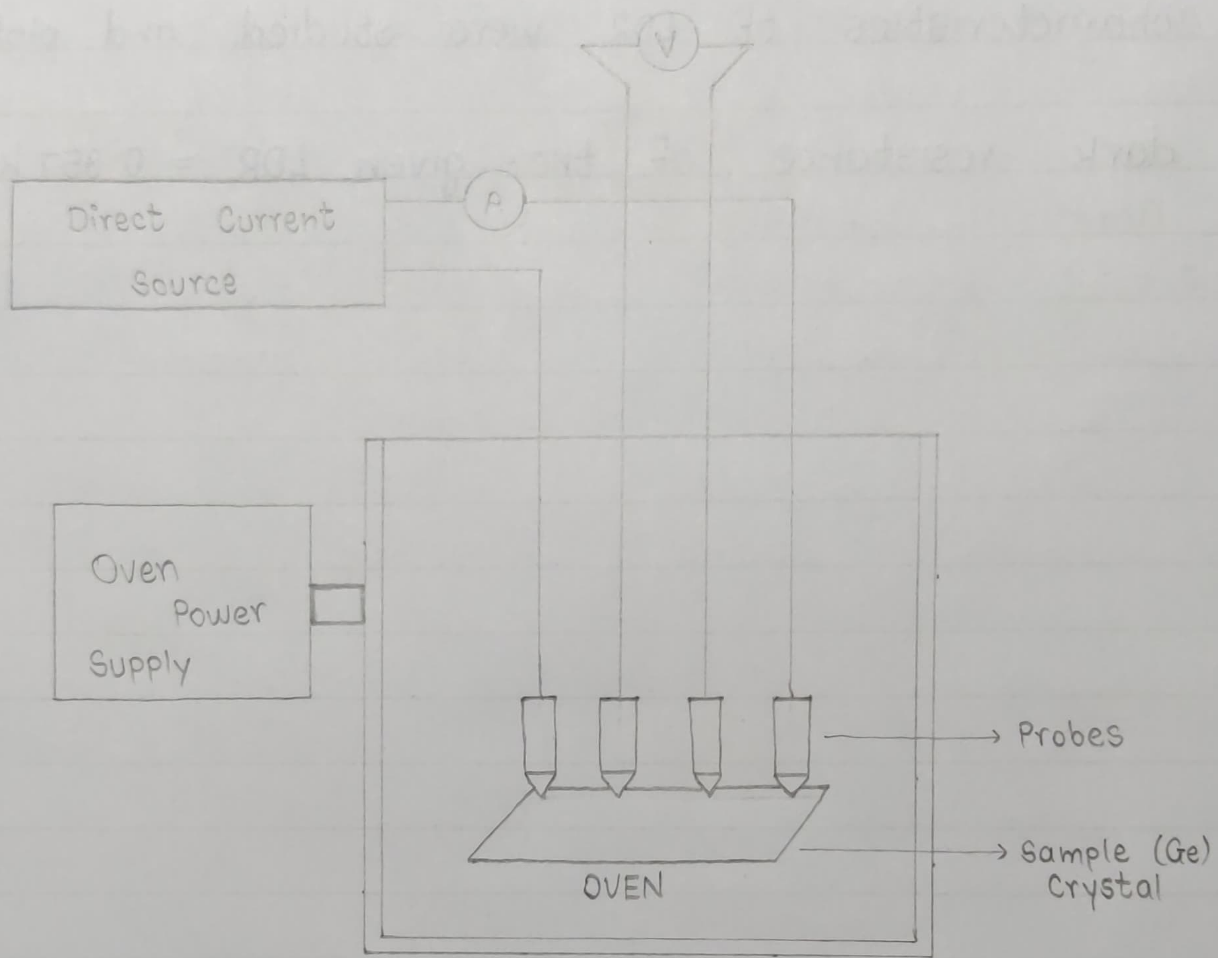
DIAGRAM ⟹



TO DETERMINE THE RESISTIVITY OF THE SEMI-CONDUCTOR FOR VARIOUS TEMPERATURES ⟹

Current (I) = 2mA.

