Modeling of Potential and Threshold Voltage in presence of Hot-Carriers for Short-Channel Double-Gate MOSFET

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Abstract—*This paper presents an analytical potential and threshold voltage model for short-channel lightly doped symmetric double-gate (DG) metal-oxide-semiconductor field-effect transistor (MOSFET) in presence of hot carrier induced interface trapped charges near the drain side. The potential distribution equation for the DG MOSFET is derived considering both positive and negative interface trapped charges. The mobile charge carrier density is incorporated in the 2D Poisson's equation with Boltzmann's approximation to derive the potential. The developed potential model is valid in the weak inversion regime. The threshold voltage is then extracted from the potential equation. The models so developed are in closed agreement with reported papers.*

1. INTRODUCTION

In the nano-dimension region, MOSFET performance degrades due to hot carrier effect and it leads a major reliability issue. For ultra-small MOSFETs, in presence of high electric field, the highly energetic electrons may damage the silicon-oxide interface and increase the interface states near the drain side in addition to production of leakage current. Therefore, inclusion of hot carrier effect in MOSFET modeling is important. There are only few reported papers [1-4] on modeling of DG MOSFET in presence of hot carriers. Moreover, most of them have derived the potential as well as threshold voltage model considering either mobile or fixed charges. Therefore, in this work, an effort has been made to develop a potential and a threshold voltage model for the DG MOSFET in presence of hot carrier induced interface trapped charges considering both mobile as well as fixed charge carriers.

2. POTENTIAL DISTRIBUTION MODEL

A schematic cross-section of the n-channel DG MOSFET is shown in Figure 1. Assume that region 1 of length *L1* is the non-damaged region and region 2 is of length *Ld* represents the damaged region with interface trapped charge density N_{it} cm^{-2}. The potential distribution of the damaged and non-damaged region is to be derived separately and combined together for the total potential with valid boundary conditions.

The 2D Poisson's equation including both fixed charge and mobile charge carriers with Boltzmann's approximation can be written as [5]

$$\frac{\partial^2\psi(x,y)}{\partial x^2}+\frac{\partial^2\psi(x,y)}{\partial y^2}=\frac{qN_a}{\varepsilon_{si}}\left(1-e^{\frac{\psi(x,y)-V}{V_T}}\right) \tag{1}$$

Where, N_a is the substrate doping concentration, ε_{si} is the dielectric constant of the silicon, V_T is the thermal voltage given by $V_T=k_BT/q$, V is the quasi-fermi potential of the electrons. Using "parabolic potential approximation" method, the 2D electrostatic potential $\psi(x,y)$ can be written as [6]

$$\psi(x,y)=c_0(y)+c_1(y)x+c_2(y)x^2 \tag{2}$$

Boundary conditions to find coefficients $c_0(y)$, $c_1(y)$ and $c_2(y)$ are:

$$\psi\left(\frac{t_{si}}{2},y\right)=\psi\left(-\frac{t_{si}}{2},y\right)=\psi_s(y) \tag{3}$$

$$\left.\frac{\partial\psi(x,y)}{\partial x}\right|_{x=t_{si}/2}=\frac{\varepsilon_{ox}}{\varepsilon_{si}}\frac{V_{g1}-\psi_s(y)}{t_{ox}} \tag{4}$$

$$\left.\frac{\partial\psi(x,y)}{\partial x}\right|_{x=0}=0 \tag{5}$$

Where, $V_{g1}=V_{gs}-V_{fb}$, V_{gs} is the gate voltage, V_{fb} is the flat-band voltage, V_{g1} is the effective gate voltage, $\psi_s(y)$ is the surface potential, ε_{ox} is the dielectric constant of the oxide, t_{si} is the silicon body thickness, t_{ox} is the oxide thickness. Solving set of equations (2) to (5) the coefficients obtained are:

$$c_0(y)=\psi_s(y)+\frac{\varepsilon_{ox}}{\varepsilon_{si}}\left(\frac{\psi_s(y)-V_{g1}}{t_{ox}}\right)\frac{t_{si}}{4} \tag{6}$$

$$c_1(y)=0 \tag{7}$$

$$c_2(y)=-\frac{\varepsilon_{ox}}{\varepsilon_{si}}\left(\frac{\psi_s(y)-V_{g1}}{t_{si}t_{ox}}\right) \tag{8}$$

