Drift, Diffusion, and Recombination Lab

Objectives:

Upon completion of this laboratory students should be able to understand the processes of diffusion, drift, recombination and generation, for carriers in semiconductors.

Pre-lab:

1) For a piece of silicon doped with 10^{17} Arsenic Atoms.

a. Find the electron and hole concentrations at equilibrium.

b. Use the plot in the book to find the mobility and then calculate the resistively of this material.

c. Are holes or electrons the "minority carriers"?

Procedure:

Diffusion, Drift and Generation and Recombination

1) Visit the virtual lab entitled "Diffusion, Drift and Recombination Virtual Experiment". This applet lets you visualize the following processes of excess minority carriers in a semiconductor:

- **diffusion**, due to the concentration gradient of carriers,
- **drift,** by the applied bias (and therefore electric filed)
- **recombination** or loss of a carrier.
- **generation** of a carriers

2) Check the checkboxes of width vs. t, displacement. vs. t, and N vs. t. This shows the three graphs at the bottom which are the width of the distribution of the minority carriers, the location of the peak of the distribution of the minority carriers, and the total number of minority carriers in the entire bar.

Diffusion: First you will examine diffusion.

3) In the applet**, set: the lifetime to infinity, bias to 0 V and material to p-type, length to .4 cm, temp to 300K, and mobility to 1900 cm^2/Vs.**

4) Start the applet, and observe the distribution of the minority carriers. Draw below what the distribution of minority carriers looks like over time, and describe it in words.

5) Notice that location of the peak doesn't move, Why?

6) Why does the total number of minority carriers stay the same?

7) Increase the mobility to 3900 cm^2/VS, and re-start the applet. What effect does the mobility have on the distribution of minority carriers?

8) What is the direction(s) of the diffusion current? (a drawing would be good here!)

Drift

9) Examine drift by setting **the lifetime to infinity, bias to +2V, material to p-type, length to .4 cm, temp to 300K, and mobility back to 1900 cm^2/Vs.**

10) Start the applet, and observe the distribution of the minority carriers. Draw below what the distribution of minority carriers looks like over time, and describe it in words.

11) Which direction does the peak move and why?? (remember the plots are for the minority carriers!)

12) Change the material to n-type, and re-start the applet. Does the peak move in the direction you expect?

13) Change the material back to p-type, and compare running the applet at +2 V bias and +4V bias. What can you say about the dependence of the voltage on the velocity of the carriers? (Some ## would be good here!)

14) Calculate the drift current in above situation for both the +2 and +4 V case.

Jdrift (@ 2V) = ___________________ Jdrift(@ 4V) = ____________________

Recombination

15) Examine recombination by setting **the lifetime to .01 ms, bias to 0 V, material to p-type, length to .4 cm, temp to 300K, and mobility to 1900 cm^2/Vs.**

16) Run the applet, and notice the third plot (total number of carriers). If the total number of electron carriers is decreasing, where are they going?

17) How many ms does it take for 2/3 of the electrons to disappear?

18) Run the applet with the lifetime set to 0.1 ms and .001 ms as well. What does the time-dependence of the Number (of minority carriers)-vs.-t data appear to have ?

19) What does the "lifetime" represent then? (think RC circuit)

Generation & general questions

20) How are the electrons in the p-type generated in this applet? (can you say anything about the maximum wavelength the laser must have)

21) How many electron-hole pairs does the laser create in this applet?

22) Why aren't the majority carriers distributions shown in the plots??