ECE 305 – Spring 2018

Homework 4 – Due Tuesday, February 13, 2018 at 12:00 PM in class or in EE 326B

1. Assume that an n-type region of gallium arsenide ($N_D = 10^{16}\ \mathrm{cm}^{-3}$) is deposited atop a p-type region of aluminum gallium arsenide ($Al_{0.5}Ga_{0.5}As$, $N_A = 10^{16}\ \mathrm{cm}^{-3}$), forming a heterojunction. Assume they have virtually identical electron affinities and dielectric constants, and that their band gaps are 1.4 eV and 2.0 eV, respectively.
    a. Draw the band diagrams for each material in isolation. Calculate and mark the corresponding Fermi levels for each.
    b. Sketch the band structure of both materials in equilibrium by aligning their Fermi energies, and then allowing the conduction and valence bands to smoothly vary across the junction, until they reach the positions associated with each bulk material in isolation. Ignore any differences in electron affinities of these materials.
    c. Qualitatively sketch the electric field $\mathcal{E}$ inside the semiconductor as a function of position *x*. Ignore any differences in dielectric constants between these materials.

2. Assume that a p-type region of crystalline silicon with $\mu_n = 1400\ \mathrm{cm}^2/\mathrm{V}\cdot\mathrm{s}$ and lifetime $\tau_n = 100\ \mu\mathrm{s}$ is in steady state in the dark. Then, starting at time $t = 0$, a light is switched on indefinitely, uniformly illuminating the sample with a photon flux $G_L = 10^{18}$ /cm^3·s.
    a. Write down the simplest form of the minority carrier diffusion equation that accurately describes its behavior. Briefly justify your answer.
    b. Sketch the time-dependent behavior of the minority carrier concentration. What happens to the majority carrier concentration?
    c. What is the value of the carrier concentration at $t = 50\ \mu\mathrm{s}$? How does this compare to the equilibrium value eventually reached for large, positive values of t?