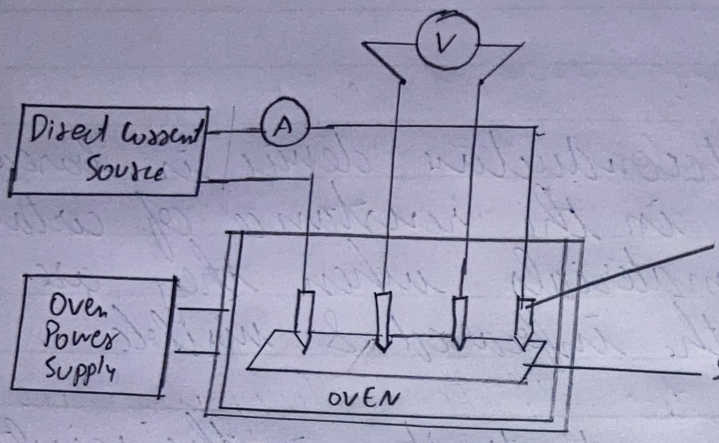
Experiment

Name .....



← Experimental Set-up

OBSERVATIONS →

Distance between probes(s) = 0.33 mm

Thickness of the crystal chip (w) = 0.5 mm

Current (I) = 2.0 mA.

- Resistivity of the semiconductor for various temperatures.

Sr. No.	Temperature. in °C	in K	Voltage(V) (mV)	Resistivity (ρ) = $\frac{V}{I}$(0.213) (ohm cm).	1/T (10⁻³) (K)	$\log_{10}\rho$ (ohm cm)
1	30	303	83.2	8.8608	3.3003	0.9474
2	35	308	81.6	8.6904	3.2467	0.9390
3	40	313	81.5	8.6797	3.1948	0.9385
4	45	318	81	8.5200	3.1446	0.9309
5	50	323	80.1	8.5306	3.0959	0.9304
6	55	328	79.0	8.4135	3.0487	0.9249
7	60	333	76.3	8.1259	3.0030	0.9098
8	65	338	73	7.7745	2.9585	0.8906
9	70	343	68.2	7.2633	2.9154	0.8611
10	75	348	63	6.7095	2.8735	0.8266
11	80	353	56.5	6.0172	2.8328	0.7793

Date 02/11/20

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RESISTIVITY DETERMINATION FOR SEMI-CONDUCTOR WAFER USING FOUR PROBE METHOD

Aim:

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

Apparatus Req:

Probe arrangements (it should have 4 probes, coated with Zn at tips). A constant current generator (open circuit voltage about 20V, current range 0-10 mA), Milli-voltmeter (100mV-3V), Power supply for oven thermometer.

Formula:

The energy band gap, E_g, of a semi-conductor is given by.

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

where

K_B is Boltzmann constant equal to 8.6×10^{-5} eV / Kelvin.

ρ is the resistivity of the semi-conductor crystal is given by

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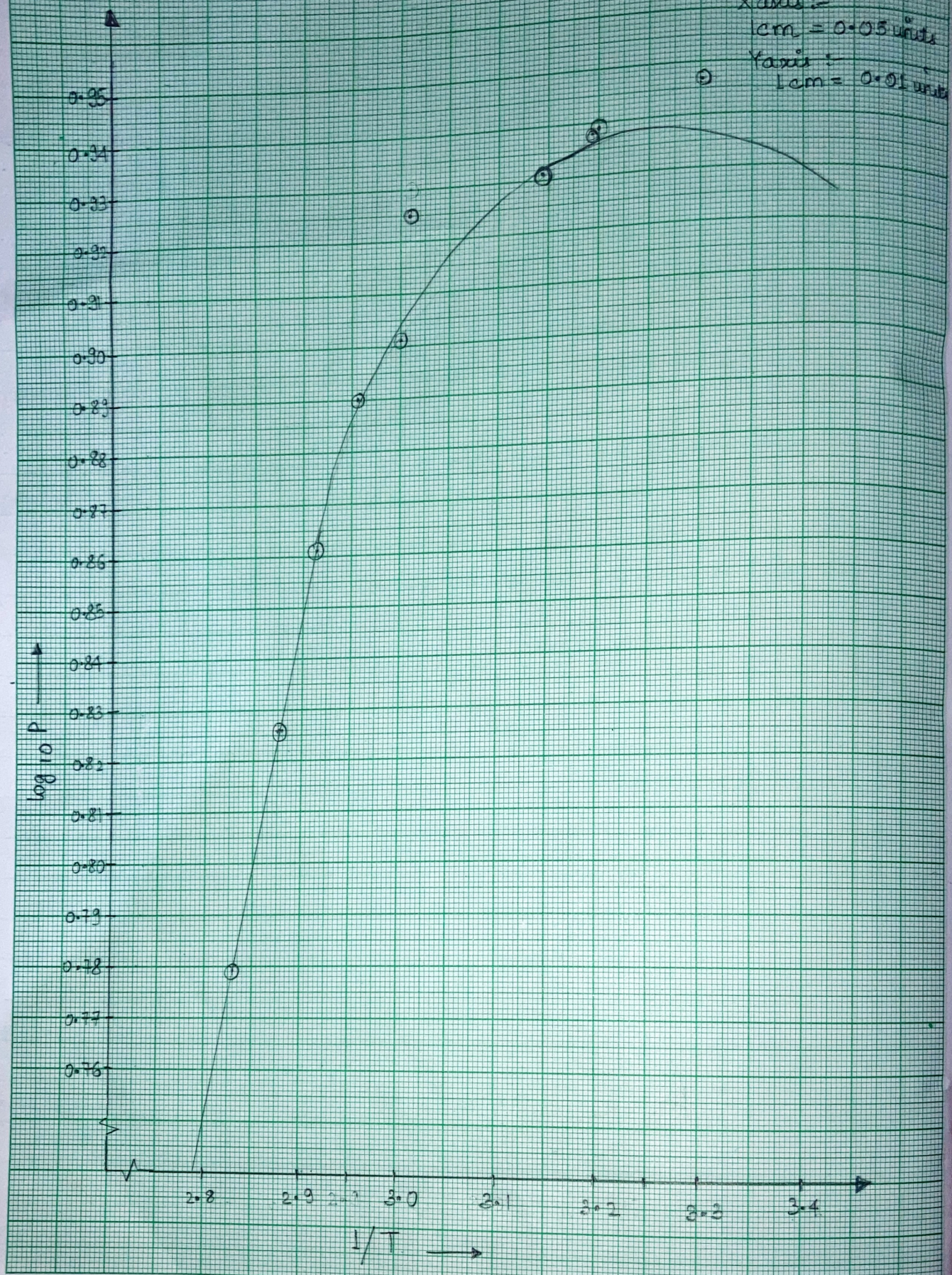
SCALE :-
X axis :-
1cm = 0.05 units
Y axis :-
1cm = 0.01 units
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0.81
0.80
0.79
0.78
0.77
0.76
log10 P
2.8
2.9
3.0
3.1
3.2
3.3
3.4
1/T

