ECE 542
Homework #8

Due: March 20, 2020

1. Consider a Germanium p-n junction with $N_A = 10^{15}$ cm^{-3} and $N_D = 10^{15}$ cm^{-3}. The minority carrier lifetime on the p-side is 50 μs, and the minority carrier lifetime on the n-side is 50 μs.
    a. What is the built-in voltage, V_{bi}?
    b. What is the excess electron concentration at $x = -x_p$, for $V_{app} = -3\ V$?
    c. What is the excess electron concentration at $x = -x_p$, for $V_{app} = 0.5\ V$?
    d. What is the reverse saturation current density, J_S?
    e. What is the current density for $V_{app} = -3\ V$?
    f. What is the current density for $V_{app} = 0.5\ V$?

For the following problems, assume:

- The cross-sectional area is 250 μm x 250 μm.
- The minority carrier lifetime on the p-side is 100 ns.
- The minority carrier lifetime on the n-side is 10 μs.

2. Consider a Si p-n junction with $N_A = 10^{18}$ cm^{-3} and $N_D = 10^{17}$ cm^{-3}.
    a. What is the reverse saturation current, I_S?
    b. What is the current for $V_{app} = 0.5\ V$?
    c. Using a computer, plot the current versus applied voltage, ranging from -1 V to 0.8 V. Turn in your code.
    d. What is the apparent turn-on voltage?

3. Consider a GaN p-n junction with $N_A = 10^{18}$ cm^{-3} and $N_D = 10^{17}$ cm^{-3}.
    a. What is the reverse saturation current, I_S?
    b. Using a computer, plot the current versus applied voltage, ranging from -1 V to 0.8 V. Turn in your code.
    c. What is the apparent turn-on voltage?
    d. Compare this graph with the graph from problem #2. For the same voltage, which diode has greater current: the silicon diode or the GaN diode?
    e. Change the x-axis so that the forward current is similar to that found for the silicon diode. Superimpose the graphs for the silicon diode and the GaN diode. Make a single, nice graph. Turn in your code.
    f. What is the apparent turn-on voltage for the silicon diode and the GaN diode?

4. Consider a Si p-n junction with $N_A = 10^{18}$ cm^{-3} and $N_D = 10^{17}$ cm^{-3}. The length of the n-region is 200 μm, and the length of the p- region is 20 μm. What are:
    a. The breakdown voltage considering only avalanche breakdown?
    b. The breakdown voltage considering only punch-through on the n-side?
    c. The breakdown voltage considering only punch-through on the p-side?
    d. The overall breakdown voltage?