S. No.	Temperature		Voltage	Resistivity	1/T	$Log_{10} \rho$
	in °C	in K	mV	Ω-cm	(10^{-3}) K	Ω-cm
1.	30	303	83.2	8.8608	3.30	0.9474
2.	35	308	81.6	8.6904	3.24	0.9390
3.	40	313	81.5	8.6797	3.19	0.9385
4.	45	318	81	8.6265	3.14	0.9358

RESISTIVITY DETERMINATION FOR A SEMICONDUCTOR WAFER USING FOUR-PROBE METHOD.

AIM ⟹

To determine the energy band gap of a semiconductor (Germanium) using four-probe method.

APPARATUS REQUIRED ⟹

Probes arrangement (it should have four probes, coated with zinc at tips). The probes should be equally spaced and must be in good electrical contact with the sample. Sample (Germanium or Silicon crystal chip with non-conducting base). Oven (for the variation of temperature of the crystal from room temperature to about 200 °c), a constant current generator (open circuit voltage about 20V, current range : 0 to 10mA), milli - voltmeter (range from 100mV to 3V), power supply for over thermometer.

FORMULA ⟹

The energy band-gap, eg of semiconductor is given by:

$$E_g = 2k_B \times \frac{2.3026 \times \log_{10}\rho}{1/T} \text{ in eV}$$

where, k_B is Boltzmann constant equal to 8.6×10^{-5} eV/Kelvin and ρ is the resistivity of the semiconductor crystal given by:

5.	50	323	80.1	8.5306	3.09	0.9309
6.	55	328	79.0	8.4135	3.04	0.9249
7.	60	333	76.3	8.1259	3.00	0.9098
8.	65	338	73.0	7.7745	2.95	0.8906
9.	70	343	68.2	7.2633	2.91	0.8611
10.	75	348	63.0	6.7095	2.87	0.8266
11.	80	353	56.5	6.0172	2.83	0.7793
				MEAN $\Longrightarrow$	3.0509	0.8985

OBSERVATIONS $\Longrightarrow$

1) Distance between probes = 0.33 mm

2) Thickness of the crystal chip (W) = 0.5 mm

3) Current (I) = 2mA

CALCULATIONS $\Longrightarrow$

1) $V = 83.2\ mV$, $I = 2mA$

$\therefore \rho = \frac{V}{I} \times 0.213$

$= \frac{83.2}{2} \times 0.213 = 8.8608$

2) $V = 81.6\ mV$, $I = 2mA$

$\therefore \rho = \frac{V}{I} \times 0.213$

$= \frac{81.6}{2} \times 0.213 = 8.6904$

$$\rho = \frac{\rho_0}{F(W/S)} \quad \text{where, } \rho_0 = \frac{V}{I} \times 2\pi S = \frac{V}{I}(0.213)$$

Here, S is distance between probes and W is the thickness of semi-conducting crystal. V and I are the voltage and current across and through the crystal chip.

3) $V = 81.5\ mV \quad , \quad I = 2mA$

$$\therefore \rho = \frac{V}{I} \times 0.213$$

$$= \frac{81.5}{0.2E} \times 0.213 = 8.6797$$

4) Energy - band - gap (from calculations).

$$E_g = 2k_B \times \frac{2.3026 \times \log_{10}\rho}{1/T} \text{ in eV}$$

$$= \frac{2 \times 8.6 \times 10^{-5} \times 2.3026 \times 0.8985}{3.0509 \times 10^{-3}}$$

$$= \frac{2 \times 8.6 \times 2.3026 \times 0.8985}{3.0509} \times \frac{10^3}{10^5}$$

$$= \frac{35584.840}{3.0509 \times 10^5} = \frac{35584.840}{305090} = 0.1166\ eV$$

5) Energy band - gap (from graph).

$$E_g = 2k_B \times \frac{2.3026 \times \log_{10}\rho}{1/T}$$

$$= 2 \times 8.6 \times 10^{-5} \times 2.3026 \times 1000 \times \frac{AB}{BC}\ eV$$

$$= 0.396 \times \frac{AB}{BC}\ eV$$

$$= 0.396 \times \overset{1.0225}{\cancel{0.0865}} = \overset{0.4049}{\cancel{0.0342}}\ eV$$

