Name: Prathapani Satwika

Reg: 20BCD7160

Title of the experiment:-

Determination of energy band gap of a semiconductor by Four probe method.

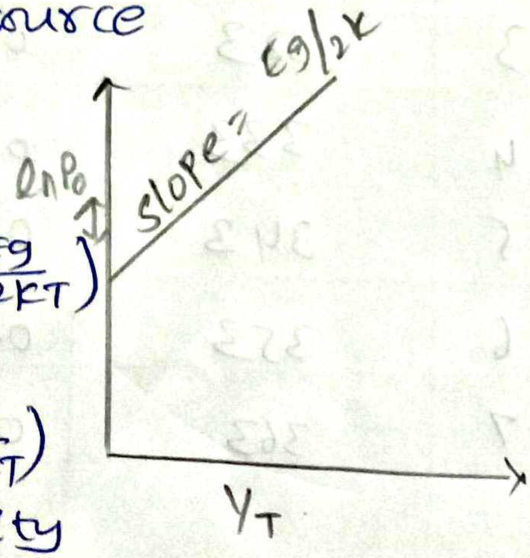
Objective:-

To determine the band gap of a semi conductor by measuring the resistivity as a function of temperature using four probe method.

Equipment list:-

1) Spring loaded four probes
2) Germanium (semiconductor) crystal
3) oven (upto 150°C)
4) Thermometer
5) Constant current source
6) Voltmeter

Formula:-




$$\sigma(T) = \sigma_0 \exp\left(-\frac{E_g}{2KT}\right)$$

$$\rho(T) = \rho_0 \exp\left(+\frac{E_g}{2KT}\right)$$

$\sigma_0$ - Residual conductivity

$\rho_0$ - Residual Resistivity

$E_g$ - Band gap of the intrinsic semiconductor

k - Boltzman constant

T - absolute temperature

$$\rho = CF\left(\frac{V}{I}\right) \Rightarrow \rho = 0.213 \times \left(\frac{V}{I}\right)$$

I - current passing through the semiconductor

V - measured voltage

<u>Band Gap Energy</u>:-

$$E_g = 2km$$

m → slope of the graph $\log_e \rho$ vs $1/T$

<u>Report</u>:- k → Boltzman constant $= 8.617 \times 10^{-5}$ eV/K

| S.NO | Temperature (K) | voltage (V) | Resistivity ($\rho$) | $1/T$ ($K^{-1}$) | $\log_e \rho$ |
|---|---|---|---|---|---|
| 1 | 300 | 0.303 | 18.63 Ωm | $3.33 \times 10^{-3}$ | 2.91 |
| 2 | 313 | 0.323 | 19.69 Ωm | $3.19 \times 10^{-3}$ | 2.97 |
| 3 | 323 | 0.331 | 20.14 Ωm | $3.09 \times 10^{-3}$ | 3.00 |
| 4 | 333 | 0.332 | 20.20 Ωm | $3.00 \times 10^{-3}$ | 3.00 |
| 5 | 343 | 0.315 | 19.17 Ωm | $2.91 \times 10^{-3}$ | 2.95 |
| 6 | 353 | 0.300 | 18.25 Ωm | $2.83 \times 10^{-3}$ | 2.90 |
| 7 | 363 | 0.223 | 13.57 Ωm | $2.75 \times 10^{-3}$ | 2.60 |

calculations :-

$\boxed{C = 0.213\ cm}$ $\boxed{I = 3.5 \times 10^{-3}}$

obs1:-

$$\rho = 0.213 \times \frac{V}{I} = 0.213 \times \frac{0.303}{3.5 \times 10^{-3}}$$

$$= 18.439\ \Omega m$$

obs2:

$$\rho = 0.213 \times \frac{V}{I} = \frac{0.213 \times 0.323}{3.5 \times 10^{-3}} = 19.65\ \Omega m$$

obs3:

$$\rho = 0.213 \times \frac{V}{I} = \frac{0.213 \times 0.331}{3.5 \times 10^{-3}} = 20.14\ \Omega m$$

obs4:

$$\rho = 0.213 \times \frac{V}{I} = \frac{0.213 \times 0.332}{3.5 \times 10^{-3}} = 20.20\ \Omega m$$

obs5:

$$\rho = 0.213 \times \frac{V}{I} = \frac{0.213 \times 0.315}{3.5 \times 10^{-3}} = 19.17\ \Omega m$$

obs6:

$$\rho = 0.213 \times \frac{V}{I} = \frac{0.213 \times 0.300}{3.5 \times 10^{-3}} = 18.25\ \Omega m$$

obs7:

$$\rho = 0.213 \times \frac{V}{I} = \frac{0.213 \times 0.223}{3.5 \times 10^{-3}} = 13.57\ \Omega m$$

From graph,

$$\rho(T) = \rho_0 \exp\left(\frac{E_g}{2kT}\right)$$

$$\log \rho(T) = \log \rho_0 + \frac{E_g}{2kT}$$

$$M = \frac{E_g}{2k}$$ [k is Boltzman's constant $k = 8.617 \times 10^{-5}$ eV/k]

$$E_g = 2k \times M$$

$$E_g = 2 \times 8.617 \times 10^{-5} \times 3.75 \times 10^{3}$$

$$\boxed{E_g = 0.64 \text{ eV}}$$

<u>Result:-</u>

The band gap energy ($E_g$) of the germanium crystal is 0.64 eV