqrt{2}}]^2]}] --(49)$$

IV. RESULT AND DISCUSSION:-

The value of parameter used for modeling results are a=0.4µm, Vgs=0.2v, Rp=0.06µm, Vbi=0.6v, σ=0.05µm, $N_p = 1X10^{23} m^{-3}$, $Ns = 1X10^{21} m^{-3}$, $\tau_n = 10^{-6} S$ $\tau_n = 10^{-8} S$ $\alpha = 10^{6} / m$, $\lambda = 8700 A^{0}$ and $T_m = 0.9$;

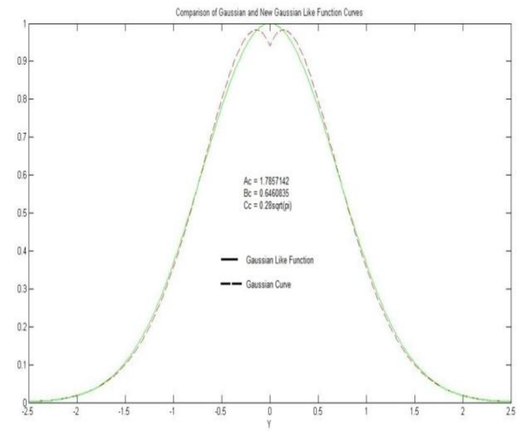

Fig.2.Comparision of Gaussian and New Gaussian like function curves

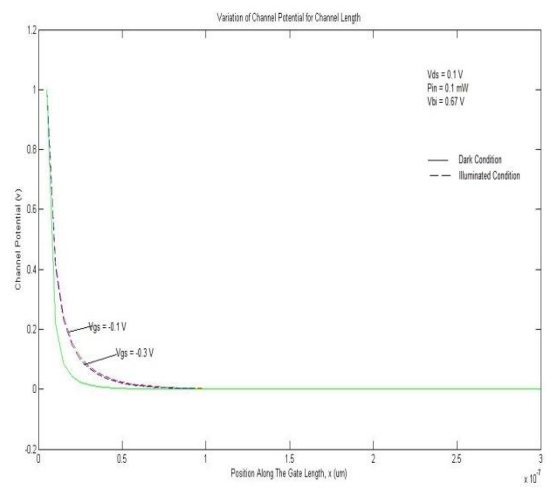

Fig.3. Variation of channel Potential along the Channel Length for dark and illuminated conditions

Fig.3 shows the variation of channel potential with gate length (L) in dark and illuminated conditions for different gate to source voltage(Vgs).it can be seen that for a given gate voltage ,the source –channel potential barrier is reduced due to the incident optical radiations on the device .this due to the fact that the photo voltage developed across the junction due to illumination forward biased the Schottky gate –channel junction and hence decreasing the source –channel potential this results that the height of depletion region below gate is decreased with increase in the level of incident illumination on the device.

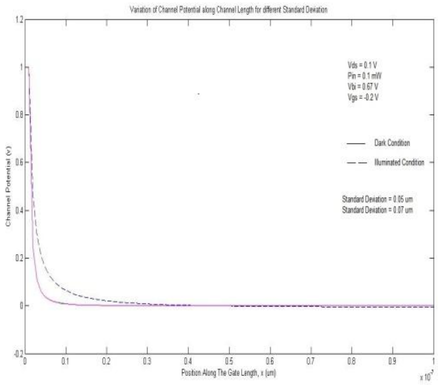

Fig.4.Variation of channel Potential along the Channel length for different standard deviation (σ)for dark and illuminated conditions

Fig.4 shows the channel potential variation as a function of channel Length (L), for different values of projected straggle σ. It is observed that source channel barrier height is decreased with the increase in the value of σ due to the increase in the average implanted ion density in the active channel region of the MESFET with increase in a σ of the profile for the constant peak doping N_p

