ECE 6453 Spring 2008
Homework 4

Due Date: February 26, 2008 (Tuesday)

No late homework will be accepted

1.Take a step PN homojunction for an example,

a. Describe the assumptions you may need to make to derive the minority carrier concentration profile in the n-type QNR: $p_n(x_n)=(n_i^2/N_D)*\exp(-|x|/L_p) *\exp(qV_A/kT)$, where p_n is the hole concentration at the n-type QNR, n_i is the intrinsic carrier concentration, L_p is the hole diffusion length, N_D is the doping concentration of the n-type semiconductor, and the V_A is the applied voltage.

b. If there is a mid-gap trap (E_t = Eg/2) in the depletion with a trap density of N_t, find the current component induced by this trap under a reverse bias V_A. (Note: V_A is negative.)

2.A p^+-N heterojunction that is formed by a p-type $In_xGa_{1-x}As$ (x = 0.53, p= 2×10^{19} cm^{-3}) and an n-type InP (n = 10^{16} cm^{-3}) layer. Assume ΔE_C: ΔE_V=1:2 and long-diode approximation is valid.

a. At zero bias, using the depletion approximation approach (as described in section 2.1 of Liu's book), calculate (i) the depletion width on each side and (ii) the potential drop ϕ_{N0} and ϕ_{P0} in the InGaAs and InP layer, respectively.

b. Use the equation given in equation 2-29 of the Liu's book. Solve for ϕ_{N0} numerically and compare with the result obtained in (a)

c. Draw a band diagram of this heterojunction system at zero bias.

d. If a forward bias of 0.4 V is applied, what is the voltage drop at the n-type region? Draw a band diagram (drawn to scale if you may) to show this condition. Use solid circles for electrons and open circles for holes. Schematically describe the carrier transport phenomenon in this system.

e. If a reverse bias of -4 V is applied, repeat (d)

3.Borrow the same material systems from in problem 1. A P^+-n heterojunction is formed by p-type InP (p= 5×10^{18} cm^{-3}) and lattice-matched n-type InGaAs (n = 10^{16} cm^{-3}).

a. Calculate the depletion width on each side and draw a band diagram of this system.

b. If a forward bias of 0.4 V is applied to this system, use a corresponding band diagram to describe possible electron and hole transport mechanisms qualitatively.