Using (6)-(8), expression for potential distribution can be written as

$$\psi(x,y)=\psi_s(y)+\frac{\varepsilon_{ox}}{\varepsilon_{si}}\left(\frac{\psi_s(y)-V_{g1}}{t_{ox}}\right)\frac{t_{si}}{4} -\frac{\varepsilon_{ox}}{\varepsilon_{si}}\left(\frac{\psi_s(y)-V_{g1}}{t_{si}t_{ox}}\right)x^2 \tag{9}$$

Putting (9) in (1) and expanding the exponential term using Maclaurin's series, a differential equation for the surface potential in the non-damaged region ($0 \le y \le L1$), is obtained as

$$\frac{d^2\psi_{s1}(y)}{dy^2}-\frac{1}{\alpha^2}\psi_{s1}(y)=\beta \tag{10}$$

With

$$\alpha=\sqrt{\frac{\lambda^2\varepsilon_{si}V_T}{\varepsilon_{si}V_T-qN_a\lambda^2}}$$

$$\beta=\frac{qN_aV}{\varepsilon_{si}V_T}-\frac{1}{\lambda^2}V_{g1}$$

$$\lambda=\sqrt{\frac{\varepsilon_{si}t_{si}t_{ox}}{2\varepsilon_{ox}}} \tag{11}$$

Where λ is the natural channel length [6]. The general solution for (10) is given by:

$$\psi_{s1}(y)=C_1e^{\frac{y}{\alpha}}+C_2e^{\frac{-y}{\alpha}}-\alpha^2\beta \tag{12}$$

Here, the boundary conditions are

$$\psi_{s1}(y)\big|_{y=0}=V_{bi}$$
$$\psi_{s1}(y)\big|_{y=L1}=V_p \tag{13}$$

Where V_{bi} is the built-in potential given by $V_{bi}=V_T ln(N_d/n_i)$, N_d is the source/drain doping concentration, n_i is the intrinsic silicon concentration, V_p is the potential developed at the boundary of region 1 and region 2. Applying boundary conditions (13), C_1 and C_2 are obtained as

$$C_1=\frac{\left(V_p+\alpha^2\beta\right)-\left(V_{bi}+\alpha^2\beta\right)e^{\frac{-L1}{\alpha}}}{e^{\frac{L1}{\alpha}}-e^{\frac{-L1}{\alpha}}}$$
$$C_2=\frac{\left(V_{bi}+\alpha^2\beta\right)e^{\frac{L1}{\alpha}}-\left(V_p+\alpha^2\beta\right)}{e^{\frac{L1}{\alpha}}-e^{\frac{-L1}{\alpha}}} \tag{14}$$

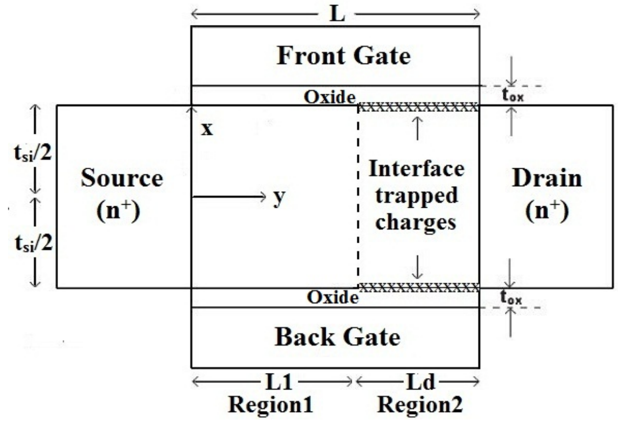


Fig. 1: Schematic cross-section of a symmetric DG MOSFET

The equation for surface potential in the non-damage region $\psi_{s1}(y)$ is written as

$$\psi_{s1}(y)=\frac{V_p\sinh\left(\frac{y}{\alpha}\right)-V_{bi}\sinh\left(\frac{y-L1}{\alpha}\right)}{\sinh\left(\frac{L1}{\alpha}\right)} +\frac{\alpha^2\beta\left(\sinh\left(\frac{y}{\alpha}\right)-\sinh\left(\frac{y-L1}{\alpha}\right)-\sinh\left(\frac{L1}{\alpha}\right)\right)}{\sinh\left(\frac{L1}{\alpha}\right)} \tag{15}$$

