

ELEG 646; ELEG 446 - Nanoelectronic Device Principles – Spring 2005
Homework #6 - due Thursday, 21 April 2005, in class

1. A symmetrical abrupt Ge p-n junction has an impurity concentration of 10^{15} atoms cm^{-3} on both sides. Calculate the avalanche breakdown voltage if the maximum field at breakdown is 2.5×10^5 V/cm. Calculate the breakdown voltage if the impurity concentration on the n-side remains the same, but on the p-side it becomes 10^{19} cm^{-3} .

2. Using the value of ionization coefficient $\alpha_i(E)$ of $1.8 \times 10^{-35} E^7 \text{ cm}^{-1}$ (where E is the electric field), use the avalanche breakdown integral condition (Eq. 4.4.9 in MKC text) to show that the avalanche breakdown voltage of an abrupt silicon p-n junction is given by: $V_B(\text{volts}) = 5.3 \times 10^{13} N_I^{-3/4}$. Here $N_I = N_A N_D / (N_A + N_D)$ is the effective doping concentration in a junction that is assumed to be equivalent to a one sided step junction so that the electric field is only on one side (from 0 to W).

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

4. A Schottky barrier diode is fabricated on n-type Si with $N_D = 1.5 \times 10^{15} \text{ cm}^{-3}$ by evaporating a metal with $q\Phi_M = 4.9$ eV. Neglecting the effect of interface states (assume an ideal non interacting picture), calculate the built in voltage, the barrier height and the depletion width at zero bias. Assume that $T = 300$ K.

5. Draw the thermal equilibrium energy band diagram of a metal p-type semiconductor system with $\Phi_M > \Phi_S$ and show that according to the non interacting Schottky picture that the contact should be Ohmic.

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.