VE320 Homework 5

Due: June 21, 2019, 10:00am

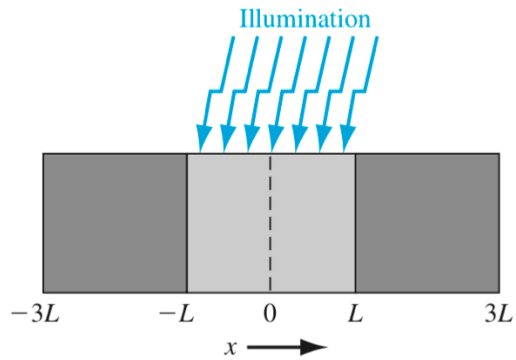
1. Consider a silicon sample at $T = 300K$ that is uniformly doped with acceptor impurity atoms at a concentration of $N_a = 10^{16} cm^{-3}$. At $t = 0$, a light source is turned on generating excess carriers uniformly throughout the sample at a rate of $g' = 8 \times 10^{20} cm^{-3} s^{-1}$. Assume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

2. A bar of silicon at $T = 300K$ has a length of $L = 0.05cm$ and a cross-sectional area of $A = 10^{-5} cm^2$. The semiconductor is uniformly doped with $N_d = 8 \times 10^{15} cm^{-3}$ and $N_a = 2 \times 10^{15} cm^{-3}$. A voltage of 10V is applied across the length of the material. For $t < 0$, the semiconductor has been uniformly illuminated with light, producing an excess carrier generation rate of $g' = 8 \times 10^{20} cm^{-3} s^{-1}$. The minority carrier lifetime is $\tau_{p0} = 5 \times 10^{-7} s$. At $t = 0$, the light source is turned off.
   Determine the current in the semiconductor as a function of time for $t \geq 0$.

3. A semiconductor is uniformly doped with $10^{17} cm^{-3}$ acceptor atoms and has the following properties: $D_n = 27 cm^2/s$, $D_p = 12 cm^2/s$, $\tau_{n0} = 5 \times 10^{-7} s$, and $\tau_{p0} = 10^{-7} s$. An external source has been turned on for $t < 0$ producing a uniform concentration of excess carriers at a generation rate of $g' = 10^{21} cm^{-3} s^{-1}$. The source turns off at time $t = 0$ and back on at time $t = 2 \times 10^{-6} s$.
   (a) Derive the expressions for the excess carrier concentration as a function of time for $0 \leq t \leq \infty$.
   (b) Determine the value of excess carrier concentration at (i) $t = 0$, (ii) $t = 2 \times 10^{-6} s$, and (iii) $t = \infty$.
   (c) Plot the excess carrier concentration as a function of time.

4. The $x = 0$ end of an $N_a = 10^{14} cm^{-3}$ doped semi-infinite ($x \geq 0$) bar of silicon maintained at $T = 300K$ 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. Consider the n-type semiconductor shown below. Illumination produces a constant excess carrier generation rate, G'_0, in the region $-L < x < +L$. Assume that the minority carrier lifetime is infinite and assume that the excess minority carrier hole concentration is zero at $x = -3L$ and at $x = +3L$.
   Find the steady-state excess carrier concentration versus x, for the case of low injection and for zero applied electric field.


Illumination
−3L
−L
0
L
3L
x