The relation between surface potential and potential at a depth ($x=t_{si}/2n$) from the surface $\psi_{x1}(y)$ is written as

$$\psi_{s1}(y)=k_n\psi_{x1}(y)+(1-k_n)V_{g1} \tag{16}$$

Where

$$k_n=\frac{\varepsilon_{si}t_{si}t_{ox}}{\varepsilon_{si}t_{si}t_{ox}+\varepsilon_{ox}\frac{t_{si}^2}{4}-\varepsilon_{ox}\frac{t_{si}^2}{4n^2}}$$

Putting (16) in (9),

$$\psi_1(x,y)=\left(k_n\psi_{x1}(y)+(1-k_n)V_{g1}\right) +\frac{\varepsilon_{ox}}{\varepsilon_{si}}\left(\frac{k_n\psi_{x1}(y)-k_nV_{g1}}{t_{ox}}\right)\frac{t_{si}}{4} -\frac{\varepsilon_{ox}}{\varepsilon_{si}}\left(\frac{k_n\psi_{x1}(y)-k_nV_{g1}}{t_{si}t_{ox}}\right)x^2 \tag{17}$$

Substituting (17) in (1), differential equation in terms of ψx1(y) is obtained as

$$\frac{d^2\psi_{x1}(y)}{dy^2} - \frac{1}{\alpha_n^2}\psi_{x1}(y) = \beta_n \quad (18)$$

With

$$\alpha_n = \sqrt{\frac{\lambda_n^2 \varepsilon_{si} V_T}{\varepsilon_{si} V_T - qN_a \lambda_n^2}}$$

$$\beta_n = \frac{qN_a V}{\varepsilon_{si} V_T} - \frac{1}{\lambda_n^2} V_{g1}$$

$$\lambda_n = \sqrt{\frac{\varepsilon_{si} t_{si} t_{ox} + \varepsilon_{ox}\frac{t_{si}^2}{4} - \varepsilon_{ox}\frac{t_{si}^2}{4n^2}}{2\varepsilon_{ox}}} \quad (19)$$

Where λ_n is the natural channel length as a function of channel depth [7]. Applying the boundary conditions (14), the expression for potential at depth is written as

$$\psi_{x1}(y) = \frac{V_p \sinh\left(\frac{y}{\alpha_n}\right) - V_{bi}\sinh\left(\frac{y-L1}{\alpha_n}\right)}{\sinh\left(\frac{L1}{\alpha_n}\right)} + \frac{\alpha_n^2 \beta_n \left(\sinh\left(\frac{y}{\alpha_n}\right) - \sinh\left(\frac{y-L1}{\alpha_n}\right) - \sinh\left(\frac{L1}{\alpha_n}\right)\right)}{\sinh\left(\frac{L1}{\alpha_n}\right)} \quad (20)$$

The 2D potential distribution for the non damaged region is obtained by putting $n=t_{si}/2x$ in (20).

$$\psi_1(x,y) = \frac{V_p \sinh\left(\frac{y}{\alpha_x}\right) - V_{bi}\sinh\left(\frac{y-L1}{\alpha_x}\right)}{\sinh\left(\frac{L1}{\alpha_x}\right)} + \frac{\alpha_x^2 \beta_x \left(\sinh\left(\frac{y}{\alpha_x}\right) - \sinh\left(\frac{y-L1}{\alpha_x}\right) - \sinh\left(\frac{L1}{\alpha_x}\right)\right)}{\sinh\left(\frac{L1}{\alpha_x}\right)} \quad (21)$$

Where

$$\alpha_x = \sqrt{\frac{\lambda_x^2 \varepsilon_{si} V_T}{\varepsilon_{si} V_T - qN_a \lambda_x^2}}$$

$$\beta_x = \frac{qN_a V}{\varepsilon_{si} V_T} - \frac{1}{\lambda_x^2} V_{g1}$$

$$\lambda_x = \sqrt{\frac{\varepsilon_{si} t_{si} t_{ox} + \varepsilon_{ox}\frac{t_{si}^2}{4} - \varepsilon_{ox} x^2}{2\varepsilon_{ox}}} \quad (22)$$

For the damaged region ($L1 \le y \le L$), (10) can be written as

$$\frac{d^2\psi_{s2}(y)}{dy^2} - \frac{1}{\alpha^2}\psi_{s2}(y) = \beta' \quad (23)$$

