NAME: MAJIGA JASWANTH
REGNO: 20BCD7171

# Experiment - 6

## Title of the experiment:

Determination of energy bandgap of a Semiconductor by four probe method

## Objective:

To determine the bandgap of a Semiconductor 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 (up to 150°c)
4. Thermometer
5. Constant current source
6. voltmeter

## formula:

$E_g$ = Energy difference between valence band and Conduction band

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

$\rho$ = resistivity

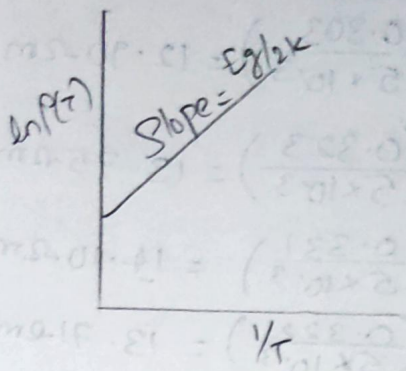
$\rho_0$ = Rendual resistivity

T = temperature

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

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

$$\ln \rho(T) = \ln \rho_0 + \frac{E_g}{2KT}$$




$\rho = cf\left(\frac{V}{I}\right)$

$\rho = 0.213 Cm\left(\frac{V}{I}\right)$

Cf = Correction-factor

I = Current Passing through Semiconductor

V = measured Voltage

Cf = 0.213Cm

Laboratory Report :-

Current $I = 5 \times 10^{-3} A$

| S/No | Temperature (K) | Voltage (V) | Resistivity $\rho = cf(V/I)$ | $1/T$ $(K^{-1})$ | $\log \rho$ |
|---|---|---|---|---|---|
| 1 | 300K | 0.303V | 12.90 Ωm | $0.0033 K^{-1}$ | 2.55 |
| 2. | 313K | 0.323V | 13.75 Ωm | $0.0031 K^{-1}$ | 2.62 |
| 3. | 323K | 0.331V | 14.10 Ωm | $0.0030 K^{-1}$ | 2.64 |
| 4. | 333K | 0.322V | 13.71 Ωm | $0.0030 K^{-1}$ | 2.61 |
| 5. | 343K | 0.315V | 13.41 Ωm | $0.0029 K^{-1}$ | 2.59 |
| 6. | 353K | 0.300V | 12.78 Ωm | $0.0028 K^{-1}$ | 2.54 |
| 7. | 363K | 0.223V | 9.49 Ωm | $0.0027 K^{-1}$ | 2.25 |

Calculation :-

$\rho = cf\left(\frac{V}{I}\right)$

$$\rho_1 = 0.213 \times \left(\frac{0.303}{5\times10^{-3}}\right) = 12.90\,\Omega m$$

$$\rho_2 = 0.213 \times \left(\frac{0.323}{5\times10^{-3}}\right) = 13.75\,\Omega m$$

$$\rho_3 = 0.213 \times \left(\frac{0.331}{5\times10^{-3}}\right) = 14.10\,\Omega m$$

$$\rho_4 = 0.213 \times \left(\frac{0.322}{5\times10^{-3}}\right) = 13.71\,\Omega m$$

$$\rho_5 = 0.213 \times \left(\frac{0.315}{5\times10^{-3}}\right) = 13.41\,\Omega m$$

$$\rho_6 = 0.213 \times \left(\frac{0.300}{5\times10^{-3}}\right) = 12.78\,\Omega m$$

$$\rho_7 = 0.213 \times \left(\frac{0.223}{5\times10^{-3}}\right) = 9.49\,\Omega m$$

Slope $m = \dfrac{2.54 - 2.25}{(2.83-2.75)\times10^{-3}} = \dfrac{0.29}{0.08\times10^{-3}} = 3.625\times10^{3}$

$$E_g = 2 \times K \times m$$

$$= 2 \times 0.8617 \times 10^{-6} \times 3.625 \times 10^{3}$$

$$E_g = 0.62\,eV$$

Result :

