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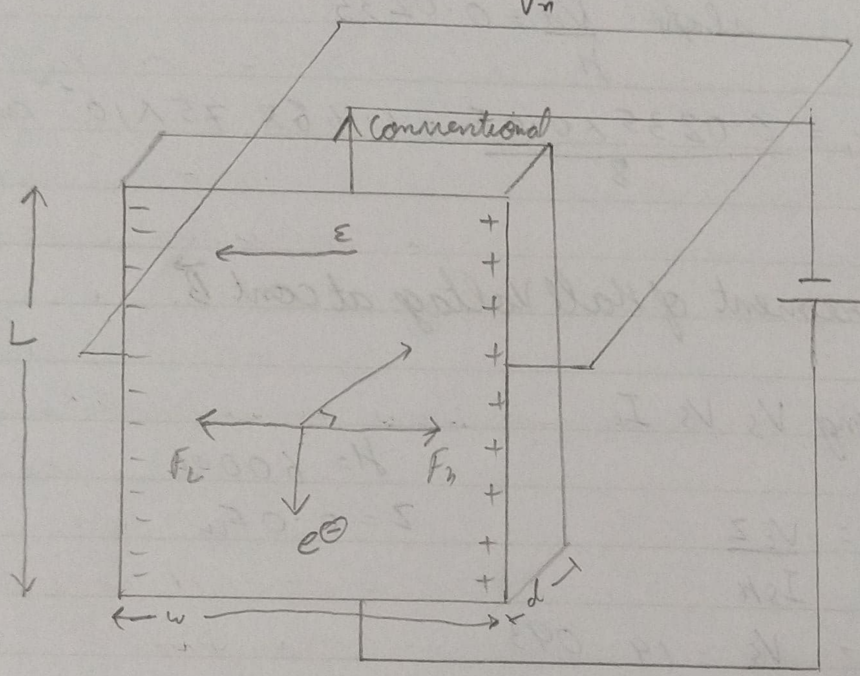
EXPERIMENT - 7

Aim: To estimate the hall coefficient, carrier conc. and their mobility in bre crystal using Hall Effect

APPARATUS: Hall Effect set up a) Hall Probe b) Hall probe (InAs), Digital Millivoltmeter, const. current power supply, electromagnet, EMV-75, Gaussmeter, GM-10+

DIAGRAM:



Hall Effect

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EXPERIMENT - 7

AIM- To estimate the hall coefficient, carrier conc. and their mobility in Ge Crystal using Hall Effect

APPARATUS- Hall effect set up a) Hall probe (Ge Crystal) b) Hall probe (In As) for measuring magnetic field, Digital Millivoltmeter, constant current power supply, Electromagnet, EMV-75, Gauss meter GM-101

THEORY- The static $\vec{B}$ has no effect on charges unless they are in motion when the charges flow, a $\vec{B}$ directed $\perp$ to the direction of flow produces a mutually $\perp$ force on the charges when this happens e^- and holes will be separated by opposite forces they will in turn produce an $\vec{E}$ known as Halls effect. In metals and heavily doped semiconductors where one type of carrier dominates, The force due to Lorentz force is balanced by the force on the charge carriers due to Hall field

$$q\,E_H = q(v \times H) \qquad (v \rightarrow \text{drift vel. of carriers})$$

$$J = q\,n\,v \qquad (q \rightarrow \text{Charge of carriers})$$

$$(n \rightarrow \text{carriers conc.})$$

$$R_H = E_H\,(J \times H) = \frac{1}{nq}$$

R_H = Hall coefficient and depends on the free charge carrier density (n) for a given material. Let us consider a semiconductor material in the form of a bar having dimensions x, Y, Z. Let J is direction along x

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and H is along Z and ε_n will be developed across Y

$$R_n = \frac{\varepsilon_n}{J_n} = \frac{V_H / Y}{\left(\frac{I}{Y_Z}\right) n} = \frac{V_H Z}{IH}$$

finally $R_n = \frac{1}{(nq)}$

From this eq. it is clear that the sign of Hall cofficient depends upon the sign of the q. This means in a p-type ~~semicon~~ specimen the R_n would be positive and in a n-type it would be negative. When it comes to one charge carriers, the conductive is given by:-

$$\sigma = nq\mu$$

μ = mobility of charge carrier $= \sigma R_n$

R_n is expressed in cm^3/C

σ in $\Omega^{-1} cm^{-1}$

$\therefore$ μ is expressed in $cm^2 V^{-1} s^{-1}$ and carrier conc is given by:-

$$n = \frac{1}{R_n q}$$

CALCULATION/RESULTS

(i) Part I: Magnetic Calibration

From the graph of H vs I_m, we get a straight line

$$H = m(I_m) + c$$

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$R = 1522 \cdot x + 151.43$

$m = 1522.1 \quad c = 151.43$

(ii) Part II : Measurement of constant sample current.

Using V_H Vs H

$R_H = \frac{V_H Z}{I_H} \quad = I_s = 8mA \quad Z = 0.05cm$

$slope = \frac{V_H}{H} = 0.0235$

$R_{H_1} = \frac{0.0235 \times 0.05}{8} = 1.46875 \times 10^{-4} \ cm^3/c$

(iii) Part III : Measurement of Hall Voltage at const $\vec{B}$

Using V_s Vs I_s

$H = 6000G$

$Z = 0.05cm$

$R_H = \frac{V_s Z}{I_s H}$

$slope = \frac{V_s}{I_s} = 19.093$

$R_{H_2} = 19.093 \times \frac{0.05}{6000} = 1.591083 \times 10^{-3} \ cm^3/c$

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RESULTS

(a) Half coefficient

$$R_H = \frac{R_{H_1} + R_{H_2}}{2} = \left(\frac{1.46875 + 1.591083}{2}\right) \times 10^{-4}$$

$$R_H = 1.5299165 \times 10^{-4} \ Cm^3/c$$

(b) carrier conc. (n)

$$n = \frac{1}{R_n q} = \frac{1}{1.52991565 \times 10^{-4} \times 1.6 \times 10^{-19}} = 4.0852 \times 10^{22} \ Cm^3$$

$$n = 4.0852 \times 10^{22} \ Cm^3$$

(c) Mobility of charge carriers

$$\mu = \sigma R_n$$

$$\sigma = \frac{1}{\rho} \Rightarrow \rho = 8 \ \Omega \ cm$$

$$\therefore \mu = \frac{R_n}{\rho} = \frac{1.5299165 \times 10^{-4}}{8}$$

$$\mu = 1.91239 \times 10^{-5} \ Cm^2 \ V^{-1} s^{-1}$$

PRECAUTIONS

1) Handle the equipments carefully
2) offset the $\vec{B}$ on the probe
3) Set the digital gauss meter to zero to avoid errors