Here β' is given by [1], [2], [4]

$$\beta' = \beta - \frac{1}{\lambda^2}\frac{qN_{it}}{C_{ox}} \quad (24)$$

Where C_{ox} is the oxide capacitance. The boundary conditions are

$$\psi_{s2}(y)\big|_{y=L1} = V_p$$

$$\psi_{s2}(y)\big|_{y=L} = V_{bi} + V_{ds} \quad (25)$$

Applying the boundary conditions (25), the expression for surface potential for the damaged region is obtained as

$$\psi_{s2}(y) = \frac{(V_{bi}+V_{ds})\sinh\left(\frac{y-L1}{\alpha}\right) - V_p \sinh\left(\frac{y-L}{\alpha}\right)}{\sinh\left(\frac{L-L1}{\alpha}\right)} + \frac{\alpha^2\beta'\left(\sinh\left(\frac{y-L1}{\alpha}\right) - \sinh\left(\frac{y-L}{\alpha}\right) - \sinh\left(\frac{L-L1}{\alpha}\right)\right)}{\sinh\left(\frac{L-L1}{\alpha}\right)} \quad (26)$$

Finally, the 2D potential distribution equation for the damaged region is expressed as

$$\psi_2(x,y) = \frac{(V_{bi}+V_{ds})\sinh\left(\frac{y-L1}{\alpha_x}\right) - V_p \sinh\left(\frac{y-L}{\alpha_x}\right)}{\sinh\left(\frac{L-L1}{\alpha_x}\right)} + \frac{\alpha_x^2\beta_x'\left(\sinh\left(\frac{y-L1}{\alpha_x}\right) - \sinh\left(\frac{y-L}{\alpha_x}\right) - \sinh\left(\frac{L-L1}{\alpha_x}\right)\right)}{\sinh\left(\frac{L-L1}{\alpha_x}\right)} \quad (27)$$

Where,

$$\beta_x' = \beta_x - \frac{1}{\lambda_x^2}\frac{qN_{it}}{C_{ox}}$$

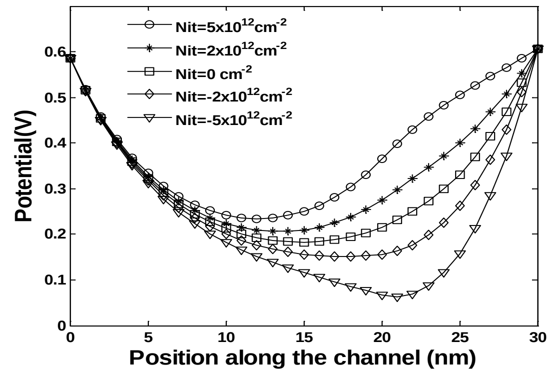
The potential V_p is obtained from continuity of electric field at the interface of damaged and non-damaged region (i.e. at $y=L1$).

$$\left.\frac{\partial\psi_1(x,y)}{\partial y}\right|_{y=L1} = \left.\frac{\partial\psi_2(x,y)}{\partial y}\right|_{y=L1}$$

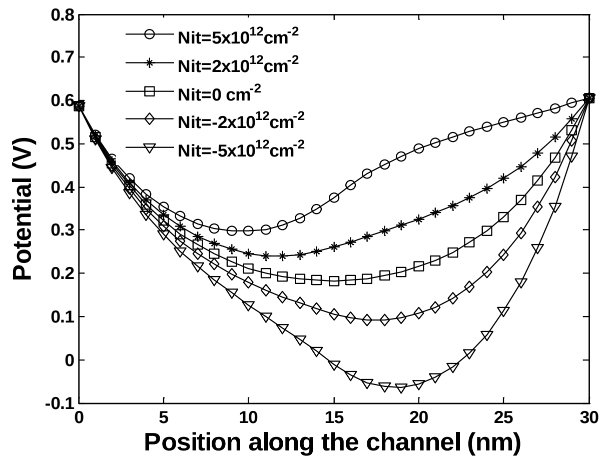
The obtained expression for V_p is written

