ECEn 450, Winter 2010
Homework #4
Due February 2, 5:00 pm

From the text Semiconductor Devices, Physics and Technology, do the following problems:

Chapter 2, problems 11, 14, 15, 19, 20

Chapter 11, problems 14, 19

Also complete the following problems:

4.1 For the Boltzmann approximation to be valid for a semiconductor, the Fermi level must be at least 3kT below the donor level in an n-type material and at least 3kT above the acceptor level in a p-type material. If T = 300 K, determine the maximum electron concentration in an n-type semiconductor and the maximum hole concentration in a p-type semiconductor for the Boltzmann approximation to be valid in (a) silicon and (b) gallium arsenide.

4.2 The Fermi level in n-type silicon at T=300K is 245 meV below the conduction band and 200 meV below the donor level. Determine the probability of finding an electron (a) in the donor level and (b) in a state in the conduction band kT above the conduction band edge.

4.3 Silicon at T=300 K is doped with acceptor atoms at a concentration of $N_a = 7 \times 10^{15}$ cm^{-3}. (a) Determine $E_F - E_V$. (b) Calculate the concentration of additional acceptor atoms that must be added to move the Fermi level a distance kT closer to the valence-band edge.

Homework hints:

2.14 Refer to Fig. 22

11.14 5Ω/sq means 5 ohms per square. Just find how many squares the metal lines have.

4.2 Probability function for electron occupying donor states:

$$\frac{n_d}{N_d} = \frac{1}{1 + \frac{1}{2}\exp(\frac{E_D - E_F}{kT})},$$

it is different than the probability function

$$f_F(E) = \frac{1}{1 + \exp(\frac{E - E_F}{kT})}$$