ECE 3030 Spring 2025 HOMEWORK ASSIGNMENT NO. 8
Due: Friday, April 4th 11:59 pm upload to Carmen 3030 SpeedGrader

1. (20 pts) (a) What is the conductivity of a piece of Ge ($n_i = 2.5x10^{13}$ cm^{-3}) doped with $5x10^{13}$ cm^{-3} donors and $2.5x10^{13}$ cm^{-3} acceptors? (D_n = 100 cm^2/s, D_p = 50 cm^2/s). (Hint: solve quadratic.) (b) If the electron affinity of Ge = 4.0 eV and we put down a metal electrode with work function = 4.5 eV, what is the work function difference? Do you expect this to be a Schottky barrier or an ohmic contact?
2. (20 pts) Consider an ideal abrupt heterojunction with a built-in potential V_0=1.6 V. The dopant concentrations in semiconductor 1 and 2 are 1 x 10^{16} donors/cm^3 and 3 x 10^{19} acceptors/cm^3, and the dielectric constants are 12 and 13, respectively. Find the built-in potentials V_{01} and V_{02} in each material at thermal equilibrium ($V_{applied}$ = 0).
3. (20 pts) Sketch the band diagrams for $Al_{0.35}Ga_{0.65}As$ on GaAs for (a) p^+-AlGaAs, n^+-GaAs, (b) p^+-AlGaAs, n - GaAs, (c) n^+-AlGaAs, intrinsic GaAs. The 35% AlGaAs composition has an indirect bandgap E_g = 2.0 eV. Assume ΔE_c = 2/3 ΔE_g.
4. (20 pts)A Si solar cell 2 cm x 2 cm with I_{th} = 32 nA has an optical generation rate of 10^{18} EHP/cm^3- s within $L_p = L_n$ = 2µm of the junction. If depletion width is 1 µm, calculate the short-circuit current and the open-circuit voltage for this cell.
5. (5 pts)If one makes an LED in a semiconductor with a band gap of 2.5 eV, what wavelength of light will it emit? Can you use it to efficiently detect photons of wavelength 900 nm? 100 nm?
6. (15 pt) For the p-i-n diode pictured in S&B Fig. 8.7, (a) explain why this detector does not have gain (more than one e-h pair per absorbed photon); (b) explain how making the device more sensitive to low light levels degrades its speed; (c) if this device is to be used to detect light with λ = 0.6 µm, what material would you rather use – GaAs or CdS?
7. Extra Credit, 20 points: A long silicon pn junction solar cell at T = 300 K has the following parameters: Na = 10^{16} cm^{-3}, $N_d = 10^{15}$ cm^{-3}, D_n = 25 cm^2/s, D_p = 10 cm^2/s, $\tau_{n0} = 10^{-6}$ s, and τ_{p0} = 5 x 10^{-7} s. The cross sectional area of the solar cell is 5 cm^2. The entire junction is uniformly illuminated such that the generation rate of electron-hole pairs is g_{op} = 5 x 10^{21} cm^{-3}s^{-1}. (a) Calculate the short circuit photocurrent generated in the space charge region. (b) Using the results of part (a), calculate the open-circuit voltage. (c) Determine the ratio of open circuit voltage V_{oc} to contact potential (built-in voltage) V_{bi}.