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Hall Effect

Aim: To find out the hall coefficient of the given semiconductor sample and to find out majority carriers and other parameters.

Apparatus: Power supply, Helmholtz coil, Gauss meter, semiconductor sample, Hall effect setup.

Working Formula:

$$V_H = \frac{R_H B I}{d}$$; V_H - Hall voltage
B - Magnetic field
d - Thickness of the sample
I - Current through the sample

$$\rho = \frac{1}{R_H e}$$; ρ - Carrier concentration in p-type semiconductor
e - elementary charge

$$\mu = |R_H| \sigma$$; μ - mobility of the sample
σ - conductivity of the sample

$$\tan \theta_H = R_H \sigma B$$; θ_H - Hall Angle

$$B_0 = \frac{1}{\mu}$$; B_0 - Hall field

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Precautions : (i) Make sure that the power supply connected does not fluctuate.

(ii) Check the digital gaussmeter, voltmeter etc. for zero error.

(iii) High current should not pass through the sample especially in case of semi conductor.

(iv) Start with controls set for zero current and gradually increase with small increments wait for it to stabalize before taking the readings.

(v) While changing the direction of magnetic field we should switch off the set-up and change the magnetic field.

(vi) Make sure that the current and voltage probes are perpendicular to each other.

(vii) Hold the sample at the center of the Helmholtz coil and fix it at a position to get stable readings.

Observations : Thickness of sample = ~~0.548~~ 0.543 mm
(measured by previous group)
Magnetic Field (B) = 5520 Gauss.
LC of Ammeter = 0.01 mA
LC of Voltmeter = 0.1 mV

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S.No.	I(mA)	V_H (mV) ($B_{forward}$)	V_H (mV) ($B_{Reverse}$)
1.	0.00	0.0	0.0
2.	0.21	2.8	-4.9
3.	0.85	14.7	-16.7
4.	1.02	~~17.6~~	~~-17.6~~ 19.9
5.	1.38	24.2	-26.9
6.	2.00	35.0	-38.7
7.	2.38	41.2	-46.1
8.	2.85	49.6	-54.3
9.	3.09	~~53.9~~	~~-59.3~~
10.	3.44	57.6	-64.2
11.	4.00	66.9	-74.9
12.	4.33	72.4	-81.5
13.	4.25	71.0	-78.6
14.	4.68	79.3	-85.8
15.	5.06	85.0	-92.9
16.	5.96	100.6	-107.3
17.	6.19	105.0	-114.5
18.	6.55	111.2	-120.6
19.	6.94	116.6	-124.1
20.	7.05	118.4	-130.4
21.	7.35	123.2	-134.9
22.	8.25	139.0	-149.7
23.	7.97	133.8	-145.5
24.	8.87	148.9	-159.9
25.	9.22	154.0	-165.2
26.	9.76	161.9	-173.6

Calculation: ① From the graph:

Slope (m) = 16.6546

$$R_H = \frac{md}{B} = \frac{16.6546 \times 0.593 \times 10^{-3}}{0.555}$$

$$R_H = 0.0163 \ m^3/C$$

From the reference diagram, it was inferred that the sample contains holes as the majority charge carrier i.e. the sample is a p-type semiconductor.

$$\text{Hall concentration } \rho = \frac{1}{R_H e} = 3.8357 \times 10^{20} \ m^{-3}$$

Error Analysis - Error in slope (Δm) = 0.0613

$$R_H = \frac{md}{B} \Rightarrow \Delta R_H = R_H\left(\frac{\Delta m}{m} + \frac{\Delta d}{d}\right)$$

$$= 0.0163\left(\frac{0.0613}{16.6546} + \frac{0.005}{0.593}\right)$$

$$\Delta R_H = 2.1 \times 10^{-4} \ m^3/C$$

$$\rho = \frac{1}{R_H e} \Rightarrow \frac{\Delta \rho}{\rho} = \frac{\Delta R_H}{R_H} = 0.049 \times 10^{20} \ m^{-3}$$

Sources of Error - ① There may be temperature fluctuation, which may lead to change in various parameters like current through coil, sample etc.

② There may be left over magnetization while reversing the direction of magnetic field.

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Result- The semi-conductor was found to be p-type.
Hall coefficient, $R_H = (0.0163 \pm 0.0003)\ m^3/C$
Hole concentration, $\rho = (3.84 \pm 0.05) \times 10^{20}\ m^{-3}$

Discussion- The observed values of Hall coefficient & Hole concentration are precise and type of semiconductor was found p- type.