The band gap of intrinsic semiconductor of Germanium Crystal is = 0.62eV

# Exp-6

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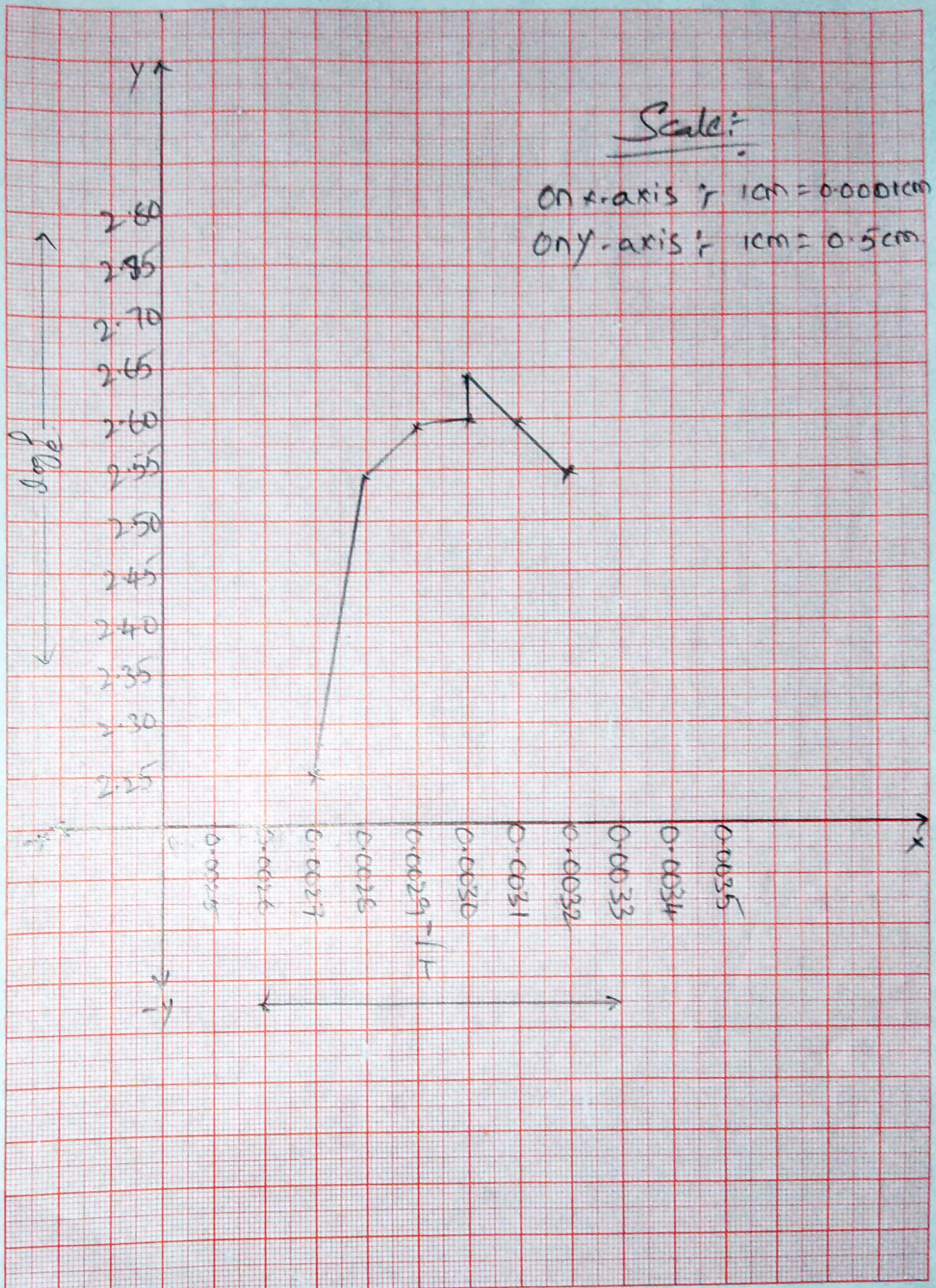
Scale:-
On x-axis :- 1cm = 0.0001cm
On y-axis :- 1cm = 0.5cm
y
x
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
2.35
2.30
2.25
0.0027
0.0028
0.0029
0.0030
0.0031
0.0032
0.0033
0.0034
0.0035
1/T
-y