$$V_p = \frac{V_{bi}\sinh\left(\frac{L-L1}{\alpha_x}\right)+\left(V_{bi}+V_{ds}\right)\sinh\left(\frac{L1}{\alpha_x}\right)}{\sinh\left(\frac{L}{\alpha_x}\right)} - \frac{\left(1-\cosh\left(\frac{L1-L}{\alpha_x}\right)\right)\sinh\left(\frac{L1}{\alpha_x}\right)\left(\frac{\alpha_x^2}{\lambda_x^2}\frac{qN_{it}}{C_{ox}}\right)}{\sinh\left(\frac{L}{\alpha_x}\right)} + \frac{\alpha_x^2\beta_x\sinh\left(\frac{L1}{\alpha_x}\right)\left(1-\cosh\left(\frac{L1-L}{\alpha_x}\right)\right)}{\sinh\left(\frac{L}{\alpha_x}\right)} + \frac{\alpha_x^2\beta_x\sinh\left(\frac{L-L1}{\alpha_x}\right)\left(1-\cosh\left(\frac{L1}{\alpha_x}\right)\right)}{\sinh\left(\frac{L}{\alpha_x}\right)} \quad (28)$$

For plotting the characteristic curves of potential distribution, the value of quasi-fermi potential is taken as $V=V_{bi}$ and for simplicity flat-band voltage (V_{fb}) is considered as $0V$. The value of substrate doping concentration is taken as $N_a=10^{16}\ cm^{-3}$ and source/drain doping concentration is $N_d=10^{20}\ cm^{-3}$. Intrinsic silicon concentration is $n_i=1.45\times10^{10}\ cm^{-3}$. Figure 2 shows the potential distribution along the effective conductive path (at a position $x=t_{si}/4$ below the surface) at bias condition $V_{gs}=0.1V$ and $V_{ds}=0.02V$, considering both positive and negative interface trapped charges. It is seen that the electrostatic potential distribution along the channel gets lowered in presence of negative interface trapped charges, whereas the positive interface trapped charges raise the potential distribution. This is because, the presence of positive interface trapped charges increase the effective gate voltage ($V_{g1}+qN_{it}/C_{ox}$) in the damaged region and this is get reduced in presence of negative interface trapped charges ($V_{g1}-qN_{it}/C_{ox}$). It is observed that degradation in the potential distribution along the channel increases as the *Ld* increases. When positive interface trapped charges are present, then the position of minimum channel potential is always located in the non-damaged region. In case of negative interface trapped charges, minimum channel potential may be located either in the damaged or in the non-damaged region depending upon the values of *Ld* and N_{it}.



(a) Ld=10 nm



(b) Ld=15 nm

Fig. 2. Potential distribution along the effective conductive path $x=t_{si}/4$ of DG MOSFET at bias conditions $V_{gs}=0.1V$ and $V_{ds}=0.02V$ with dimensions $L=30nm$, $t_{si}=10nm$, $t_{ox}=2nm$ and damaged length *(a) Ld=10nm*, (b) *Ld=15nmn*

3. THRESHOLD VOLTAGE MODEL

The threshold voltage is defined as the gate voltage at which the inversion charge sheet density Q_{inv} at the position of minimum channel potential reaches a value Q_{th} which is sufficiently enough to turn on the device. The extraction of threshold voltage can be divided into two parts. One corresponds to the non-damaged region V_{th1} and other one is for damaged region V_{th2}. The position of minimum potential at the effective conductive path [7] can be calculated from the relation

$$\left.\frac{d\psi_{1,2}\left(t_{si}/4, y\right)}{dy}\right|_{y_{\min 1,2}} = 0 \quad (29)$$

Expression for y_{min1} is written as

$$y_{\min 1} = \frac{\alpha_1}{2}\ln\left(\frac{\left(V_{bi}+\alpha_1^2\beta_1\right)e^{\frac{L1}{\alpha_1}}-\left(V_p+\alpha_1^2\beta_1\right)}{\left(V_p+\alpha_1^2\beta_1\right)-\left(V_{bi}+\alpha_1^2\beta_1\right)e^{\frac{-L1}{\alpha_1}}}\right) \qquad (30)$$

Value of V_{gs} at which $Q_{inv}=Q_{th}$ gives an implicit expression for the threshold voltage as [8]

$$Q_{th} = n_i t_{si} e^{\frac{\psi\left(\frac{t_{si}}{4}, y_{\min 1,2}\right)}{V_T}} \qquad (31)$$

