EE_735 Assignment 3 (27/08/2019)

Use Newton-Raphson method to solve the poisson's equation for the given devices under thermal equilibrium condition. Use finite central difference scheme for numerical solutions.

The poisson's equation is

$$\frac{d^2V}{dx^2} = -\frac{\rho}{\varepsilon} \quad ; \quad \text{where } \rho = q \times (N_D^+ - N_A^- + p - n)\,;$$

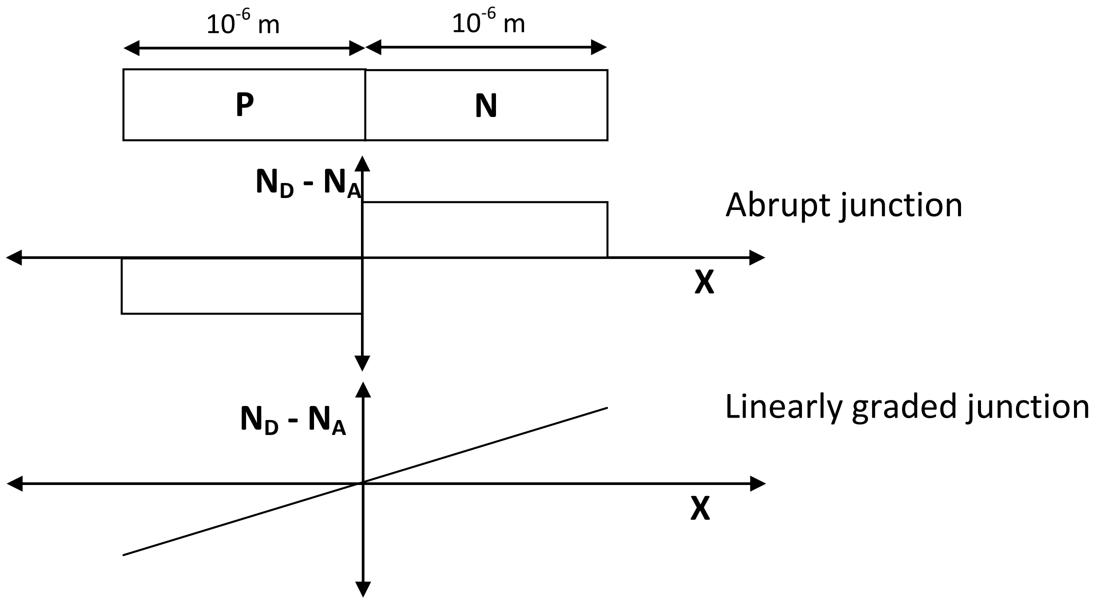
Use Maxwell-Bolzmann statistics for electron (*n*) and hole (*p*) concentrations. Consider complete ionization of donor (N_D) and acceptor (N_A) dopants. Use intrinsic carrier concentration $n_i = 1.45 \times 10^{10}\ /cm^3$, relative permittivity $\varepsilon_r = 12$, energy band gap $E_G = 1.12\ eV$ .Temperature is 300 kelvin.

Plot the following profiles as function of X (i.e. spatial variation) for all the questions:

a) Potential (V)
b) Electric field (E)
c) Charge concentration (ρ/q)
d) Electron (n) and hole (p) concentrations
e) Energy band diagram depicting conduction band minimum (E_C), valence band maximum (E_V), mid gap energy level (E_{mid}), fermi energy level E_F .

Q1.

A P-N junction diode with a) abrupt junction b) linearly graded junction. $N_D = N_A = 10^{16}\ /cm^3$.



Compare the V vs X graph with the one obtained in Assignment 2 using depletion approximation. Give a qualitative description of your observation.

Q2.

An N^+-N abrupt junction with doping concentrations 10^{17} /cm^3 and 10^{16} /cm^3 on the respective sides. Dimensions are same as in Q1 with P region replaced by N^+ region. Compare the E vs X profile with the one in Q1. Explain your observation.

Q3.

An N^+-P-N^+ structure with abrupt junctions. Doping in N^+ regions is $N_D = 10^{17}/cm^3$ and that in P region is $N_A = 10^{16}/cm^3$. Length of N^+ regions is 10^{-6} m each and that of P region is varied over the following range: (1, 0.9, 0.8, 0.7, 0.6) x 10^{-6} m. Show the variation of (V vs X) as function of P region length (L_P). Give a qualitative description of your observation.