EEE 352A, Properties of Electronic Materials, Spring 2007

Homework 12

Due: Friday, April 27, in class

1. (20 points) Consider an n-type semiconductor of length L. Show that, under steady-state conditions

$$\Delta p_n(x) = \Delta p_{n0}(1 - x/L), \quad 0 \leq x \leq L$$

is the special-case solution of the minority-carrier diffusion equation that will result if (1) L is much smaller than the diffusion length so that all recombination-generation processes can be neglected, and (2) one employs the boundary condition $\Delta p_n(0) = \Delta p_{n0}$ and $\Delta p_n(L) = 0$.

2. (30 points) The earth is hit by a mysterious ray that momentarily wipes out all minority carriers. Majority carriers are unaffected. Initially in equilibrium and not affected by room light, a uniformly doped silicon wafer sitting on your desk is struck by the ray at time $t = 0$. The wafer doping is $N_a = 10^{16}/\text{cm}^3$, $\tau_n = 10^{-6}$s, and $T = 300$K.

   (a) What is Δn at $t = 0^+$?

   (b) Do low-level injection conditions exist inside the wafer at $t = 0^+$? Explain.

   (c) Starting from the appropriate differential equation, derive $\Delta n_p(t)$ for $t > 0$.

3. (25 points) A silicon wafer ($N_a = 10^{14}/\text{cm}^3$, $\tau_n = 10^{-6}$s, and $T = 300$K) is first illuminated for a time $t >> \tau_n$ with light which generates $G_{L0} = 10^{16}$ electron-hole pairs per $\text{cm}^3 - \text{sec}$ uniformly throughout the volume of the silicon. At time $t = 0$ the light intensity is reduced, making $G_L = G_{L0}/2$ for $t \geq 0$. Determine $\Delta n_p(t)$ for $t \geq 0$.

4. (25 points) A semi-infinite p-type bar defined for $0 \leq x < \infty$ is illuminated with light which generates G_L electron-hole pairs per cm^3-sec uniformly throughout the volume of the semiconductor. Simultaneously, carriers are extracted at $x = 0$, making $\Delta n_p = 0$ at $x = 0$. Assuming that a steady-state condition has been established and $\Delta n_p(x)$ is much much smaller than p_0 for all x, solve for $\Delta n_p(x)$.