ELEC-3140 Semiconductor physics **Nov 16, 2021**

Exercise 6: Electrical properties

1. The electron mobility of an InGaAs layer is 10 000 cm^2/Vs at T = 300 K. a) Calculate the drift velocity of the electrons in an electric field of 10 kV/cm, which is a typical field strength in semiconductors. b) The relaxation times of electrons and holes are assumed to be equal. Calculate the mobility of holes when $m_e^* = 0.050\,m_0$ and $m_h^* = 0.40\,m_0$.

2. Electron mobility in weakly n-type (n = 1x10^{13} cm^{-3}) GaAs $\left(m_e^* = 0,067\,m_0\right)$ layer is 200 000 cm^2/Vs at T = 77 K. a) Calculate the average distance l_e and time τ_e between collisions for thermally moving electron (assuming kinetic energy of $E = 3k_BT/2$ for the electron). b) Calculate the conductivity of the sample at 77 K. The effect of holes to the conductivity can be ignored.

3. For intrinsic semiconductor the relaxation times for phonon scattering and ionised impurity scattering at T = 300 K are $\tau_L = 1.1\,ps$ and $\tau_I = 1.9\,ps$, respectively. The effective mass of the carriers is $0.10\,m_0$. The temperature dependences of the scattering processes are

$$\tau_L \propto T^{-\frac{3}{2}} \quad \wedge \quad \tau_I \propto T^{\frac{3}{2}}.$$

Other scattering processes can be ignored. a) At what temperature is the mobility largest?
b) What is the value of the largest mobility?

4. An n-type InGaAs layer with a thickness of 2.5 μm is grown on a semi-insulating InP wafer. A 1.0 mm wide and 2.0 mm long strip is etched from the layer. The Hall voltage of V_H = 12 mV is obtained from the layer in Hall measurement with a normal magnetic field of B_z = 0.50 T when 10 mA current is led through the sample. At the same time voltage difference V_x = 150 mV is measured between the ends of the strip. Calculate the carrier (electron) density and mobility in the InGaAs layer.