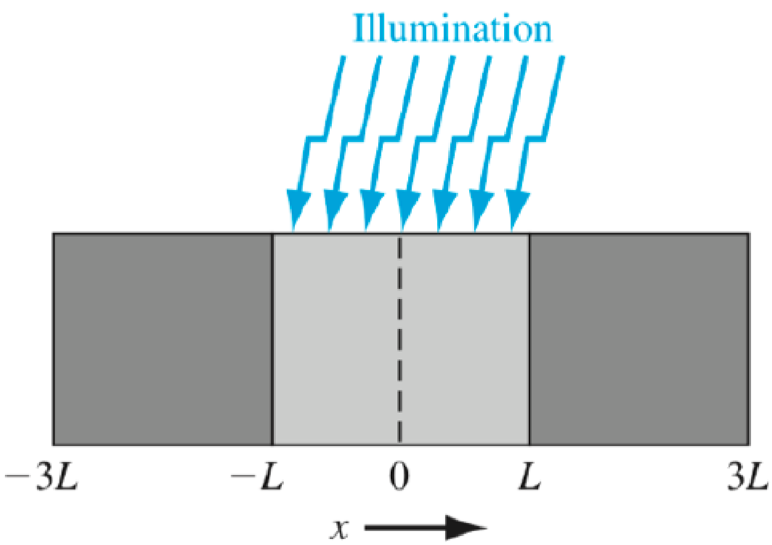
VE320 Homework 4

Due Oct. 29, 23:59pm

1. Consider a silicon sample at T=300K that is uniformly doped with acceptor impurity atoms at a concentration of Na=$10^{16}cm^{-3}$. At t=0, a light source is turned on generating excess carriers uniformly throughout the sample at a rate of g' =8×$10^{20}cm^{-3}s^{-1}$. Assume the minority carrier lifetime is τ_{n0}=$5 \times 10^{-7}s$, and assume mobility values of $\mu_n = 900cm^2/V - s$ and $\mu p = 380cm^2/V - s$.(a) Determine the conductivity of the silicon as a function of time for t⩾0.(b) What is the value of conductivity at (i) t=0 and (ii) t=∞?
2. A semiconductor is uniformly doped with $10^{17}cm^{-3}$ acceptor atoms and has the following properties: $D_n = 27cm^2/s$, $D_p = 12cm^2/s$, $\tau_{n0} = 5 \times 10^{-7}s$, 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.
3. 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.



4.

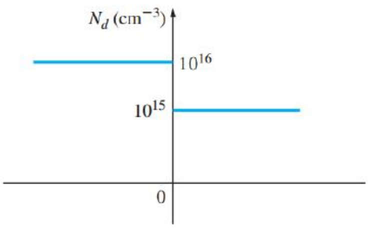
A silicon pn junction in thermal equilibrium at $T = 300$ K is doped such that $E_F - E_{Fi} = 0.365$ eV in the n region and $E_{Fi} - E_F = 0.330$ eV in the p region. (*a*) Sketch the energy-band diagram for the pn junction. (*b*) Find the impurity doping concentration in each region. (*c*) Determine V_{bi}.

5.

(*a*) Consider a uniformly doped silicon pn junction at $T = 300$ K. At zero bias, 25 percent of the total space charge region is in the n-region. The built-in potential barrier is $V_{bi} = 0.710$ V. Determine (*i*) N_a, (*ii*) N_d, (*iii*) x_n, (*iv*) x_p, and (*v*) $|E_{max}|$. (*b*) Repeat part (*a*) for a GaAs pn junction with $V_{bi} = 1.180$ V.

6.

An "isotype" step junction is one in which the same impurity type doping changes from one concentration value to another value. An n-n isotype doping profile is shown in Figure P7.12. (*a*) Sketch the thermal equilibrium energy-band diagram of the isotype junction. (*b*) Using the energy-band diagram, determine the built-in potential barrier. (*c*) Discuss the charge distribution through the junction.



7.

An ideal one-sided silicon p$^+$n junction at $T = 300$ K is uniformly doped on both sides of the metallurgical junction. It is found that the doping relation is $N_a = 80\, N_d$ and the built-in potential barrier is $V_{bi} = 0.740$ V. A reverse-biased voltage of $V_R = 10$ V is applied. Determine (*a*) N_a, N_d; (*b*) x_p, x_n; (*c*) $|E_{max}|$; and (*d*) C'_j.

8.

A silicon pn junction at $T = 300$ K has the doping profile shown in Figure P7.28. Calculate (*a*) V_{bi}, (*b*) x_n and x_p at zero bias, and (*c*) the applied bias required so that $x_n = 30\ \mu$m.