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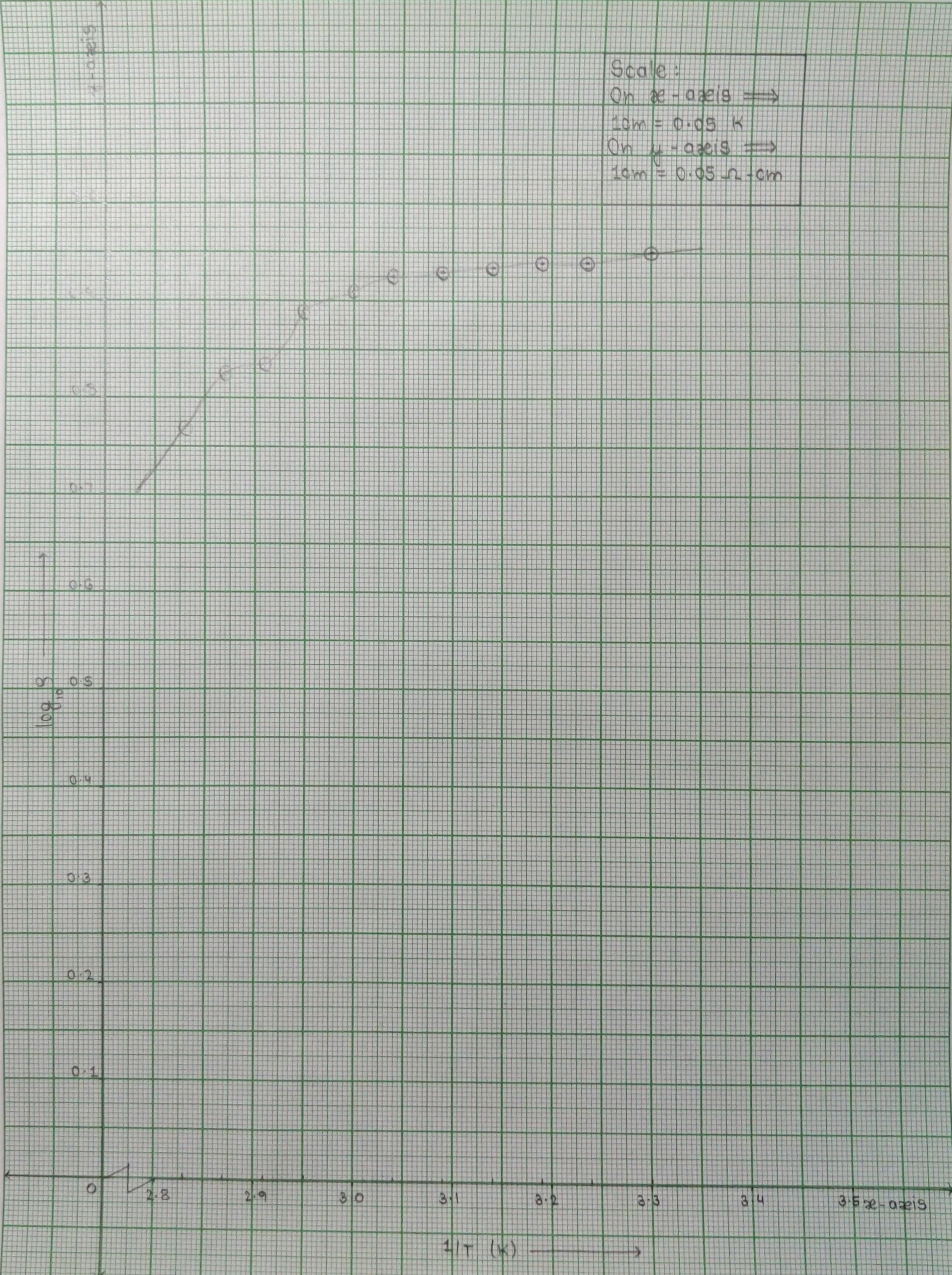
RESULT ⟹

The energy band gap of the semiconductor material is 0.4049 eV.

Teacher's Signature ________


Scale :
On x-axis ⟹
1cm = 0.05 K
On y-axis ⟹
1cm = 0.05 Ω-cm
y-axis
$\log_{10} \rho$
0.6
0.5
0.4
0.3
0.2
0.1
0
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5
x-axis
1/T (K)

$$\text{slope}\left(\frac{dy}{dx}\right) = \frac{AB}{BC}$$

$$= \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{0.8611 - 0.7793}{2.91 - 2.83}$$

$$= \frac{0.0818}{0.08} = 1.0225$$