AIM - To study Hall effect and to measure carrier concentration and Hall constant / coefficient for unknown semiconductor.

APPARATUS - Gauss and Tesla meter NV621, measurement unit NV622, constant current power supply NV623, hall probe, InAs probe.

PROCEDURE - • Take constant current power supply and set the current Adjust potentiometer at fully anticlockwise position. Connect electromagnet with constant current power supply such that two coils of electromagnet is in series i.e. the direction of current in both the coils should be same otherwise little or no electromagnetic field would results.

- Keep the poles of electromagnet at some distance of 20 mm.
- Take Gauss & Tesla meter from the set of Hall Effect Trainer.
- connect InAs probe and switch on Gauss and Tesla meter.
- Adjust zero reading on display by zero adjustment potentiometer and keep ready for measurement.
- Now take measurement unit and set the switch position as follows.

Observations

Probe current I(mA)	Magnetic field B (T)	zero field potential (offset voltage) V_{zero}	Hall voltage for one side of probe		Hall voltage for second side of probe		Mean voltage $V_H = \frac{V_H' - V_H''}{2}$
			with offset voltage	without offset voltage	with offset voltage	without offset voltage	
constant current = 1A							
0.5	0.0036	9.5	9.1	0.4	9.4	0.1	0.15
1.0	0.0036	21.7	20.7	1.0	21.2	0.5	0.25
1.5	0.0036	33.7	32.7	1.0	33.3	0.4	0.30
constant current = 2A							
0.5	0.0104	9.5	8.9	0.6	9.4	0.1	0.25
1.0	0.0104	21.4	20.2	1.2	21.0	0.4	0.40
1.5	0.0104	33.1	32.0	1.1	32.5	0.6	0.25
constant current = 3A							
0.5	0.0296	10.4	9.2	1.7	10.4	0.5	0.61
1.0	0.0296	21.1	19.9	1.8	20.9	0.4	0.70
1.5	0.0296	32.3	30.1	2.2	31.5	0.8	0.70

Calculations

For $I_1 = 1A$

$$n_{mean} = 4.607 \times 10^{20}\ m^{-3}$$

$$R_{H_1} = \frac{I_1}{n_1 e} = \frac{1}{4.607\times10^{20}\times1.6\times10^{-19}} = 1.35\times10^{-2}\ m^3/c$$

For $I_2 = 2A$

$$n_{mean} = 7.962\ \times10^{20}\ m^{-3}$$

$$R_{H_2} = \frac{I_2}{n_2 e} = \frac{2}{7.962\ \times10^{20}\times1.6\times10^{-19}} = 1.57\times10^{-2}\ m^3/c$$

For $I_3 = 3A$

$$n_{mean} = 12.335\ \times10^{20}\ m^{-3}$$

$$R_{H_3} = \frac{I_3}{n_3 e} = \frac{3}{12.335\times10^{20}\times1.6\times10^{-19}} = 1.52\times10^{-2}\ m^3/c$$

(a) Heater current potentiometer at minimum position.
(b) Probe current potentiometer at minimum position.

- Connect Hall Probe in given probe socket (NV622).
- Switch on constant current Power supply and set some low value of current.
- Switch on the measurement unit and increase probe current by probe current potentiometer and fix it at 5 mA.
- There may be some voltage reading even outside the magnetic field. This is due to imperfect arrangement of the four contact of the hall probe and generally known as "zero field potential". In this case, this error should be subtracted from the Hall voltage reading as we consider it as a reference.
- Now place the Hall probe between magnetic poles using stand such that the magnetic and electric field should be perpendicular to each other.
- Due to this arrangement a force is generated in semiconductor, therefore a potential difference is developed in semiconductor wafer, which is perpendicular of both field. This potential difference is called Hall voltage.
- You can measure and record the potential difference on the display.
- Measure Hall voltage for both sides of probe.

Value of Hall coefficient of Germanium (observed)

$$= \frac{(1.35 + 1.57 + 1.52)\, 10^{-2}}{3} \, m^3/c$$

$$= 1.48 \times 10^{-2} \, m^3/c$$

Value of Hall coefficient of Germanium (theoritical)

$$= 1.55 \times 10^{-2} \, m^3/c$$

$$\% \text{ error} = \left(\frac{1.55 \times 10^{-2} - 1.48 \times 10^{-2}}{1.55 \times 10^{-2}} \right) \times 100$$

$$= 4.52\%$$

- Subtract zero field potential and take the mean of both sides Hall voltages readings. This is Hall voltage V_H.
- charge carrier density.

$$n = \frac{BI}{V_H \times t \times e}.$$

- Hall coefficient.

$$R_H = \frac{n}{ne}.$$

Here,

n = carrier concentration.

B = magnetic field

I = current of probe

V_H = Hall voltage.

t = Width of Hall crystal

e = Electron charge = 1.6×10^{-19} C.