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$$\rho = \frac{\rho_0}{f(w/s)}$$

where,

$$\rho_0 = \frac{V}{I} \times 2\pi s \quad ; \rho = \frac{V}{I}\,(0.213).$$

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

GRAPH →

The graph is plotted for $10^3/T$ and $\log_{10}\rho$.

The slope of the curve $\frac{AB}{BC} = \frac{\log_{10}\rho}{10^3/T}$.

$=$.

$$\therefore E_g = 2k \times 2.3026 \times \frac{AB}{BC} \times 1000\,eV.$$

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

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RESULT →

(i). The Energy Band Gap of the semiconductor material = 0.4602 eV.

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CALCULATIONS (Formulas Used $\Rightarrow \rho = \frac{V}{I}(0.213)$).

① $\rho_1 = \frac{V}{I}(0.213) = \frac{83.2}{2}(0.213) = 8.8608\ \Omega cm$

$10^3/T = 1000/303 = 3.3003\ K^{-1}$.

$\log_{10}\rho = 0.9474$.

② $\rho = \frac{V}{I}(0.213) = \frac{81.6}{2}(0.213) = 8.6904\ \Omega cm$

$10^3/T = 1000/308 = 3.2467\ K^{-1}$

$\log_{10}\rho = 0.9390$

③ $\rho = \frac{V}{I}(0.213) = \frac{81.5}{2}(0.213) = 8.6797\ \Omega cm$

$10^3/T = 1000/313 = 3.1948\ K^{-1}$

$\log_{10}\rho = 0.9385$

④ $\rho = \frac{V}{I}(0.213) = \frac{81}{2}(0.213) = 8.6265\ \Omega cm$

$10^3/T = 1000/318 = 3.1446\ K^{-1}$

$\log_{10}\rho = 0.9358$

⑤ $\rho = \frac{V}{I}(0.213) = \frac{80.1}{2}(0.213) = 8.5306\ \Omega cm$

$10^3/T = 1000/323 = 3.0959\ K^{-1}$

$\log_{10}\rho = 0.9309$

⑥ $\rho = \frac{V}{I}(0.213) = \frac{79}{2}(0.213) = 8.4259\ \Omega cm$

$10^3/T = 1000/328 = 3.0487\ K^{-1}$

$\log_{10}\rho = 0.9249$

⑦ $\rho = \frac{V}{I}(0.213) = \frac{76.3}{2}(0.213) = 8.4135\ \Omega cm$

$10^3/T = 1000/333 = 3.0030\ K^{-1}$

$\log_{10}\rho = 0.9098$

⑧ $\rho = \frac{V}{I}(0.213) = \frac{73}{2}(0.213) = 7.7745\ \Omega cm$

$10^3/T = 1000/338 = 2.9585\ K^{-1}$

$\log_{10}\rho = 0.8906$

⑨ $\rho = \frac{V}{I}(0.213) = \frac{68.2}{2}(0.213) = 7.2633\ \Omega cm$

$10^3/T = 1000/443 = 2.9154\ K^{-1}$

$\log_{10}\rho = 0.8611$

⑩ $\rho = \frac{V}{I}(0.213) = \frac{63}{2}(0.213) = 6.7095\ \Omega cm$

$10^3/T = 1000/448 = 2.8735\ K^{-1}$

$\log_{10}\rho = 0.8266$

$$\text{Slope} = \frac{d\eta}{d\varepsilon} = \frac{\log_{10}\rho}{1/T \times 10^{-3}} = \frac{0.8266 - 0.7793}{2.8735 - 2.8328} = \frac{0.0473}{0.0407} = 1.1621.$$

Band Gap:

$E_g = 0.396 \times \text{slope}\ eV = 0.396 \times 1.1621$

$= 0.4602\ eV$

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