ELEG 646; ELEG 446 - Nanoelectronic Device Principles – Spring 2011

Homework #8 - due Friday, 15 April 2011, in class

1. A. symmetrical abrupt Ge p-n junction has dopant concentrations of 10^{15} atoms cm^{-3} on both sides. Calculate the avalanche breakdown voltage if the maximum field at breakdown is 2.5 $x10^5$ V/cm. Hint: Careful to use Ge materials data rather than Si.

2. In the problem (1) above for Ge with doping impurity concentration $N_I = 10^{15} cm^{-3}$, compare your breakdown voltage with the value obtained by using the following universal (but approximate) expression breakdown voltage for materials with different bandgaps: $BV(volts) = 60(Eg/1.1)^{3/2} (N_I/10^{16})^{-3/4}$. Here E_g is in eV, and N_I is in cm^{-3}. Is this "universal" expression useful?

3. Problem 4.13 in chapter 4, Muller & Kamins, p. 224 in 3rd edition. Hint: In the discussion following Eq. 4.4.20, there is a discussion in the text of current (10 mA), atomic density (5E22 cm^{-3}), etc. Use the data and the equations in this section to determine the tunneling probability, then work back to find the L, and then the field, to show they are consistent with the L for tunneling, and a reasonable value for $\mathcal{E}_{crit}$.

4. The donor and acceptor concentrations on the n- and p-sides of a Si abrupt p-n junction are equal to 10^{16} cm^{-3}. The whole semiconductor is illuminated uniformly such that the hole concentration in the neutral n-region rises to 10^{13} cm^{-3}. No current is allowed to flow. What will be the reading of a voltmeter whose positive terminal is connected to the p-side at 290 K? (Hint: use law of the junction for $p_n(0)$).

5. A long-base Si abrupt p-n junction diode with a junction area of 10^{-2} cm^{-2} has uniform dopings N_D = 10^{18} cm^{-3}, $N_A = 10^{17}$ cm^{-3}, $\tau_p = 10^{-8}$ sec, $\tau_n = 10^{-6}$ sec, $D_p = 5.2$ cm^2 sec^{-1}, and $D_n = 20$ cm^2 sec^{-1}. Calculate the ***real*** diode current at room temperature (300 K) under a ***reverse*** bias of 5 V. Include the ideal diode reverse current and the generation-recombination current from within the depletion region. Assume a carrier lifetime parameter $\tau_o = 10^{-7}$ sec within the depletion region.

Homework assignments will appear on the web at:
http://www.ece.udel.edu/~kolodzey/courses/eleg646s11.html

Include your name, due date, assignment number, and course number on each submission.