Final Exam. of Semiconductor

July, 10th , 2008

1.open book, individual effort
2. 100minutes.
3. You have opt0inal problems for take home to submit
   to 301-1004 by 10am, Wednesday, 11st of June, 2008

1. MOS CV(quantum effect)

MOS capacitor is made with N+ polysilicon(Ef =Ec), Oxide with Tox, and p type silicon with the concentration of $N_{\#}$. The area of the gate is A.

Assume $\pm_{FP}$, $V\#_{FB}$ are known.

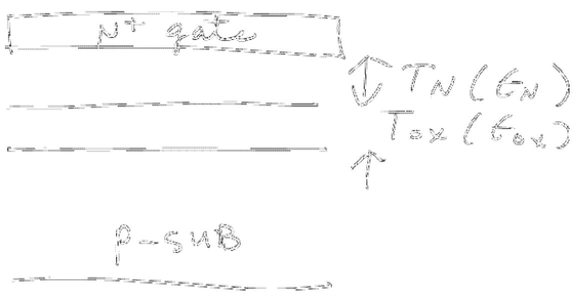
a) Represent the capacitance components of MOS capacitance in series connection.(here include the poly depletion effect)

b) Plot(qualitatively) the dependence of each component in a) as the function of VG.

c) Plot total gate capacitance $C\#_{G}$.

d) If you do not consider the quantum effects, what component in a) is most modified. Also, how is $C\#_{G}$ modified? Show in fig. in c).

2. Now the MOS Capacitor is modified as in the figure below.



a) Draw the energy band diagram in the depth direction when VG = VFB.

b) Write the MOS equation. (VG vs. $\pm_{\#}$ relation)

c) If interface charges(Q# C/cm²) are located at the oxide-nitride interface, what is the change in V#?

3.(MOS short channel effects)

You have built MOSFET out of the device in prob.1 above.
In the source region, there is the lateral field as shown in the following figure with the intensity of $-\frac{dE_y}{dy} = -\frac{2(V_{bi} - \Psi_s(0))}{L_{eff}^2}$ where V# is the built in potential between N+P junction(Source Drain junction) and ±#(0) is the surface potential at the source end of the channel.

a) Write the MOS equation at the source channel (VG vs. ±# relation) excluding the lateral field effect.
b) Do the same thing in a) including the lateral field effect.
c) Obtain the change in the threshold voltage between two cases.

4. (Optional: Take home examination)

Consider again the device(MOS capacitor) in the problem 1. Now you apply V# from 0V to V#DD(>V#) in the unit step function at t=0) and the 'steady state' is reached so that ±S=2± FP,n (electron quasi Fermi level). Here there is the tunneling current from the inversion layer electrons to the gate. Assume that I #unneling# (A) = f(Eox, Qn) is given.

a)Obtain the oxide field. Express the field intensity in terms of Tox, ±FP, etc.
b)Now obtain the thermal generation current in the depletion layer and neutral region.
c)Now write down the equation(current continuity) in the steady state and express the equation for Efn(electron quasi Fermi level).
d) Draw the energy band diagram in the steady state and indicate 'clearly' the electron and hole quasi Fermi levels.