EE 471: Transport Phenomena in Solid State Devices

HW 3

Due: 2/23/18

Please show all working (including equations you use to calculate your answers).

All numerical answers should include units

Calculate numerical answers to 3 sig. figs.

1. Consider a silicon PN junction diode with $N_A = 3.5 \times 10^{16}\ cm^{-3}$ and $N_D = 5.5 \times 10^{16}\ cm^{-3}$ and a cross-sectional area of $40\mu m \times 60\mu m$ at 300°K.
   Assume also that:

   Distance from N-side contact to depletion layer edge $= 50\mu m$
   Distance from P-side contact to depletion layer edge $= 50\mu m$
   Electron minority carrier lifetime $\tau_n = 6 \times 10^{-7}\ s$
   Hole minority carrier lifetime $\tau_p = 1 \times 10^{-6}\ s$
   Electron mobility $\mu_n = 1300\ cm^2/V.s$
   Hole mobility $\mu_p = 430\ cm^2/V.s$

   a. What is the built-in potential $\emptyset_{bi}$? *(3 points)*

   b. Calculate the depletion layer width W_{dep} at zero bias and its length on the N side x_n and on the P side x_p *(5 points)*

   c. If the diode is now reverse biased with $V_R = 4V$, what will be the new depletion width W_{dep} ? *(2 points)*

   d. What will be the capacitance under these reverse bias conditions? *(3 points)*

   e. What will be the maximum electric field under these reverse bias conditions? *(3 points)*

   f. What will be the (ideal) reverse current under these reverse bias conditions? *(4 points)*

2. This same diode (as in Problem 1) is now forward biased and the forward current is measured at 2.5 mA. (If you did not get a reasonable answer for 1(f), use I_0 = 0.1 fA in this problem)
   a. What is the forward bias on the diode? *(5 points)*
   b. What is the concentration of <u>excess</u> minority electrons in the P region at the depletion region boundary under these conditions? *(4 points)*
   c. What is the concentration of <u>excess</u> majority holes in the P region at the depletion region boundary? *(3 points)*
   d. What is the resistivity of the N type silicon in the neutral region? *(3 points)*

e. What will be the voltage drop across the N neutral region under these forward bias conditions? Was it reasonable to ignore this drop when calculating the forward bias on the diode? *(3 extra credit points)*