September 13, 2018 Thursday **EE735: Microelectronics Simulations Lab Assignment:#3** ***Vineesh A.S.V Roll No:173079020***

Q1.

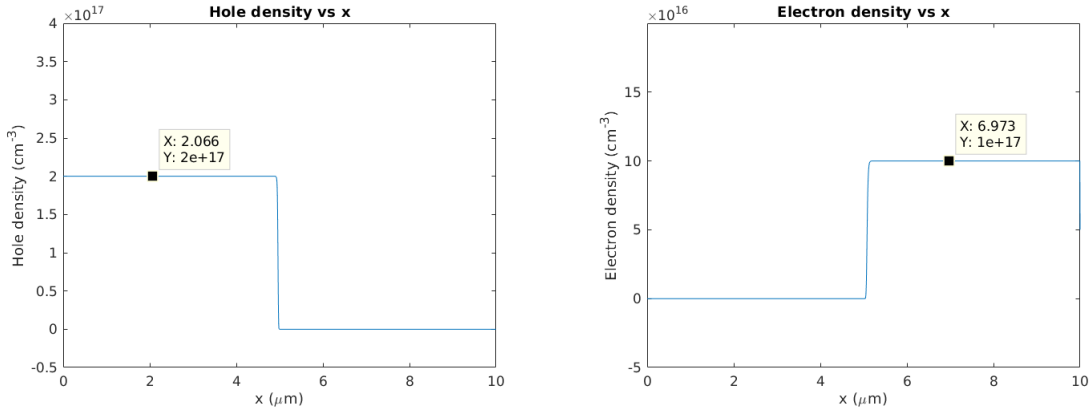

Figure 1: Electron and Hole densities

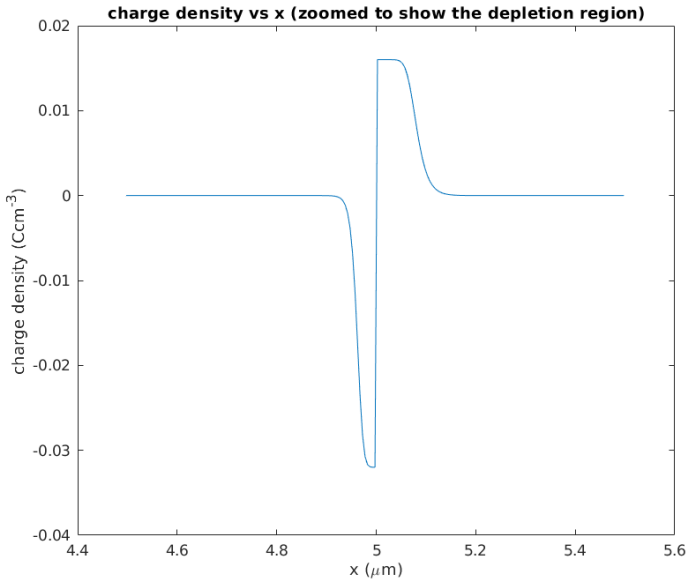

Figure 2: Charge density

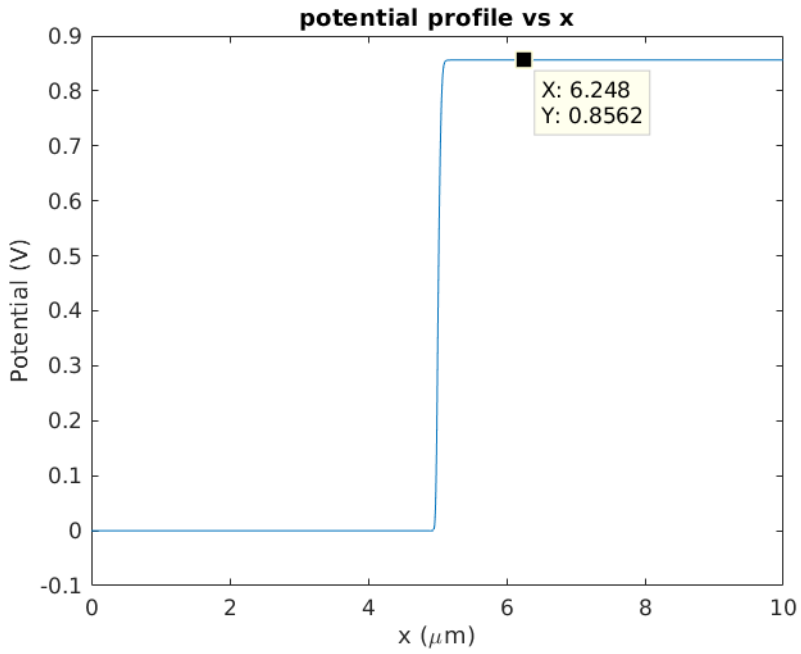

Figure 3: Potential Profile

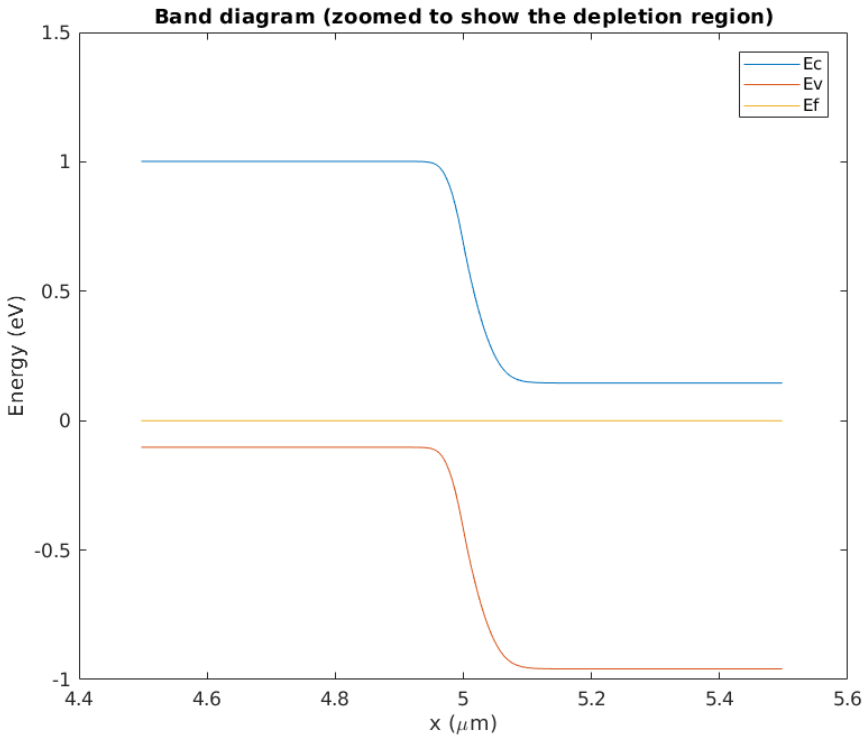

Figure 4: Band diagram

Analytical equation for built in potential is

$$\begin{aligned} V_{bi} &= V_t ln\left(\frac{N_A * N_D}{n_i^2}\right) \\ &= 0.8562\ V \end{aligned} \tag{1}$$

From Eq.1 and Fig.3, it is clear that the simulations and the anlytical results match.
Also, from Fig.2 we see that the depletion region in the p side x_n is smaller than that of the depletion region in the n side x_p, which is analytically expected since $N_A x_p = N_D x_n$
From Fig.1 we see that far away from the depletion region the electron and holes densities are equal to the doping densities which is consistent with the boundary conditions and analytical results.

Numerical Solution Procedure

Discrete form of poisson's equation is given by

$$\phi(i) = \frac{\phi(i+1) + \phi(i-1)}{2} + \frac{\rho(i)\Delta^2}{2\epsilon} \tag{2}$$

where $\phi(i)$ and $\rho(i)$ are the potential and charge density at point i respectively. Under equilibrium conditions the current density at every point is zero. Using this fact and applying Scharfetter-Gummel discretization scheme we get

$$n(i) = n(i-1)exp\left(\frac{\phi(i+1) - \phi(i-1)}{2V_t}\right) \tag{3}$$

$$p(i) = p(i-1)exp\left(\frac{\phi(i-1) - \phi(i+1)}{2V_t}\right) \tag{4}$$

Also,

$$\rho(i) = q(p(i) - n(i) + N_D(i) - N_A(i)) \tag{5}$$

By assuming some initial condition of ρ we solve Eq. 2 and find the values of ϕ for all grid points. Now using this value of ϕ we update the value of ρ, using Eqs. 3,4 and 5, which is in turn used to calculate the new value of ϕ in the next iteration. In each iteration the values of ρ and ϕ are updated and the iterations stop when the values are within a desired error tolerance.