UNIVERSITY
OF WOLLONGONG
IN DUBAI

Tutorial 9 – Week 10

Aims:

Upon successfully completing these tutorial exercises, students should be able to:

- Demonstrate an understanding of concepts related to electrical conductivity
- Perform calculations related to electrical properties of materials

Question 1

(a) Compute the electrical conductivity of a cylindrical silicon specimen 7.0 mm diameter and 57 mm in length in which a current of 0.25 A passes in an axial direction. A voltage of 24 V is measured across two probes that are separated by 45 mm.

(b) Compute the resistance over the entire 57 mm of the specimen.

Question 2

An aluminium wire 10 m long must experience a voltage drop of less than 1.0 V when a current of 5 A passes through it. Given the electrical conductivity for aluminium at room temperature is 3.8×10^7 S/m, Compute the minimum diameter of the wire.

Question 3

For **intrinsic** germanium, the electrical conductivity at room temperature is 2.20 S/m. If the charge of an electron is -1.602×10^{-19} C, and the electron and hole mobilities are 0.38 m^2/V.s and 0.18 m^2/V.s respectively:

a) Calculate the **intrinsic** carrier concentration (n_i) of the germanium at room temperature (25°C)

b) Compare your answer from part (a) to the information provided in Figure 1

Intrinsic semi-conductor

$$\sigma = n_i|q|(\mu_n + \mu_p)$$

where
n_i = intrinsic carrier concentration
q = charge of an electron
μ_n = electron mobility
μ_p = hole mobility

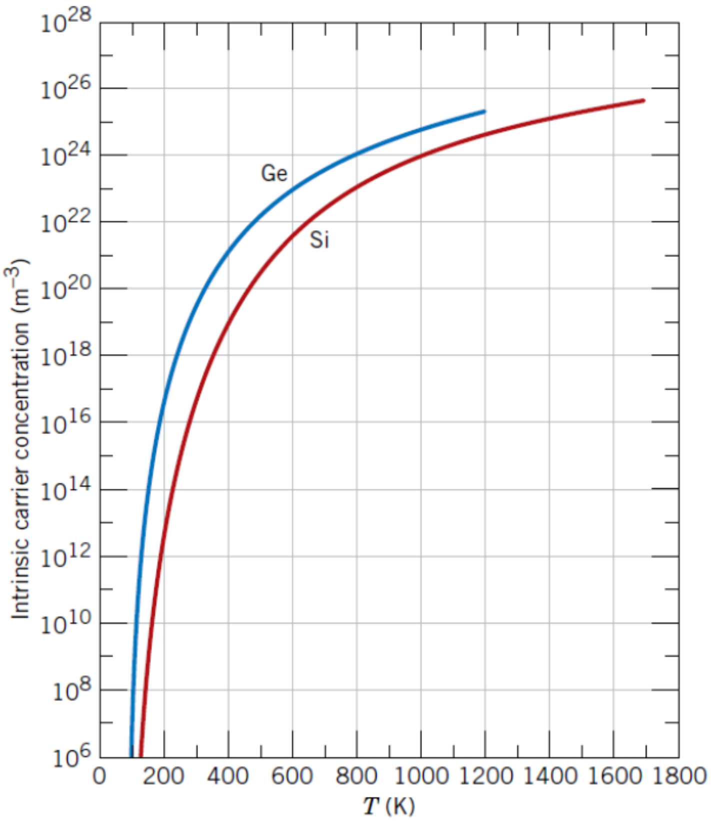


Figure 1. Intrinsic carrier concentration for germanium (Ge) and silicon (Si) as a function of temperature. (From Figure 18.16, Callister *Materials Science and Engineering, an Introduction*, 9th ed. 2014, New Jersey: John Wiley & Sons, Inc.).

