

ECE 221A Winter 2009
Homework 2
Due: Thursday February 5, 2009

- I. PN Junctions
- a. 4.19
 - b. 4.20
 - c. 4.22
 - d. 4.28

Problem 4.19 When we derived the law of the junction, we assumed that the electron and hole quasi-fermi levels were constant across the depletion region. Inherent in this assumption is another assumption, that the electron and hole mobilities are high enough that most reasonable current densities can be provided by a minimum change in the quasi-fermi level across the depletion edge, or ΔE_{Fn} is small. $J_n = q\mu_n n \frac{\Delta E_{Fn}}{\Delta x}$. What if this were not true and I had a p-n junction made of a semiconductor where the hole mobility was very low? Assuming no recombination in the junction calculate and plot the hole concentration at the edge of the depletion region as a function of bias for $\mu_p = 10 \frac{cm^2}{Vs}$ and compare to the value obtained from the law of the junction. State your assumptions.

Problem 4.20 Consider the GaAs diode shown in figure 4.36, where the n-type region has a small width $W_N \ll L_P$ while the p-region is thick.

1. Plot the minority and majority carrier and currents distributions in the n and p regions of this diode.
2. Now the diode is illuminated leading to an optical generation of $10^{20} cm^{-3}s^{-1}$. Plot the carrier distributions and currents in the n and p regions. Calculate the current in the diode under forward bias and reverse bias voltages of 0.5 V and -1 V respectively. Both sides are doped at $10^{17} cm^{-3}$. Assume that there are ohmic contacts on both sides, and that they have infinite recombination velocities.

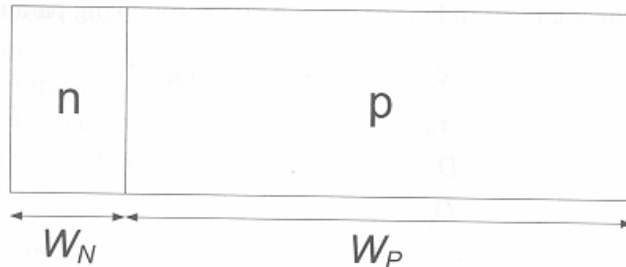


Figure 4.36: Figure for problem 4.20.

Problem 4.22 Consider a GaAs p - n diode with $N_a = 10^{17} \text{ cm}^{-3}$, $N_d = 10^{17} \text{ cm}^{-3}$. The diode area is 10^{-3} cm^2 and the minority carrier mobilities are (at 300 K) $\mu_n = 3000 \text{ cm}^2/\text{V}\cdot\text{s}$; $\mu_p = 200 \text{ cm}^2/\text{V}\cdot\text{s}$. The electron-hole recombination times are 10^{-8} s ($\tau_p = \tau_n = \tau$). Calculate the diode current at a reverse bias of 5 V. Plot the diode forward-bias current including generation-recombination current between 0.1 V and 1.0 V.

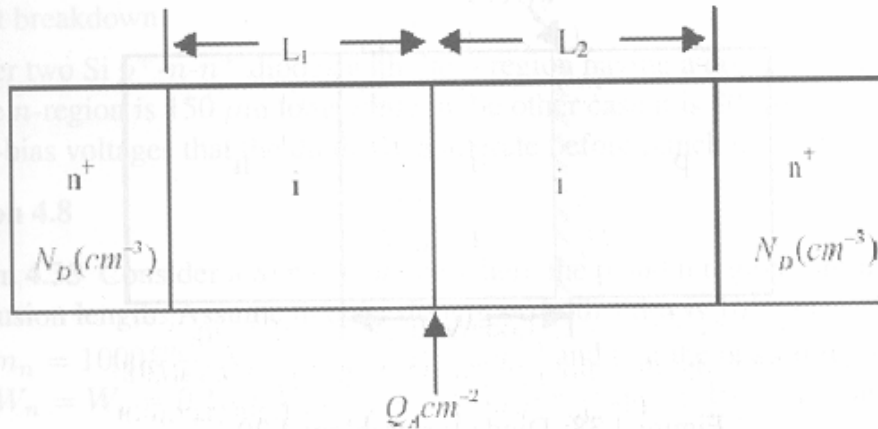


Figure 4.37: Diode for problem 4.28.

Problem 4.28 Consider the diode in figure 4.37. A sheet of acceptors of areal density Q_A is placed in an intrinsic region of GaAs such that it is at a distance L_1 from one n^+ region and L_2 from another.

- Calculate an expression for the potential across the structure in terms of Q_A , L_1 , L_2 , N_D and other material parameters of GaAs.
- Sketch the band diagram for the case where $L_1 = 0.1 \mu\text{m}$, $L_2 = 0.2 \mu\text{m}$, $Q_A = 5 \times 10^{11} \text{ cm}^{-2}$ and $N_D = N_C$. What will the turn-on voltage of the diode be in each direction?
- Calculate the maximum value of Q_A , $Q_{A,MAX}$ that gives the highest turn-on voltage in each direction/polarity.
- If I now set $Q_A = 2Q_{A,MAX}$, what will the turn-on voltage of the diode be? Explain what happens.