EE 735: ASSIGNMENT 2 REPORT

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$$n_i^2 = N_c N_v \exp \left[\frac{-(E_c - E_{Fi})}{kT} \right] \cdot \exp \left[\frac{-(E_{FI} - E_v)}{kT} \right]$$

$$= N_c N_v \exp \left[\frac{-(E_c - E_v)}{kT} \right]$$

$$= N_c N_v \exp \left[\frac{-E_g}{kT} \right] \dots (7)$$

$$N_c \text{ and } N_v \text{ vary at } T^{3/2}$$

Using these formulae, we calculate $n_i = 1.3766*10^{10}$ cm $^{-3}$ Grid spacing is 1nm

Q1. ABRUPT

• This potential is called "built-in potential"

$$V_0 = V_T \ln \left(\frac{N_A N_D}{n_i^2} \right)$$

 V_T : thermal voltage (= 26 mV at room temp)

 N_A : acceptor concentration on p-side

 N_D : donor concentration on n-side

 n_i : intrinsic carrier concentration

$$x_p = \frac{N_D}{N_A + N_D} W, \qquad x_n = \frac{N_A}{N_A + N_D} W$$

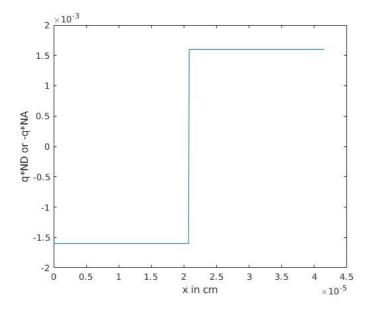
$$W = \sqrt{\frac{2e_S}{q} \left(\frac{1}{N_A} + \frac{1}{N_D}\right) V_0} \quad : \quad \text{Depletion Width}$$

$$\begin{split} &V_0 \text{ (the built in voltage)} = 0.6984 \ V \\ &using \ V_T = k_B T/q \ with \\ &k_B = 1.38*10^{-23} \\ &T = 300 K \\ &q = 1.6*10^{-19} \\ &N_D = 10^{16} \ cm^{-3} \ , \ N_A = 10^{16} \ cm^{-3} \end{split}$$

$$K_{Si} = 11.8$$

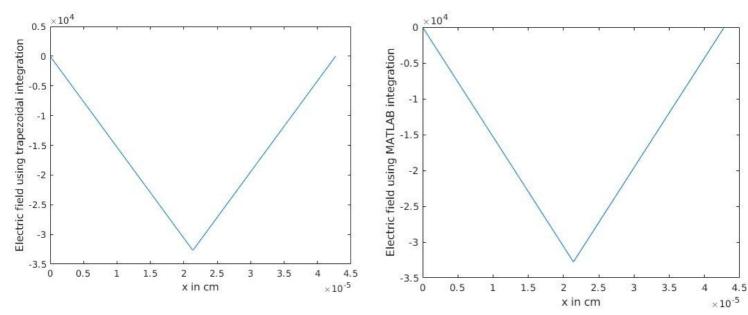
 $e_s = K_{si}*8.854*10^{-14}$
 $x_P = x_N = 214 \text{ nm}$

roh is as follows:



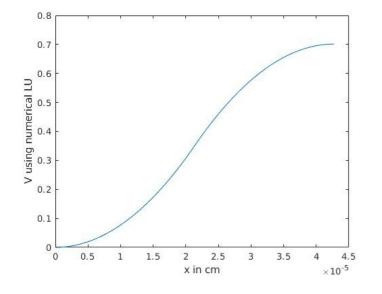
y-axis unit: C-cm⁻³

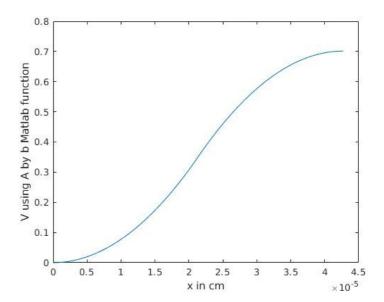




Numerical and MATLAB integration work similarly. At the rightmost edge, numerical integration shows a slight error by being non-zero. On changing grid spacing, this error reduces. (Note: Electric field is in Volt/cm)

