Department of ECE, Bennett University

EECE105L: Fundamentals of Electrical and Electronics Engineering

Tutorial Sheet-12

Topics Covered: Introduction to semiconductor devices

Material Constants of Si: $n_i = 1.5 \times 10^{10}$ cm^{-3}, $\mu_n = 1500$ cm^{2}V^{-1}s^{-1}, $\mu_p = 500$ cm^{2}V^{-1}s^{-1}. $E_G = 1.12$ eV.

Universal Constants: Unit charge (q) = 1.6×10^{-19} C, Boltzmann constant (k) = 1.38×10^{-23} JK^{-1}.

1. A piece of silicon has doping concentration $N_D = 10^{16}$ cm^{-3}. Answer the following questions.
   i) Draw band diagram by showing various energy levels.
   ii) Find conductivity and resistivity.

   Hint: conductivity is given by $\sigma = q(n\mu_n + p\mu_p)$, where n and p are electron and hole concentrations respectively and μ_n and μ_p are electron and hole mobility respectively. Resistivity is inverse of conductivity.
   iii) Find the difference between Fermi level and valance band.
   iv) Find the electron density.
2. In a piece of silicon semiconductor, Fermi level lies 0.7 eV away from the conduction band. Answer the following questions.
   i) Find electron density and hole density.
   ii) Find conductivity and resistivity.
   iii) Draw the energy band diagram.
3. Find the built-in potential of a PN junction diode having n-side and p-side doping concentrations at 10^{16} cm^{-3} and 10^{17} cm^{-3} respectively. What is the charge density in the respective sides of depletion region?
4. A p-type silicon bar having a resistivity of 0.25 Ω·cm and an n-type silicon bar having a resistivity of 0.1 Ω·cm are used to from a PN Junction. Answer the following questions.
   i) Find majority carrier concentration and minority carrier concentration on each side of the junction.
   ii) What is the built-in potential of the diode?
5. The reverse saturation current for a set of diodes varies between $5 \times 10^{-14} \leq I_O \leq 5 \times 10^{-12}$ A. The diodes are all to be biased at 2 mA. What is the range of forward voltages that must be applied?
6. A PN junction diode having reverse saturation current of 10^{-11} A is forward biased so that the current through the diode is 150 μA. Find the diode voltage.
7. At what reverse bias voltage does the reverse bias current in a PN Junction reaches 90% of its reverse saturation current?
8. What is the ratio of the current for a forward-bias voltage of 0.2 V to the current for a reverse-bias voltage of 0.2 V?

9. A PN junction diode is in series with a 100 kΩ resistor and 3.5 V supply. If the diode is forward biased, determine the current through the diode and voltage across the diode. Given that the reverse saturation voltage is 5 nA and built-in voltage of diode is 0.6 V.

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