
EE566 Solid State Devices

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Dept of Electrical Engineering

University of Notre Dame

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Assignment 9

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Due: 04/22/2005

Reading

Chapters 8 and 9 of Muller/Kamins/Chan (MKC).

Problem 1 (MOS Memory device)

MKC Problem 8.6.

Also, explain how this MOS capacitor can be used as a memory device.

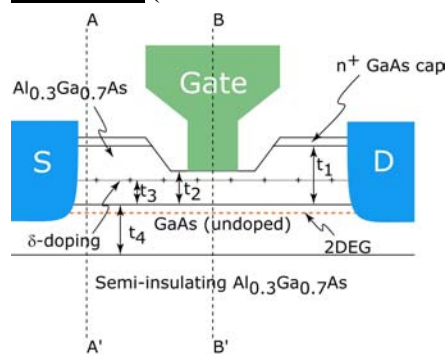
Problem 2 (Charge and band-bending in MOSFET)

- Calculate *exactly* the total charge Q_s stored near the surface of the semiconductor in a MOS capacitor as a function of the surface band-bending ϕ_{bs} with respect to the body of the semiconductor layer.
- Plot it in the form shown in Figure 8.8 in MKC, but as a sheet density (units cm^{-2}). Compare with the plot in figure in pg 139 in handouts.
- Draw the band-diagrams for each part of the plot.

Problem 3 (Hysteresis in MOS capacitance-voltage measurements)

Problem 8.14, MKC. Include the band-diagrams in each part of your table. Your solution to this problem will be helpful in the research of a graduate student of mine, who is observing large hysteresis in C-V plots in nanowire-based FETs.

Problem 4: (AlGaAs/GaAs HEMT charge control and transconductance)



Consider the AlGaAs/GaAs HEMT structure shown. The structure is grown by MBE, and the thickness and doping of the layers are - cap layer: $N_D=7*10^{17}/\text{cm}^3$, $t_{cap}=5\text{nm}$, $\text{Al}_{0.3}\text{Ga}_{0.7}\text{As}$ layer thickness $t_1=25\text{nm}$, after gate-recess etch, AlGaAs thickness $t_2=17\text{nm}$, delta-doped layer thickness= 1nm & effective 3D-doping= $3.5*10^{19}/\text{cm}^3$, $t_3=5\text{nm}$, and GaAs quantum well thickness $t_4=10\text{nm}$. Assume the surface barrier is pinned at $q\Phi_s=0.6\text{eV}$ below the conduction band edge for both GaAs and AlGaAs.

- Calculate the 2DEG sheet density in the GaAs QW below the gate. Draw the charge-field-band diagram along line B-B' for finding the sheet density. Verify your calculated value with 1D Poisson simulation of the charge-field-band diagram. Is there any quantum-confinement¹? How many quantum-confined states are formed in the GaAs QW? What are the eigenvalues?
- Calculate the 2DEG sheet density in the GaAs QW below the source-and drain-access regions. Draw the charge-field-band diagram along line A-A' for finding the sheet density. Verify your calculated value with 1D Poisson simulation of the charge-field-band diagram. Comment on quantum confinement and eigenvalues.
- What is the gate-capacitance C_g ? Assuming the HEMT to be a short-channel FET, calculate the transconductance g_m using GaAs material parameters. Calculate the threshold voltage V_{th} for the HEMT.
- Explain, using 2DEG-sheet density results of parts a) and b) and the transconductance of part c), what is gained by the gate-recess process. What would the transconductance be if the gate was not recessed?

¹ Run the "schrodingerstart", and "schrodingerstop" functions, and use the "*.status" file in 1-D Poisson.