Birla Institute of Technology and Science, Pilani

EEE G594, Advanced VLSI Devices

Mid Semester Examination, I Semester 2017-2018

OPEN BOOK

Time: 90 min.	Max. Marks=70	Date: 09-10-2016

[Given: ε_{Si} = 11.9, ε_{ox} = 3.9, ε_0 = 8.85×10^{-12} F/m, n_i(Si) = 1.5×10^{10} cm^{-3}, E_g(Si)=1.12 eV, q=1.6×10^{-19} C, k=1.38×10^{-23} m^{2}kgs^{-2}k^{-1}, T=300 K, μ_n=450 cm^2/V-s, μ_p=250 cm^2/V-s]

[1] Consider a n-channel n$^+$ poly-SiO$_2$-Si MOSFET with gate oxide thickness (t_{OX})=5 nm, channel length (L) = 0.6 μm and acceptor impurity (N_A)=2×10^{17} cm^{-3}. Calculate V_{Dsat} value with and without gradual channel approximation considering flat band voltage (V_{FB}) -1.1 V, V_{GS}=2 V and bulk to source voltage (V_{BS}) zero. Again calculate the V_{DSat} considering velocity saturation where saturated velocity of electron at room temperature (v_s) is 10^7 cm/s. **[14]**

[2] For a n-channel bulk MOSFET, t_{OX}=5 nm and N_A=2×10^{17} cm^{-3}. Also consider the threshold voltage (V_{T0}) of the device is 0.4 V, subthreshold slope 100 mV/decade and drain current 0.1 μA at V_{T0}. What is the subthreshold leakage current at V_{GS}=0 V? Also calculate the required additional back gate bias (substrate to source voltage) to reduce the leakage current by one order of magnitude. **[12]**

[3] For a short channel bulk n-MOSFET device t_{OX}=50 nm, N_A=2×10^{16} cm^{-3}, L =0.6 μm, source/drain junction depth (x_j)=1 μm, source/drain doping (N_D)=10^{17} cm^{-3}. Calculate minimum drain to source voltage (V_{DSPT}) when punch-through starts. Also, calculate the amount of DIBL using charge sharing model for V_D^{low}=0 V and V_{Supply}=V_{DSPT} (Consider, V_{FB}=-1.1 V and V_{BS}=0). **[20]**

[4] SOI device shown in the Fig. 1 having N_A=2×10^{17} cm^{-3} Q_f/q=5×10^{11} cm^{-2}.

   (a) Calculate threshold voltage when (i) t_{si}=50 nm and (ii) t_{si}=100 nm.
   (b) Also calculate subthreshold slope (s) for (i) t_{si}=50 nm and (ii) t_{si}=100 nm.
   (c) Consider, SOI device with t_{si}=100 nm: At, V_{GS}=1 V and V_{DS}=2 V, impact-ionization starts and silicon body potential increases to 0.5 V. What is the new value of threshold voltage (V_T) and what is the increment of drain current due to new V_T. (Consider, body factor n=1 and λ=0). **[24]**
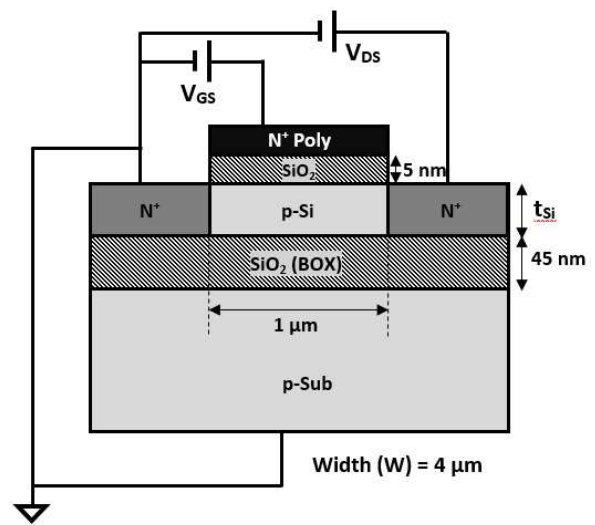

Fig. 1

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