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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)
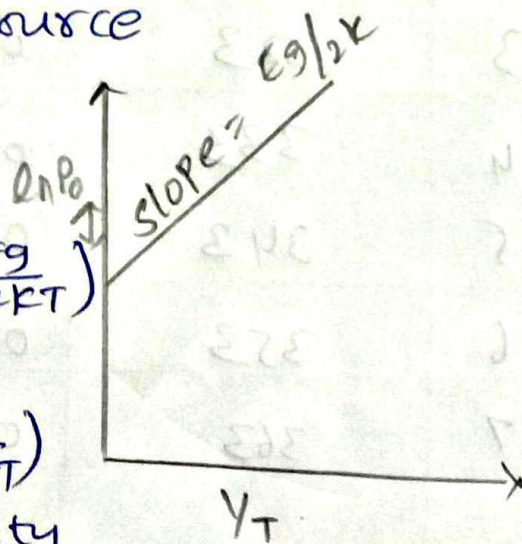
4) Thermometer

5) constant current source

6) voltmeter

Formula:-

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

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

σ_0 - Residual conductivity

ρ_0 - Residual Resistivity

E_g - Band gap of the intrinsic semiconductor

k - Boltzman constant

T - absolute temperature

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

I - current passing through the semiconductor

V - measured voltage

Band Gap Energy:-
$$E_g = 2km$$

$m \to$ slope of the graph $\log_e P$ vs $1/T$

Report:- $k \to$ Boltzman constant $= 8.617 \times 10^{-5}$ eV/K

S.NO	Temperature (K)	Voltage (V)	Resistivity (P)	$1/T$ (K⁻¹)	$\log_e P$
1	300	0.303	18.65 Ωm	3.33×10^{-3}	2.91
2	313	0.323	19.69 Ωm	3.19×10^{-3}	2.97
3	323	0.331	20.14 Ωm	3.09×10^{-3}	3.00
4	333	0.332	20.20 Ωm	3.00×10^{-3}	3.00
5	343	0.315	19.17 Ωm	2.91×10^{-3}	2.95
6	353	0.300	18.25 Ωm	2.83×10^{-3}	2.90
7	363	0.223	13.57 Ωm	2.75×10^{-3}	2.60

calculations :-

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

obs1:-

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

$$= 18.439 \; \Omega m$$

obs2:

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

obs3:

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

obs4:

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

obs5:

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

obs6:

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

obs7:

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

From graph,

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

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

$$M = \frac{E_g}{2k} \qquad \left[\begin{array}{l} k \text{ is Boltzman's constant} \\ k = 8.617 \times 10^{-5} \text{ ev/k} \end{array}\right]$$

$$E_g = 2k \times M$$

$$E_g = 2 \times 8.617 \times 10^{-5} \times 3.25 \times 10^{3}$$

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

Result:-

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

Y

$(\log P)$

scale.
x-axis : 1 unit = 0.9×10^{-3} $k=1$
y-axis : 1 unit = 0.9

3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2

0   0.2   0.4   0.6   0.8   1.0   1.2   1.4   1.6   1.8   2.0   2.2   2.4   2.6   2.8   3.0   3.2

$\rightarrow X \times 10^{-3}$ X

$\leftarrow 1/T \rightarrow$