Solving (31), the expression for threshold voltage is obtained as

$$\begin{aligned} V_{th1} &= V_{fb} + \frac{\alpha_1^2 q N_a V}{\varepsilon_{si} V_T} - \frac{C_2}{C_1}V_{bi} - \frac{C_3}{C_1}A \\ &+ \frac{\sinh^2\left(L1/\alpha_1\right)}{C_1} V_T \ln\left(\frac{Q_{th}}{n_i t_{si}}\right) - \frac{\sinh\left(L1/\alpha_1\right)}{C_1}\Big[C_4 V_{bi}^2 \\ &+ 2C_3 A V_{bi} - 2C_3 A V_T \ln\left(\frac{Q_{th}}{n_i t_{si}}\right) - 2C_2 V_{bi} V_T \ln\left(\frac{Q_{th}}{n_i t_{si}}\right) \\ &- C_5\left(V_T \ln\left(\frac{Q_{th}}{n_i t_{si}}\right)\right)^2\Big]^{\frac{1}{2}} \end{aligned} \qquad (32)$$

Where:

$$\begin{aligned} A &= \frac{V_{bi}\sinh\left(\frac{L-L1}{\alpha_1}\right) + \left(V_{bi}+V_{ds}\right)\sinh\left(\frac{L1}{\alpha_1}\right)}{\sinh\left(\frac{L}{\alpha_1}\right)} \\ &- \frac{\left(1-\cosh\left(\frac{L1-L}{\alpha_1}\right)\right)\sinh\left(\frac{L1}{\alpha_1}\right)\left(\frac{\alpha_1^2 q N_{it}}{\lambda_1^2 C_{ox}}\right)}{\sinh\left(\frac{L}{\alpha_1}\right)} \end{aligned}$$

$$\begin{aligned} B &= \frac{\alpha_1^2\beta_1 \sinh\left(\frac{L1}{\alpha_1}\right)\left(1-\cosh\left(\frac{L1-L}{\alpha_1}\right)\right)}{\sinh\left(\frac{L}{\alpha_1}\right)} \\ &+ \frac{\alpha_1^2\beta_1 \sinh\left(\frac{L-L1}{\alpha_1}\right)\left(1-\cosh\left(\frac{L1}{\alpha_1}\right)\right)}{\sinh\left(\frac{L}{\alpha_1}\right)} \end{aligned}$$

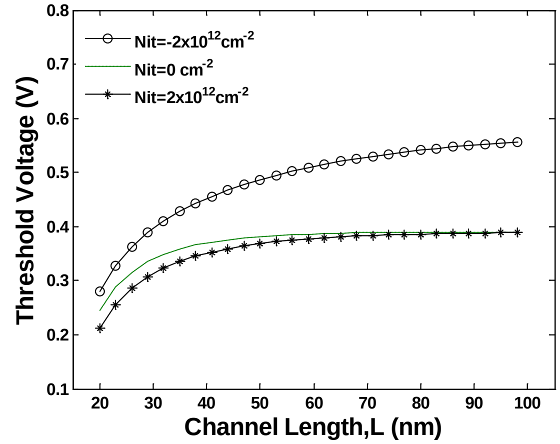


Fig. 3: Threshold voltage versus channel length plots with dimensions t_{si}=10nm, t_{ox}=2nm, considering both positive and negative interface trapped charges with damaged region length *Ld=L/3*

$$C_1 = \left[\left(B+1\right)-\cosh\left(\frac{L1}{\alpha_1}\right)\right]^2$$

$$C_2 = \left[\left(B+1\right)\cosh\left(\frac{L1}{\alpha_1}\right)-1\right]$$

$$C_3 = \left[\cosh\left(\frac{L1}{\alpha_1}\right)-\left(B+1\right)\right]$$

$$C_4 = \left[B\left(B+2\right)\right]$$

$$C_5 = \left[\left(B+1\right)^2 - 2\left(B+1\right)\cosh\left(\frac{L1}{\alpha_1}\right)+1\right]$$

The position of minimum channel potential for the damaged region y_{min2} is expressed as

$$y_{\min 2} = \frac{\alpha_1}{2}\ln\left(\frac{\left(V_p+\alpha_1^2\beta_1'\right)e^{\frac{L}{\alpha_1}}-\left(V_{bi}+V_{ds}+\alpha_1^2\beta_1'\right)e^{\frac{L1}{\alpha_1}}}{\left(V_{bi}+V_{ds}+\alpha_1^2\beta_1'\right)e^{\frac{-L1}{\alpha_1}}-\left(V_p+\alpha_1^2\beta_1'\right)e^{\frac{-L}{\alpha_1}}}\right) \qquad (33)$$

