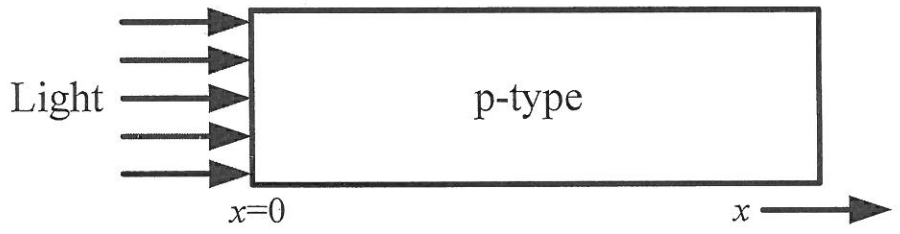
1. A particular semiconductor material is doped at $N_d=2\times10^{14}cm^{-3}$ and $N_a=1.2\times10^{14}cm^{-3}$. The thermal equilibrium electron concentration is found to be $n_0=1.1\times10^{14}cm^{-3}$. Assuming complete ionization, determine the intrinsic carrier concentration and the thermal equilibrium hole concentration at T=300 K. Also determine the position of the Fermi level respect with the intrinsic Fermi level. **(25%)**

2. Consider a bar of p-type Si that is uniformly doped to a value of $N_a=2\times10^{16}cm^{-3}$ at T= 300 K. The applied electric field is zero. A light source is incident on the end of the semiconductor as shown in the figure. The steady-state concentration of excess carriers generated at x=0 is $\delta p(0)=\delta n(0)=2\times10^{14}cm^{-3}$. Assume the following parameters: the electron mobility is μ_n=1200 cm^2/V-s; the hole mobility is μ_p=1200 cm^2/V-s; the electron lifetime is τ_n=1μs; and the hole lifetime is μ_p=0.5μs. Determine the steady-state excess electron and hole concentrations as a function of distance into the semiconductor. Also calculate the steady-state electron and hole diffusion current densities as a function of distance into the semiconductor. **(25%)**



3. Please explain the following items：
   (a) Electroluminescence. **(5%)**
   (b) Gunn effect diode. **(5%)**
   (c) Flat-band voltage. **(5%)**
   (d) Negative differential mobility. **(5%)**
   (e) PIN photodiode. **(5%)**

4. (a) Please explain clearly how to obtain a Schottky contact for the metal /N-type Si junction **(10%)**
   (b) Please plot the low-frequency and high-frequency capacitance versus gate voltage of a MOS capacitor with a P-type substrate and explain why that? **(15%)**