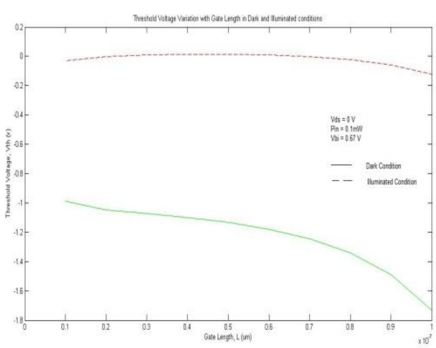

Fig.5.Threshhold Voltage V_{th} variation with gate length(L) for dark and illuminated conditions

Fig.5shows the threshold voltage variation with gate length for dark and illuminated conditions .it has been observed that, for gate length less than 0,2µm drain induced barrier lowering (DIBL) effect becomes prominent which intern, reduces the threshold voltage of the device, It is also found that the threshold voltage under illuminated condition is smaller than that obtained under dark condition of the device. This is due to development of photo voltage at the Schottky gate, as optical radiation make junction forward biased

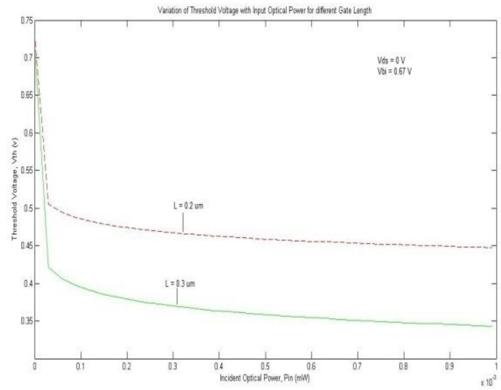

Fig.6.Variation of Threshold Voltages V_{th} with incident optical power (Pin)for different gate length (L)

Fig.6 shows the variation of the threshold voltage with incident optical power on the device, as the threshold voltage is decreased with increase in the incident optical power, for smaller change in the threshold voltages at 0.1mW is due to fact that developed photo voltage is too small to make a change in the device characteristics below the mentioned power level .Once the optical power increased beyond the active level ,the photo-generated carriers become sufficient in number to develop significant amount of photo voltage which forward biases the gate – channel junction and reduce the threshold voltage of the device

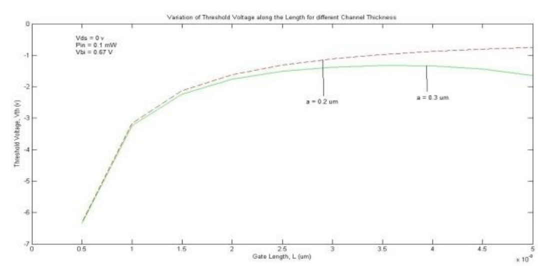

Fig.7. Variation of Threshold voltage (V_{th}) With gate length (L) for different channel thickness

Fig.7 shows the variation of threshold voltage with gate length under illuminated condition of the device for different thickness (a) it is observed that threshold voltage degradation due to short channel effect can optimized by reducing the channel thickness.

V. CONCLUSIONS:-

In this paper a 2D channel potential has been modeled for optically depleted GaAs MESFET device with a Gaussian – like doping profile in the vertical direction

The potential distribution has been derived by solving 2D Poisson's equation using superposition method .optical radiation dependent on threshold voltage have been derived and compare with dark condition .The observed threshold voltage degradation due to short channel effects can be minimized by reducing channel thickness of GaAs MESFET .The proposed model results are found to be match with MATLAB

REFERENCES:-

[1] S. Sabat, L.D.S. Coelho, A. Abraham, "MESFETDC model parameter extraction using quantum particle swarm optimization," *Microelectronics Reliability* Vol.49, No. pp.660-666, Apr., 2009

[2] J. M. Zamanillo, J. Portilla, C. Navarro, C. Pérez-Vega., "Optical Ports: Next generation of MMIC control devices," *Proceedings of 35th European Microwave Conference (EuMC),* pp.1391-1394, Oct.,2005

[3] J. Rodriguez-Tellez, K. A. Mezheg, N T. AIi, T.Fernandei, A. Mediavilla, A. Tazon, C. Navarro,"Optically controlled 2.4GHz MMIC Amplifier," *Proceedings of 10th International Conference on Electronics, Circuits Systems (ICECS),* pp.970-973, Dec., 2003.

