ELEG 646; ELEG 446 - Nanoelectronic Device Principles – Spring 2005
Homework #7 - due Thursday, 28 April 2005, in class

1. Consider the thermionic emission model of a Schottky barrier diode, and use the standard I-V equation with ideality factor η. The measured forward current at 300 K is 3 x 10^{-8} A at 0.2 V and 1 x 10^{-6} A at 0.3 Volts. The diode area is 0.2 cm^2 and ϕ_B = 1V. Calculate the saturation current I_s, the ideality factor η, and the value of A* (Richardson constant).

2. Draw the energy band diagrams for an n-p-n transistor when it is biased in (a) the saturation region, and (b) the cutoff region.

3. Consider a p-n-p transistor biased in the normal active region of operation at room temperature. In this situation, both I_B and I_C flow out of the device. Now if I_C is held constant and the temperature is raised gradually, I_B will decrease and ultimately will flow into the Base terminal. Explain this behavior in terms of physical phenomena that occur in the device.

4. A symmetrical Ge p-n-p transistor with emitter-base and collector-base junctions, each 1 mm in diameter, has an impurity concentration of 5 x $10^{15}cm^{-3}$ in the base and $10^{18}cm^{-3}$ in the emitter and the collector. The base-width is 10 μm, τ_B = 4 x 10^{-6} sec, τ_E = 10^{-8} sec, and the emitter region is much longer than the diffusion length L_E. Calculate the current gains α and h_{FE} of the transistor. Take D_B = 47 cm^2 sec^{-1} and D_E = 52 $cm^2 sec^{-1}$.

5. A Si n-p-n transistor has the following parameters at 300 K: N_A = 5 x $10^{16}cm^{-3}$, $N_D(E)$ = 1 x $10^{18}cm^{-3}$, W_B = 2 μm, W_E = 0.2 μm, μ_B = 1000 cm^2 V^{-1} sec^{-1}, $\mu_p(E)$ = 150 cm^2 V^{-1} sec^{-1}, τ_B= 10^{-6} sec, and τ_E= 10^{-8} sec. The emitter-base junction area is 0.01 cm^2, I_E = 1 mA, and the collector-base junction is reverse biased by 2 V. Neglect carrier generation and recombination in the two junction depletion regions. (a) Calculate the emitter-base junction voltage and the excess electron concentration in the base at the edge of the emitter-base junction depletion region. (b) Calculate γ, α_T, and h_{FE} for the transistor.

Homework assignments will appear on the web at:
http://www.ece.udel.edu/~kolodzey/courses/eleg646s05.html
Note: On each homework and report submission, you must please give your name, the due date, assignment number and the course number.