EE303 - Problem Set

Problem 1

A silicon wafer is doped with donors at a concentration of $N_D=10^{15}$ cm^{-3}

(a) What is the electron concentration n_o (cm^{-3}) at room temperature?

(b) What is the holes concentration p_o (cm^{-3}) at room temperature?

Problem 2

Calculate the drift current density for a given semiconductor. Consider silicon at T = 300 °K doped with arsenic atoms at a concentration of $N_D=8\times10^{15}$ cm^{-3}. Assume mobility values of μ_n = 1350 cm^2/(Vs) and μ_p = 480 cm^2/(Vs). Assume the applied electric field is 100 V/cm.

Problem 3

Calculate the diffusion current density for a given semiconductor. Consider silicon at T = 300 °K. Assume the electron concentration varies linearly from $n=10^{12}$ cm^{-3} to $n=10^{16}$ cm^{-3} over the distance from x=0 to x=3μm. Assume D_n=35 cm^2/s

Problem 4

Given a silicon wafer doped with donors with $N_D=7.5\times10^{17}$ cm^{-3} we add an acceptor concentration of $N_A=5.5\times10^{17}$ to a particular region.

(a) What type is the region (n or p)?

(b) What is the electron concentration n_o (cm^{-3}) in the region?

(c) What is the hole concentration p_o (cm^{-3}) in the region?

Problem 5

Find the resistivity of (a) intrinsic silicon and (b) *p*-type silicon with $N_A = 10^{16}/\text{cm}^3$. Use $n_i = 1.5\times10^{10}/\text{cm}^3$, and assume that for intrinsic silicon $\mu_n = 1350\ \text{cm}^2/\text{V}\cdot\text{s}$ and $\mu_p = 480\ \text{cm}^2/\text{V}\cdot\text{s}$, and for the doped silicon $\mu_n = 1110\ \text{cm}^2/\text{V}\cdot\text{s}$ and $\mu_p = 400\ \text{cm}^2/\text{V}\cdot\text{s}$. (Note that doping results in reduced carrier mobilities).

Problem 6

A uniform bar of *n*-type silicon of 2 μm length has a voltage of 1 V applied across it. If $N_D = 10^{16}/\text{cm}^3$ and $\mu_n = 1350\ \text{cm}^2/\text{V}\cdot\text{s}$, find (a) the electron drift velocity, (b) the time it takes an electron to cross the 2-μm length, (c) the drift-current density, and (d) the drift current in the case the silicon bar has a cross sectional area of 0.25 μm^2.

Problem 7

A silicon diode said to be a 1-mA device displays a forward voltage of 0.7 V at a current of 1 mA. Evaluate the junction scaling constant I_S. What scaling constants would apply for a 1-A diode of the same manufacture that conducts 1 A at 0.7 V?

Problem 8

For the circuits shown in Fig. P4.2 using ideal diodes, find the values of the voltages and currents indicated.

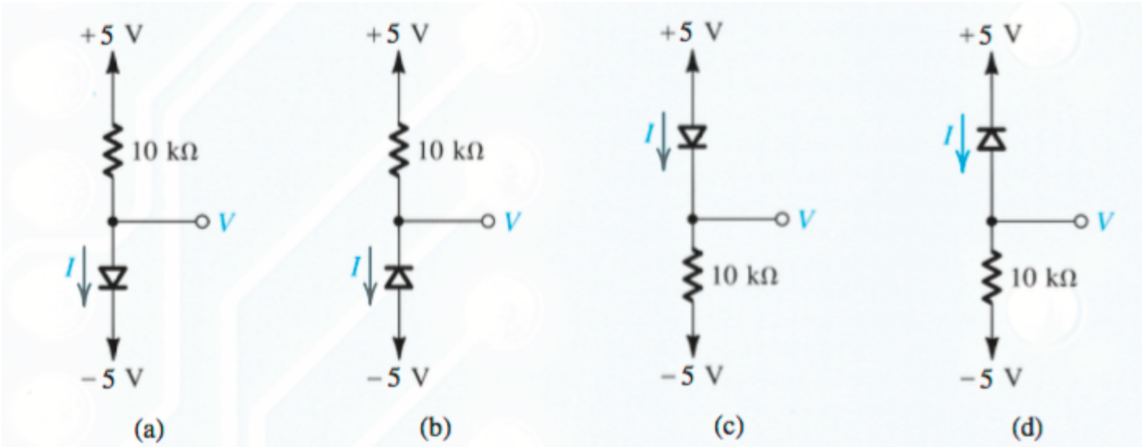

Figure P4.2

Problem 9

The diode in the circuit of Fig. E4.9 is a large high-current device whose reverse leakage is reasonably independent of voltage. If $V = 1$ V at 20°C, find the value of V at 40°C and at 0°C.

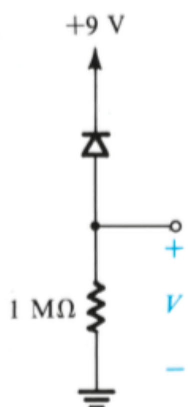

Figure E4.9

Problem 10

Find the change in diode voltage if the current changes from 0.1 mA to 10 mA.

Problem 11

A silicon junction diode has $v = 0.7$ V at i = 1 mA. Find the voltage drop at i = 0.1 mA and i = 10 mA.

Problem 12

Using the fact that a silicon diode has $I_S = 10^{-14}$ A at 25°C and that I_S increases by 15% per °C rise in temperature, find the value of I_S at 125°C.