Question 4

Using the information provided in Figure2, a and b:

i) Calculate the electrical conductivity of **intrinsic** silicon at 150 °C (use <10^{20} m^{-3} graphs below to find electron and hole mobilities)

a) Calculate the room temperature electrical conductivity of a high-purity silicon which has been doped with 10^{23} m^{-3} **arsenic** atoms. (**Extrinsic** (**n-type**) electron mobility)

b) Calculate the electrical conductivity of this same doped silicon at 100 °C

Intrinsic semi-conductor

$$\sigma = n_i|q|(\mu_n + \mu_p)$$

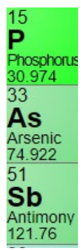
where
n_i = intrinsic carrier concentration
q = charge of an electron
μ_n = electron mobility
μ_p = hole mobility

Doped:

n-type: $\sigma \cong n\ |q|\mu_n$

p-type: $\sigma \cong p\ |q|\mu_p$

n-type extrinsic semiconductors An extra non-bonded electron (or electrons) is supplied by impurity atoms.



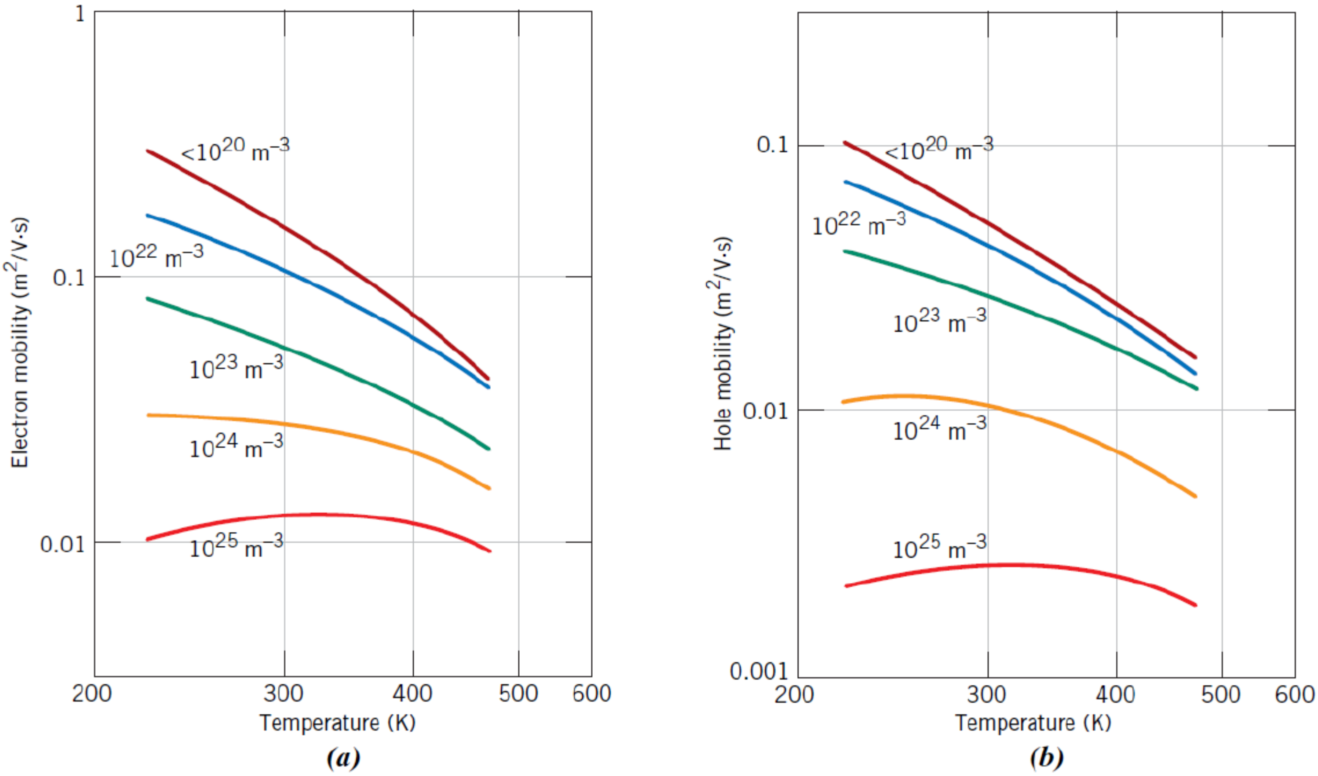


Figure 2. Temperature dependence of (a) electron and (b) hole mobilities for silicon doped with various donor and acceptor concentrations. (From Figure 18.19, Callister *Materials Science and Engineering, an Introduction*, 9th ed. 2014, New Jersey: John Wiley & Sons, Inc.).