VE320 Introduction of Semiconductor Device
Homework 5
Due Date: July 11

5.1 An abrupt silicon pn junction at zero bias has dopant concentrations of $N_a = 10^{17}$ cm^{-3} and $N_d = 5*10^{15}$ cm^{-3}. T = 300 K.
(a) Calculate the Fermi level on each side of the junction with respect to the intrinsic Fermi level.
(*b*) Sketch the equilibrium energy-band diagram for the junction and determine V_{bi} from the diagram and the results of part (*a*).
(*c*) Calculate V_{bi} using Equation (7.10), and compare the results to part (*b*).
(*d*) Determine x_n, x_p, and the peak electric field for this junction

5.2 A silicon pn junction in thermal equilibrium at T =300 K is doped such that $E_F - E_{Fi} = 0.365$ eV in the n region and $E_{Fi} - E_F = 0.330$ eV in the p region.
(*a*) Sketch the energy-band diagram for the pn junction.
(*b*) Find the impurity doping concentration in each region.
(*c*) Determine V_{bi}.

5.3 (*a*) Consider a uniformly doped silicon pn junction at T = 300 K. At zero bias, 25 percent of the total space charge region is in the n-region. The built-in potential barrier is $V_{bi} = 0.710$ V. Determine (*i*) N_a, (*ii*) N_d, (*iii*) x_n, (*iv*) x_p, and (*v*) E_{max}.

5.4 An "isotype" step junction is one in which the same impurity type doping changes from one concentration value to another value. An n-n isotype doping profile is shown in Figure 1. (*a*) Sketch the thermal equilibrium energy-band diagram of the isotype junction. (*b*) Using the energy-band diagram, determine the built-in potential barrier. (*c*) Discuss the charge distribution through the junction

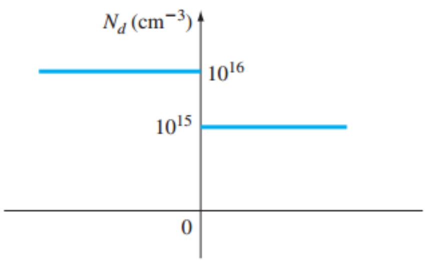

Figure 1

5.5 An abrupt silicon pn junction at T = 300 K has impurity doping concentrations of $Na = 5*10^{16}$ cm^{-3} and $N_d = 10^{15}$ cm^{-3}. Calculate (*a*) V_{bi}, (*b*) W at (*i*) $V_R = 0$ and (*ii*) $V_R = 5$ V, and (*c*) $|E_{max}|$ at (*i*) $V_R = 0$ and (*ii*) $V_R = 5$V.

5.6 An ideal one-sided silicon p^+n junction at T = 300 K is uniformly doped on both sides of the metallurgical junction. It is found that the doping relation is $N_a = 80N_d$ and the built-in potential barrier is V_{bi} = 0.740 V. A reverse-biased voltage of V_R = 10 V is applied. Determine (a) N_a, N_d , (b) x_p, x_n, (c) $|E_{max}|$, and (d)C_j'.

5.7 Consider a silicon pn junction with the doping profile shown in Figure 2. T = 300 K. (a) Calculate the applied reverse-biased voltage required so that the space charge region extends entirely through the p region. (b) Determine the space charge width into the n^+ region with the reverse-biased voltage calculated in part (a). (c) Calculate the peak electric field for this applied voltage.(You can ignore the influence of p^+)

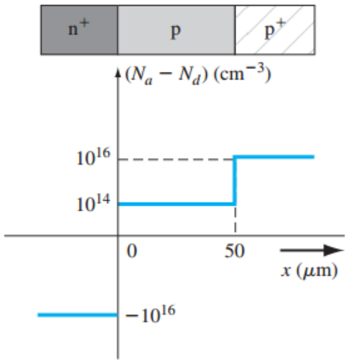

Figure 2