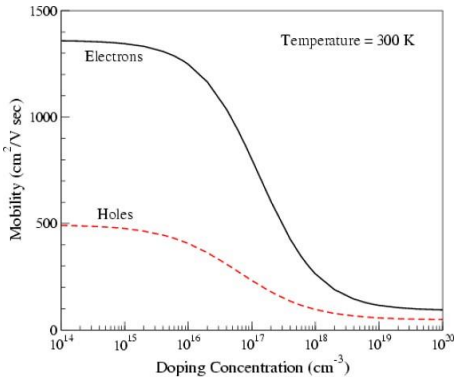
ECE 3030 Spring 2025 HOMEWORK ASSIGNMENT NO. 5

Due: Friday, February 26th 11:59 pm upload to Carmen 3030 SpeedGrader

Please complete the following exercises:

1. (20 pts) A Si sample with 10^{16} cm^{-3} donors is optically excited such that 10^{19} cm^{-3} EHPs are generated per second uniformly. The laser used causes the Si to heat up to 450 K. Find F_n and F_p and the change in conductivity σ upon shining the light. τ_e and τ_h = 10 μs. D_p = 12 cm^2/s; D_n = 36 cm^2/s at 450 K. What is the change in σ upon shining the light?

2. (15 pts) A Si bar 0.1 cm long and 100 μm^2 (10^{-6} cm^2) in cross sectional area is doped with 10^{17} cm^{-3} antimony. (a) Find the current at 300K with 10V applied. Repeat for a Si bar 1 μm long. (b) How long does it take an average electron to drift 1 μm in *pure* Si at an electric field of 50 V/ cm? Repeat for 5x10^5 V/cm.



3. (15 pts) For a hypothetical semiconductor, we have $\mu_n = \mu_p$ = 1000 cm^2/V-s and $N_C = N_V = 10^{19}$ cm^{-3}. If the conductivity of the intrinsic semiconductor at 300 K is 4x10^{-6} (Ω-cm)$^{-1}$, what is the conductivity at 600 K? Assume that N_C, N_V, and E_G do not vary with T.

4. (20 pts) Referring to S&B Fig. 3-25, consider a semiconductor bar with w = 0.01 cm, t = 10 μm, and L = 5 mm. For B = 10 kG in the direction shown (1 kG = 10^{-5} Wb/cm^2) and a current of 1 mA, we have V_{AB} = -2 mV, V_{CD} = 100 mV. Find the type, concentration, and mobility of the majority carrier.

5. (15 pts) Boron is diffused into an intrinsic Si sample such that $N_a=N_0\exp(-ax)$, where x=0 at the surface. (a) Find an expression for $\mathcal{E}(x)$ at equilibrium over the range for which $N_a >> n_i$. (b) Evaluate $\mathcal{E}(x)$ when a = 2 (μm)$^{-1}$. Sketch the equilibrium band diagram to show the direction and slope of the resulting electric field, for $N_a(x) >> n_i$. Repeat for phosphorus with $N_d(x) > n_i$. *Note: kT/q = 0.0259. (q cancels e.)*

6. (15 pts) In Fig. 4-17, the steady state excess hole concentration at x = 0 is $\Delta p = 10^{17}$cm^{-3}. The semi-infinite Si bar has a cross section A = 10^{-3} cm^2. The hole diffusion length L_p is 10^{-3} cm, and the hole lifetime is 10^{-7} s.
   (a) What is the steady state stored charge Q_p in the exponential excess hole distribution?
   (b) What is the hole current $I_p(x = 0)$ feeding this steady state distribution?
   (c) What is the slope of the distribution (in cm^{-4}) at x = 0?

7. Bonus (20 Pts) Design and sketch a photoconductor using a 5-μm-thick film of CdS, assuming that $\tau_n = \tau_p = 10^{-6}$ s and $N_d = 10^{14}$ cm^{-3}. The dark resistance (with g_{op} = 0) should be 10 MΩ, and the device must fit in a square 0.5 cm on a side; therefore, some sort of folded or zigzag pattern is in order. With an excitation of $g_{op} = 10^{20}$ EHP/cm^2-s, what is the resistance change?