ECE236C   Spring 2009
Homework Set #2

Handed out: Apr 14   Due: Apr 23

Problem 1

A FATFET has been constructed to characterize a given AlGaAs/GaAs HFET structure, with dimensions 100um channel length and 100um channel width. Capacitance vs gate voltage measurements are made with the source and drain grounded. Measurements are also made of the current flow for a 0.1V drain bias vs gate voltage (source is grounded). The data are represented by the following (sorry, you will have to enter this manually):

Vg (V)	Cg(pF)	Id (mA)
-1	14.58	0.0052
-0.9	20.83	0.0137
-0.8	24.01	0.0244
-0.7	25.65	0.0371
-0.6	26.6	0.0511
-0.5	27.31	0.067
-0.4	28.24	0.0843
-0.3	30.2	0.108
-0.2	33.97	0.125
0	43.53	0.154
0.1	48.3	0.141
0.2	53.54	0.168
0.3	59.87	0.158
0.4	68.27	0.164
0.5	80.8	0.131

From these results, determine Ns vs Vg. Determine also the effective mobility as a function of Ns. What is the likely structure of this HFET? Why does the mobility change as a function of bias?

Problem 2

In this problem you are asked to design the epitaxial layer structure for a pHEMT device based on a GaAs substrate, using InGaAs in the channel layer. Choose a barrier layer of AlGaAs with xAL=0.28eV (in order to avoid DX centers and minimize growth problems), with thickness 32nm, as in HW1. You may assign doping to the barrier layer however you like. Please use a Schottky barrier height of 1.0 eV (larger than for HW1; it is more realistic for a Schottky barrier on AlGaAs). Now determine a good choice for the thickness and In mol fraction for the channel layer. For the combination you choose, determine whether the critical thickness condition is violated! Then compute the maximum carrier density in the 2DEG that you can get without spillover of carriers into the "parallel MESFET" (by using the 1D Poisson-Schrodinger solver, and varying Vgs as needed). Try several choices of thickness and In fraction; what are the critical effects that govern your choices? Investigate whether quantum effects are important for the layer structure that you design (do they change Nsmax?).

Problem 3

Consider an AlGaN/GaN HFET employing a 250A thick barrier layer containing 30% Al, and a GaN layer as channel and buffer layer (which can be considered to be lightly doped p type, Na~1e15cm-3, for simplicity).

a) Determine the effective polarization charge that is present at the heterointerface. Include it in the 1D Poisson solver, distributed over 10A for simplicity. You may assume that the Schottky barrier height is 1.2eV, and that dEc at the heterointerface is 0.6eV.

b) Calculate the charge in the channel at Vg=0.

c) Use classical and the quantum mechanical solutions to determine the effective distribution of electrons in the channel region.

d) By varying the gate voltage, determine the electron fermi level vs sheet carrier density. Use these data to compute an effective distance from the charge distribution to the interface. Compare your results with your determination of part c.