ECE 132 Fall 2018

UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Electrical and Computer Engineering

Homework 2 – due October 31, 2018 by 5:00pm

1. A student goes into lab to make a Hall measurement. She applies an *x* directed electric field and a *z* directed magnetic field to her sample, and then measures the *y* directed Hall voltage between points *A* and *B*. However, points *A* and *B* are misaligned on the *x* axis, with a separation Δx. This separation causes an additional voltage between the contacts; therefore, the voltage that she measures is not the Hall voltage.

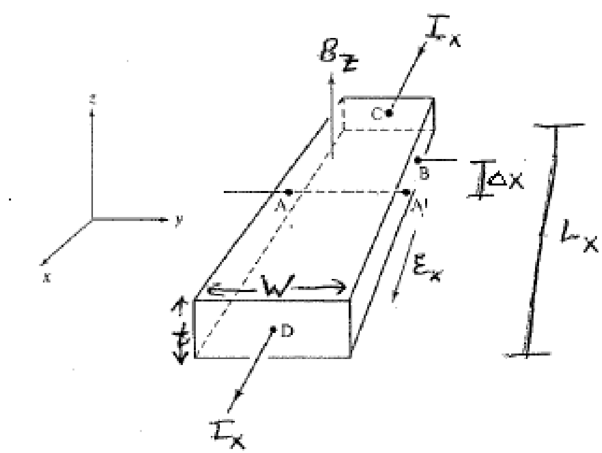

FIG. 1: Hall measurement setup

(a) Suggest a simple procedure to get the correct Hall voltage from this setup, if the sample is *n*-type. Aligning the contacts is not an option.

(b) Repeat part (a) for *p*-type.

2. An *n*-type silicon sample with $n_0 = 4 \times 10^{16}$ cm^{-3} is excited with a pulse of light at $t = 0$ which results in an excess carrier concentration of 1×10^{14} EHP/cm^3.

(a) If the hole lifetime $\tau_p = 1$ μs, find an expression for the hole concentration as a function of time $p(t)$.

(b) What is the hole concentration after one hole lifetime (τ_p) has elapsed?

3. A silicon sample with 10^{17} cm^{-3} donors is optically excited by a laser such that 10^{20} cm^{-3} electron-hole pairs (EHPs) are generated per second uniformly in the sample. The laser causes the sample to heat up to 450 K. Find the positions of the quasi-Fermi levels, and draw a band diagram indicating their positions. Also find the change in conductivity of the sample upon shining the light. Assume the electron and hole lifetimes are both 10 μs, $D_p = 12$ cm^2/s, $D_n = 36$ cm^2/s, $n_i = 1.5 \times 10^{10}$ cm^{-3} at 300 K, and $n_i = 10^{14}$ cm^{-3} at 450 K.

4. The current required to feed the hole injection at $x = 0$ in Streetman Fig. 4-17 is obtained by evaluating the following equation at $x = 0$:

$$J_p(x) = -qD_p\frac{dp}{dx} = -qD_p\frac{d\delta p}{dx} = q\frac{D_p}{L_p}\Delta p e^{-x/L_p} = q\frac{D_p}{L_p}\delta p(x)$$

The result is $I_p(x = 0) = qAD_p\Delta p/L_p$. Show that this current can be calculated by integrating the charge stored in the steady state hole distribution $\delta p(x)$ and then dividing by the average hole lifetime τ_p. Explain why this approach gives us the correct expression for $I_p(x = 0)$.

5. Reading Assignment: *Streetman*: Ch. 3 and 4 (all)