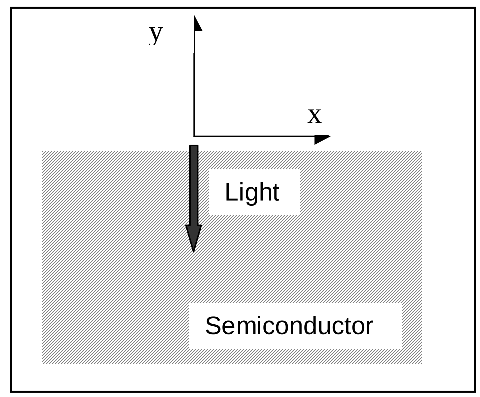
Homework#7 (Drift-Diffusion Formalisim)

1. In a sample of n-Si containing 10^{16} cm^{-3} donors, the lifetime of holes is found to be 200 μs. (a) Evaluate the lifetime of the majority electrons assuming all the donors are ionized. (b) Evaluate the equilibrium generation rate of electrons and holes. (c) Evaluate the equilibrium recombination rate for electrons and holes in this sample.
2. A sample of n-Si has a uniform donor concentration of 2.0×10^{16} cm^{-3} (fully ionized) at room temperature. (a) Find and evaluate the ambipolar diffusion coefficient and ambipolar drift mobility for excess carriers in this sample at 300 K. (b) Find and evaluate the electron and hole lifetimes in the sample assuming the lifetime of excess carriers is measured to be 240 μs for very low excess densities.
3. Assume that an n-type extrinsic semiconductor is illuminated with a cross-gap light beam along the y axis as shown to the right, and that there is a uniform electric field E_0 along the x axis. (a) Show that in the steady state the excess minority carrier density is given by $\delta p = A\exp(\Gamma_- x/L)$ for x > 0, and $\delta p = A\exp(\Gamma_+ x/L)$ for x < 0, where $\Gamma_{+/-} = \gamma \pm (1 + \gamma^2)^{1/2}$, $\gamma = -\mu^* E_0 L/2D^*$, and $L^2 *\tau^*$.



(b) Now suppose that the excess carrier concentration is know at two points, x = a and x = b along the x axis. Show that the diffusion length can be written from the ratio $K = \delta p(a)/\delta p(b)$ and the separation d = b - a as follows: $L = d / \sqrt{\ln K (\ln K + eEd/kT)}$

4. Assume a uniform sample of InGaAs having $n_o = 1 \times 10^{16}/cm^3$ and $p_0 = 5.3 \times 10^{10}/cm^3$ at room temperature that is perturbed by the presence of two excess-charge "regions", one containing $\delta n = 1 \times 10^{13}$ $/cm^3$ electrons over a distance of 10 μm and another 1-mm away containing $\delta p = 1 \times 10^{13}$ $/cm^3$ holes over a distance of 10 μm. (a) calculate the magnitude of the electric field between the excess-charge regions. (b) Calculate the rate of charge depletion in these regions by taking the difference of current densities on either side of them. (c) Calculate and evaluate the time required for the exess charge to neutralize to 1/e of its initial value, where e is the natural exponent.