ECSE-2210 Microelectronics Technology
Fall 2005
Class Activity 11

1. A Si step junction maintained at room temperature is doped such that $E_F = E_V$ on the p-side and $E_F = E_C - 4kT$ on the n-side.

   a. Draw the equilibrium energy band diagram for this junction.

   b. Determine the built-in voltage (V_{bi}). (Read-off from the diagram above)

2. An abrupt Si p-n junction has the doping concentrations as follows:

   P-side: $N_A = 1.5 \times 10^{17}$ cm^{-3}, and $N_D = 5 \times 10^{16}$ cm^{-3}.
   N-side: $N_A = 0$, and $N_D = 1 \times 10^{16}$ cm^{-3}.

   Calculate the position of the Fermi levels at 300 K, draw the equilibrium band diagram and find the built-in voltage, V_{bi}, from the diagram. Also, calculate the built-in voltage, V_{bi}, from equation 5.10. in the textbook

$$V_{bi} = \frac{kT}{q} \ln\left(\frac{N_A N_D}{n_i^2}\right)$$

3. Compare the contact potential V_{bi} of the Si device of Problem 2 with similarly doped GaAs device. GaAs has an n_{i} value of $1 \times 10^{6}\mathrm{cm}^{-3}$. What trend do you notice?

4. Can we measure this built-in voltage using a multi-meter? Explain.

5. Explain in your own words what is meant by the term “depletion layer or space charge layer"?

6. In a p-n junction, what prevents the complete recombination of holes in the p-side with the electrons from the n-side? In other words, why can’t the holes and electrons diffuse across the junction and make the concentration uniform throughout?

7. The p-n junction shown below is under thermal equilibrium. Qualitatively, mark the directions of hole currents (drift and diffusion) and electron currents (drift and diffusion). (Note: electron flux is opposite to electron current). Draw the length of the arrows to indicate the magnitude of the currents. Which will be larger? Hole currents or electron currents? No need to calculate anything.