VE311 Electronic Circuits

Homework 02

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The course homework is intended for the students to learn and to think rather that just copy and paste. This is why, me and my TAs team are confident that you're going to learn.

- Based on the set of equations provided by the lecture as well as the info in the book, please solve the follow set of problems.

  1. Pure aluminum has a resistivity of $2.83 \times 10^{-6} \Omega$cm. Based on its resistivity, should aluminum be classified as an insulator, semiconductor, or conductor?
  2. The maximum drift velocities of electrons and holes in silicon are approximately 10^7 cm/s. What are the electron and hole current densities if n = 10^{18}/cm^3 and p = 10^2 /cm^3? What is the total current density (J)?
  3. Calculate the intrinsic carrier densities in silicon and germanium at (a) 77 K, (b) 300 K, and (c) 500 K. Use the information according to Figure 1:

	B ($K^{-3} \cdot cm^{-6}$)	E_G (eV)
Si	1.08×10^{31}	1.12
Ge	2.31×10^{30}	0.66
GaAs	1.27×10^{29}	1.42

Figure 1: Intrinsec carrier densities for several materials

  4. At what temperature will intrinsic silicon become an insulator, based on the definitions in Figure 2? Assume that $\mu_n = 2000$ cm^2 /V·s and μ_p=750 cm^2/Vs.

TABLE **2.1**
Electrical Classification of Solid Materials

MATERIALS	RESISTIVITY (! · cm)
Insulators	$10^5 < \rho$
Semiconductors	$10^{-3} < \rho < 10^5$
Conductors	$\rho < 10^{-3}$

Figure 2: Material properties for some materials

5. Suppose a semiconductor has $N_D = 10^{16}$ /cm^3 , $N_A = 5\times10^{16}$/cm^3, and ni = 10^{11}/cm^3. What are the electron and hole concentrations?

6. InP is composed of equal atoms of indium and phosphorus in a lattice similar to that of silicon. (a) Suppose a germanium atom replaces an indium atom in the lattice. Do you expect the germanium atom to behave as a donor or acceptor impurity? Why? (b) Suppose a germanium atom replaces a phosphorus atom in the lattice. Do you expect the germanium atom to behave as a donor or acceptor impurity? Explain.

7. Silicon is doped with 10^{16} boron atoms/cm^3. How many boron atoms will be in a silicon region that is 0.5 μm long, 5 μm wide and 0.5 μm deep?

8. It is conceptually possible to produce extrinsic silicon with a higher resistivity than that of intrinsic silicon. How would this occur?

9. Make a table of the values of thermal voltage V_T forT = 50 K,75 K,100 K,150 K,200 K,250 K, 300 K, 350 K, and 400 K.

10. The electron concentration in a region of silicon is shown in Fig. 3. If the electron mobility is 350 cm^2/V $\cdot$ s and the width W_B = 0.5 μm, determine the electron diffusion current density. Assume room temperature.

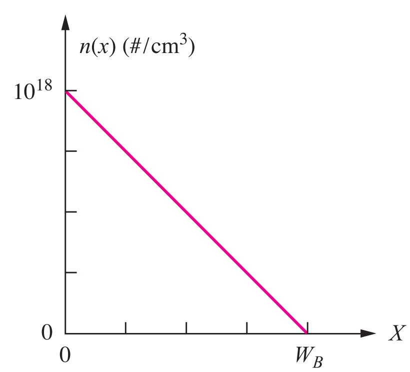

Figure P2.49

Figure 3: Electron density movement ish

11. Figure 4 gives the electron and hole concentrations in a 2-μm-wide region of silicon. In addition, there is a constant electric field of 20 V/cm present in the sample. What is the total current density at x = 0? What are the individual drift and diffusion components of the hole and electron current densities at x = 1.0 μm?
Assume that the electron and hole mobilities are 350 and 150 cm^2/V $\cdot$ s, respectively.

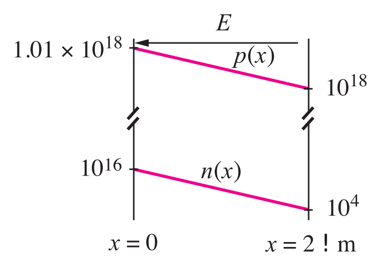

Figure 4: Electron density movement ish