Q1b)



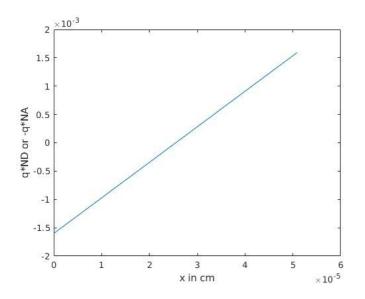


Using central difference discretization scheme, solved the Poisson equation with depletion approximation. We see that we get the correct built in potential. LU decomposition matrices obtained were nearly equal from numerical and MATLAB methods (Note: Potential is in Volts)

Q1. LINEAR

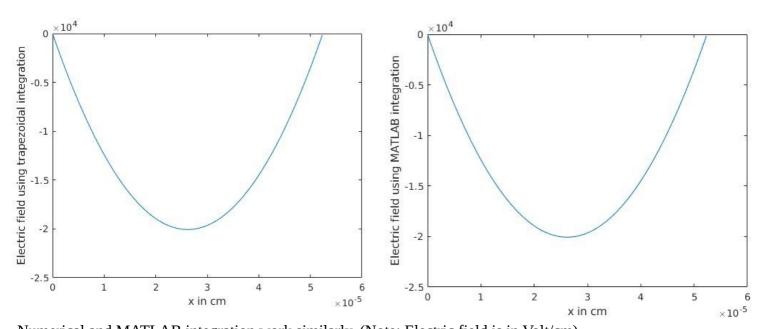
 $x_n = ((3*e_S/(q*(N_A+N_D)))*(2*k*T/q)*ln(0.5*(N_A+N_D)/n_i))^{0.5} \ for a linear graded system. Using the parameters as used in abrupt, we obtain <math display="block">x_P = x_N = 262 \ nm$

roh is as follows:



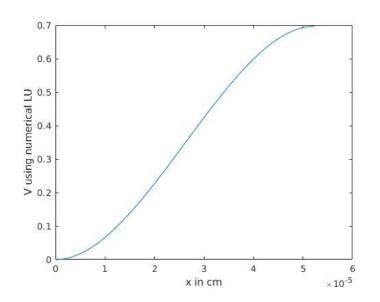
y-axis unit: C-cm⁻³

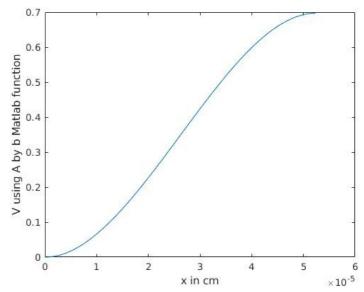
Q1a)



Numerical and MATLAB integration work similarly. (Note: Electric field is in Volt/cm)

Q1b)





Using central difference discretization scheme, solved the Poisson equation with depletion approximation. LU decomposition matrices obtained were nearly equal from numerical and MATLAB methods. (Note: Potential is in Volts)

The built in potential is given as

$$: 2 \ V_t \ln[\frac{ax_n}{n_i}]$$

where $V_T = k_B T/q$ and $a = (N_D + N_A)/(x_n + x_p) = N_D/x_n$ due to symmetry resulting in the same built in potential as the abrupt case.

Q2. Doping concentrations $N_D=10^{16}\, cm^{-3}$, $N_A=2*10^{15}\, cm^{-3}$. Used Newton Raphson method to solve the charge neutrality equation for finding the fermi energy E_F .

Taking E_V = 0; E_D = E_C – 0.045 eV; E_A = E_V + 0.045eV at 300K and solving the equation, we obtain E_F = 0.8895 eV