Answer on Question#53377 - Solid State Physics

A sample of Germanium shows no Hall Effect. If the mobility of electrons in Germanium is $\mu_e = 3500\,\frac{\text{cm}^2}{\text{V}\cdot\text{s}}$ and that of holes is $\mu_h = 1400\,\frac{\text{cm}^2}{\text{V}\cdot\text{s}}$. What fraction of the current in the sample is carried by electrons?

Solution:

The speed of charge carriers is related to their mobility by means of the following expression

$$v = \mu E,$$

where E – is the electric field applied across the sample of Germanium. Thus the net current due to electrons is given by

$$I_e = v_e \cdot e \cdot n \cdot A = \mu_e \cdot E \cdot e \cdot n \cdot A,$$

where A – is the cross-sectional area of the sample, n – is the concentration of the electrons in the sample, e – elementary electric charge. If the sample is electrically neutral, the concentration of holes is also n and the current due to holes is given by

$$I_h = v_h \cdot e \cdot n \cdot A = \mu_h \cdot E \cdot e \cdot n \cdot A$$

Therefore the fraction of the current in the sample carried by electrons is

$$\frac{I_e}{I} = \frac{I_e}{I_e + I_h} = \frac{\mu_e \cdot E \cdot e \cdot n \cdot A}{(\mu_e + \mu_h) \cdot E \cdot e \cdot n \cdot A} = \frac{\mu_e}{\mu_e + \mu_h} = \frac{3500\,\frac{\text{cm}^2}{\text{V}\cdot\text{s}}}{3500\,\frac{\text{cm}^2}{\text{V}\cdot\text{s}} + 1400\,\frac{\text{cm}^2}{\text{V}\cdot\text{s}}} = \frac{5}{7}$$

Answer: $\frac{5}{7}$.