On solving (31), the threshold voltage expression for damaged region is obtained as

$$\begin{aligned} V_{th2} &= V_{fb} + \frac{\alpha_1^2 q N_a V}{\varepsilon_{si} V_T} - \frac{C_{2d}}{C_{1d}}V_{BI} - \frac{C_{3d}}{C_{1d}}A_I \\ &+ \frac{\sinh^2\left(\frac{L-L1}{\alpha_1}\right)}{C_{1d}}V_{TI} - \frac{\sinh\left(\frac{L-L1}{\alpha_1}\right)}{C_{1d}}\Big[C_{4d}V_{BI}^2 \\ &+ 2C_{3d}A_I V_{BI} - 2C_{3d}A_I V_{TI} - 2C_{2d}V_{BI}V_{TI} - C_{5d}V_{TI}^2\Big]^{\frac{1}{2}} \end{aligned} \qquad (34)$$

Where

$$C_{1d}=\left[\left(B+1\right)-\cosh\left(\frac{L-L1}{\alpha_1}\right)\right]^2$$

$$C_{2d}=\left[\left(B+1\right)\cosh\left(\frac{L-L1}{\alpha_1}\right)-1\right]$$

$$C_{3d}=\left[\cosh\left(\frac{L-L1}{\alpha_1}\right)-\left(B+1\right)\right]$$

$$C_{4d}=\left[B\left(B+2\right)\right]$$

$$C_{5d}=\left[\left(B+1\right)^2-2\left(B+1\right)\cosh\left(\frac{L-L1}{\alpha_1}\right)+1\right]$$

$$V_{BI}=V_{bi}+V_{ds}-\frac{\alpha_1^2}{\lambda_1^2}\frac{qN_{it}}{C_{ox}}$$

$$A_I=A-\frac{\alpha_1^2}{\lambda_1^2}\frac{qN_{it}}{C_{ox}}$$

$$V_{TI}=V_T\ln\left(\frac{Q_{th}}{n_i t_{si}}\right)-\frac{\alpha_1^2}{\lambda_1^2}\frac{qN_{it}}{C_{ox}}$$

The characteristic curve of V_{th} versus L is plotted with damaged length $Ld=L/3$ and different interface trapped charge densities. The value of Q_{th} is found to be approximately $3\times10^{10}\ cm^{-2}$ [4]. In presence of positive interface trapped charges, the threshold voltage equation corresponding to the non-damaged region V_{th1} is used to calculate the threshold voltage of the DG MOSFET. In presence of negative interface trapped charges, the threshold voltage of the DG MOSFET can be generalized as

$$V_{th}=real(V_{th1},V_{th2}) \tag{35}$$

Because, in short channel MOSFETs, the condition (29) exists either in damaged or in non-damaged region. In Figure 3, higher values of threshold voltage have been observed in presence of negative interface trapped charges. This is because negative interface trapped charges lower the potential distribution in the damaged region. Thus more gate voltage is required to attain the inversion charge density Q_{th}.

4. CONCLUSION

For a DG MOSFET, with $L=30nm$, $t_{si}=10nm$, $t_{ox}=2nm$, in absence of any interface trapped charges ($N_{it}=0cm^{-2}$) the calculated value of threshold voltage is $V_{th}=0.3400V$. For $N_{it}=2\times10^{12}cm^{-2}$ with damaged length $Ld=10nm$, the threshold voltage has been found $V_{th}=0.3135V$. Threshold voltage has been decreased from $0.3400V$ to $0.3135V$ ($-0.0265V$) due to the presence of positive interface trapped charges. For $N_{it}=-2\times10^{12}cm^{-2}$ with damaged length $Ld=10nm$, the threshold voltage has been found $V_{th}=0.3970V$. In the presence of negative interface trapped charges threshold voltage has been increased from $0.3400V$ to $0.3970V$ $(0.057V)$. The plots obtained are found to be in close agreement with the simulation results given in [1].

5. ACKNOWLEDGEMENTS

This work was supported by DST SERB, Government of India, under Grant No. SB/FTP/ETA-268/2012.

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