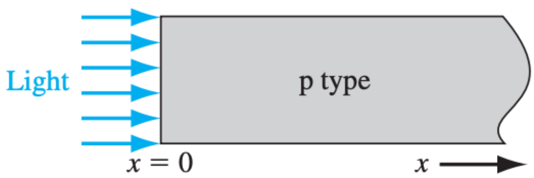
VE320 Homework Five

Due: 2021/6/23 23:59

1. (a) A sample of semiconductor has a cross-sectional area of $1\ \mathrm{cm}^2$ and a thickness of $0.1\ \mathrm{cm}$. Determine the number of electron-hole pairs that are generated per unit volume per unit time by the uniform absorption of 1 watt of light at a wavelength of $6300 Å$. Assume each photon creates one electron-hole pair. (b) If the excess minority carrier lifetime is $10 \mu s$, what is the steady-state excess carrier concentration?

2. Consider a silicon sample at $T = 300\ \mathrm{K}$ that is uniformly doped with acceptor impurity atoms at a concentration of $N_a = 10^{16}\ \mathrm{cm}^{-3}$. At $t = 0$, a light source is turned on generating excess carriers uniformly throughout the sample at a rate of $g' = 8 \times\ 10^{20}\ \mathrm{cm}^{-3}\ \mathrm{s}^{-1}$. Assume the minority carrier lifetime is $\tau_{n0} = 5 \times 10^{-7}\ \mathrm{s}$, and assume mobility values of $\mu_n = 900\ \mathrm{cm}^2/\mathrm{V}\cdot\mathrm{s}$ and $\mu_p = 380\ \mathrm{cm}^2/\mathrm{V}\cdot\mathrm{s}$. (a) Determine the conductivity of the silicon as a function of time for $t \geq 0$. (b) What is the value of conductivity at (i) $t = 0$ and (ii) $t = \infty$?

3. Consider a bar of p-type silicon that is uniformly doped to a value of $N_a = 2 \times 10^{16}\ \mathrm{cm}^{-3}$ at $T = 300\ \mathrm{K}$. The applied electric field is zero. A light source is incident on the end of the semiconductor as shown in Figure below. The steady-state concentration of excess carriers generated at $x = 0$ is $\delta p(0) = \delta n(0) = 2 \times 10^{14}\ \mathrm{cm}^{-3}$. Assume the following parameters: $\mu_n = 1200\ \mathrm{cm}^2/\mathrm{V}\cdot\mathrm{s}$, $\mu_p = 400\ \mathrm{cm}^2/\mathrm{V}\cdot\mathrm{s}$, $\tau_{n0} = 10^{-6}\ \mathrm{s}$, and $\tau_{p0} = 5 \times 10^{-7}\ \mathrm{s}$ Neglecting surface effects, (a) determine the steady-state excess electron and hole concentrations as a function of distance into the semiconductor, and (b) calculate the steady-state electron and hole diffusion current densities as a function of distance into the semiconductor.



4. The $x = 0$ end of an $N_a = 1 \times 10^{14}\ \mathrm{cm}^{-3}$ doped semi-infinite $(x \geq 0)$ bar of silicon maintained at $T = 300\ \mathrm{K}$ is attached to a "minority carrier digester" which makes $n_p = 0$ at $x = 0$ $(n_p$ is the minority carrier electron concentration in a p-type semiconductor). The electric field is zero. (a) Determine the thermal-equilibrium values of n_{p0} and p_{p0}.
(b) What is the excess minority carrier concentration at $x = 0$? (c) Derive the expression for the steady-state excess minority carrier concentration as a function of x.

5. An n-type silicon semiconductor, doped at $N_d = 4 \times 10^{16}\ \mathrm{cm}^{-3}$, is steadily illuminated such that $g' = 2 \times 10^{21}\ \mathrm{cm}^{-3}\ \mathrm{s}^{-1}$. Assume $\tau_{n0} = 10^{-6}\ \mathrm{s}$ and $\tau_{p0} = 5 \times 10^{-7}\ \mathrm{s}$.
(a) Determine the thermal-equilibrium value of $E_F - E_{Fi}$. (b) Calculate the quasi-Fermi

levels for electrons and holes with respect to E_{Fi}. (c) What is the difference (in eV) between E_{Fn} and E_F ?

6. Consider an n-type semiconductor as shown in Figure below, doped at $N_d = 10^{16}\ \mathrm{cm}^{-3}$ and with a uniform excess carrier generation rate equal to $g' = 10^{21}\ \mathrm{cm}^{-3} \cdot \mathrm{s}^{-1}$. Assume that $D_p = 10\ \mathrm{cm}^2/\mathrm{s}$ and $\tau_{p0} = 10^{-7}$ s. The electric field is zero. (a) Determine the steady-state excess minority carrier concentration versus x if the surface recombination velocity at $x = 0$ is $(i) s = 0$, $(ii) s = 2000\ \mathrm{cm/s}$, and $(iii) s = \infty$. (b) Calculate the excess minority carrier concentration at $x = 0$ for $(i) s = 0$, $(ii) s = 2000\ \mathrm{cm/s}$ and $(iii) s = \infty$.