[4]S. Bose, M. Gupta, R.S. Gupta, "Cut-off frequency and optimum noise figure of GaAs optically controlled FET," *Microwave Opt. Technol. Lett.*Vol.26, No.5, pp.279-282, Sep., 2000.

[5] S.Bose, Adarsh, R.S. Gupta, "Unilateral power gain of optically biased GaAs MESFET," *Appl Microwave Wireless* , Vol.13, No.8, pp.68-77, Aug., 2001.

[6] Madjar, A. Paolella, P. R. Herczfeld, "Analytical model for optically generated currents in GaAs MESFETs," *IEEE Trans. Microwave Theory Tech.*Vol.40, No.8, pp.1681-1691, Aug., 1992.

[7] S. Mishra, V. K. Singh, B. B. Pal, "Effect of radiation and surface recombination on the characteristics of an ion-implanted GaAs MESFET,"*IEEE Trans. Electron Device* Vol.37, No.1, pp.2-10,Jan., 1990.

[8] P.Calvani, A. Corsaro, "Microwave operation of sub-micrometer gate surface channel MESFETs in polycrystalline diamond," *Microwave Opt. Technol. Lett.* Vol.51, No.11, pp.2786-2788, Nov., 2009.

[9] N. Kato, K. Yamasaki, K. Asai, K. Ohwada, "Electron beam lithography in n+ self-aligned GaAs MESFET fabrication," *IEEE Trans. Electron Device* Vol.30,No.6 , pp.663-668, June, 1983.

[10] P. C. Chao, P. M. Smith, S. Wanuga, W. H. Perkins, E. D. Wolf, "Channel length effects in quarter micrometer gate-length GaAs MESFETs," *IEEE Electron Device Lett.* Vol.4, No.9, pp.326-328, Sep.,1983.

[11] C. H. Liu, L. W. Wu, S. J. Chang, J. F. Chen, U. H.Liaw, S. C. Chen, "Ion-implantation technology for improved GaAs MESFETs performance," *J. of Mater. Sci.:Mater in Electronics* Vol.15, No.2,pp.91-93, Feb., 2004.

[12] A. Dasgupta, S. K. Lahiri, "A novel analytical threshold voltage model of MOSFETs with implanted channels," *Int. J. Electronics* Vol.61,No.5, pp.655-669, May, 1986.

[13] S. A Bashar "Study of Indium Tin Oxide (ITO) for Novel Optoelectronic Devices," *PhD Thesis, King's College of London*, University of London, 1998.

[14] S.M. Sze, *Physics of semiconductor devices*, second ed., Wiley, New York, 1981.

[15] A. Dasgupta, S. K. Lahiri, "A two-dimensional analytical model of threshold voltages of short channel MOSFETs with Gaussian-doped channels,"*IEEE Trans. Electron Device* Vol.35, No.3, pp.390-392, Mar., 1988.

[16] S. Kabra, H. Kaur, S. Haldar, M. Gupta, R.S. Gupta, "Two-dimensional sub threshold analysis of submicron GaN MESFET," *Microelectronics Journal*Vol.38, No.4 pp.547-555, Apr., 2007.

[17] S. Jit**,** G. Bandhawakar, B. B. Pal, "Analytical Modeling of a DCFL Inverter Using Normally-off GaAs MESFETs Under Dark and Illuminated Conditions," *Solid-State Electronics* Vol.49, No.4,pp.628-633, Feb., 2005.

[39] E. Kreyszig, *Advanced Engineering Mathematics*, seventh ed., Wiley, New York, 1993.

[40] S. P. Chin, C. Y. Wu, "A new two dimensional model for the potential distribution of short gate length MESFETs and its application," *IEEE Trans. Electron Device* Vol.39, No.8, pp.1928-1937 Aug., 1992.