TMT 4185 Materials Sci. and Eng.

Exercise 11

Part 1

1. The Ohm`s law can be expressed as:
   V=IR or $J=\sigma\varepsilon$

   Demonstrate the equivalence of the two Ohm`s law expressions.

2. Show schematically the difference, in terms of band structures, between metals, semiconductors and insulators.

3. What is the Matthiessen`s rule? Write the equation and describe its meaning.

4. What is the difference between intrinsic and extrinsic semiconductors?

5. Show schematically a p-n rectifying junction with a) no electrical potential, b) forward bias and c) reverse bias.

Part 2

1. Let's assume pure (undoped) silicon (Si). Silicon has cubic diamond structure with a lattice parameter a = 5.4307 Å. It is further given that Si at 25 ^{o}C has a (intrinsic) conductivity of σ = 5. x 10^{-4} $\Omega^{-1}m^{-1}$.

(a) Calculate the number of valence electrons in Si per unit volume?

For pure silicon at 25 ^{0} C, calculate

(i) Number of charge carriers (intrinsic conduction)? (you can use the data for Si in Table 18.3)
(ii) Fraction of electrons in the conduction band?

(b) We want to make a p-doped semiconductor by adding boron to high purity Si which gives a nearly constant conductivity over a range of temperatures (i.e. where we may assume "acceptor saturation").

Calculate the atom fraction of boron needed to give a conductivity σ = 1.0 10^{2} $\Omega^{-1}m^{-1}$.