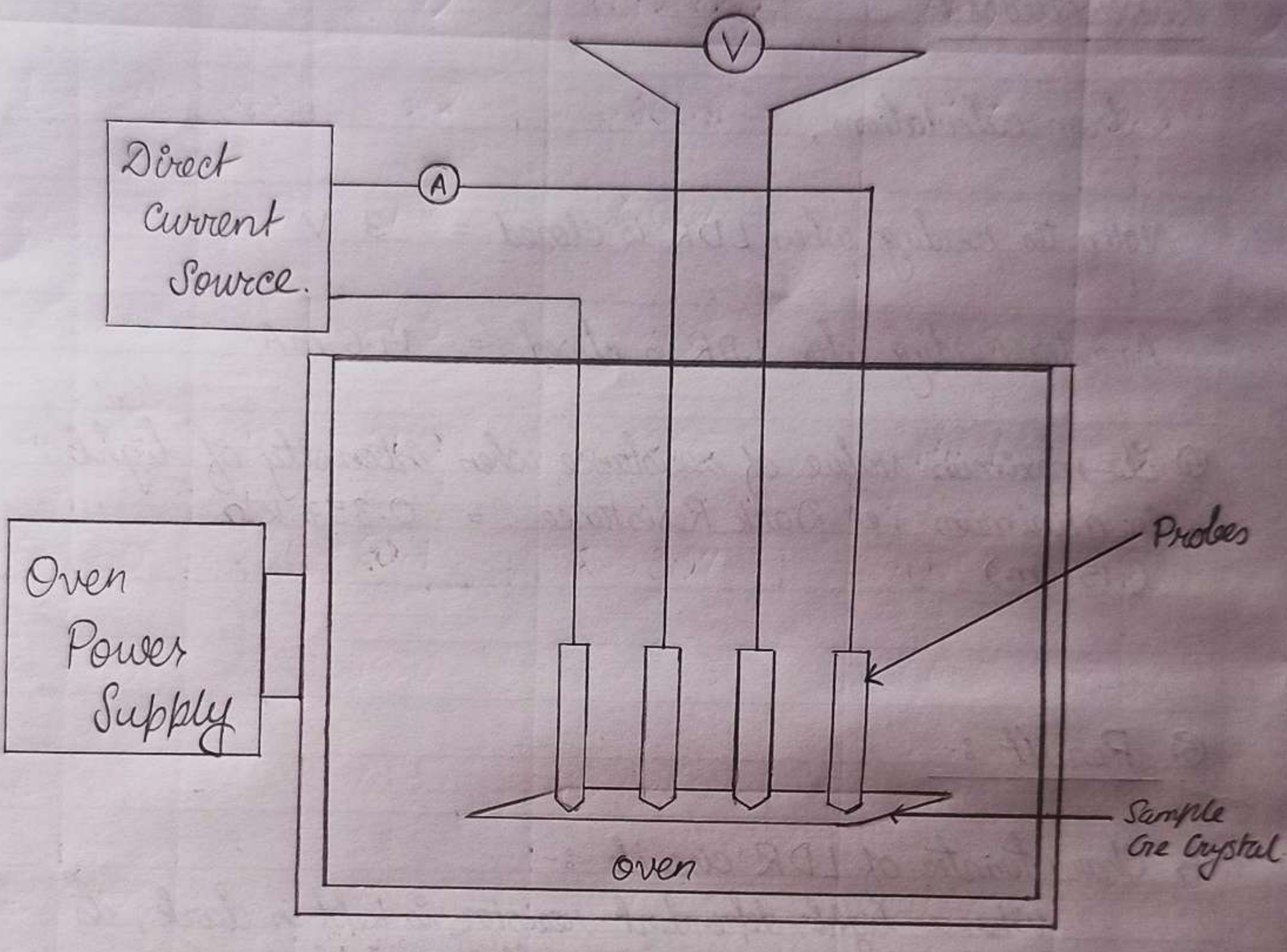


Experimental Setup

Expt. No. 04

Resistivity Determination for a Semiconductor Wafer using Four Probe Method

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

APPARATUS REQUIRED :

Probe arrangements (It should have four probes, coated with Zinc at the tips). A constant current generator (open circuit voltage about 20 V, current range 0 to 10 mA), Milli-voltmeter (range from 100 mV to 3 V), Power supply for oven, Thermometer.

FORMULAS :

The energy band gap, Eg., of 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, and ρ is the resistivity of the semi-conductor crystal given by

$$\rho = \frac{\rho_0}{f(W/s)} \text{ where } \rho_0 = \frac{V}{I} \times 2\pi s \text{ ; } \rho = \frac{V}{I}(0.213)$$

Here s is the distance between the probes and W is the thickness

OXFORD

Teacher's Signature ....

To determine the resistivity of the semi-conductor for various temperatures:

S.No	Temperature		Voltage (V)	Resistivity (ρ) $= V/I\ (0.213)$	$1/T\ (10^{-3})$	$\log_{10}\rho$
	in °C	in K	(mV)	(ohm cm)	(K)	(ohm cm)
1.	30	303	83.2	8.8608	3.3003	0.9475
2.	35	308	81.6	8.6904	3.2468	0.9390
3.	40	313	81.5	8.6798	3.1949	0.9385
4.	45	318	81.0	8.6265	3.1447	0.9358
5.	50	323	80.1	8.5307	3.0960	0.9308
6.	55	328	79.0	8.4135	3.0488	0.9250
7.	60	333	76.3	8.1260	3.0030	0.9099
8.	65	338	73.0	7.7745	2.9586	0.8907
9.	70	343	68.2	7.2633	2.9155	0.8821
10.	75	348	63.0	6.7095	2.8736	0.8267
11.	80	353	56.5	6.0173	2.8329	0.7794

Current (I) = 2 mA

of the semi conducting crystal. V and I are the voltage and current accross and through the crystal chip.

① OBSERVATIONS:

Distance between probes (S) = 0.33 mm

Thickness of crystal chip (W) = 0.50 mm

Current (I) = 2.00 mA

CALCULATIONS:

1. $\rho = V/I\,(0.213) = (81.2/2)\,0.213 = 8.8608\ \Omega cm$; $1/T = 1/303 = 3.3003\times10^{-3}\ K$
   $\log_{10}\rho = \log_{10} 8.8608 = 0.9475\ \Omega cm.$

2. $\rho = V/I\,(0.213) = (81.6/2)\,0.213 = 8.6904\ \Omega cm$; $1/T = 1/308 = 3.2468\times10^{-3}\ K$
   $\log_{10}\rho = \log_{10} 8.6904 = 0.9390\ \Omega cm.$

3. $\rho = V/I\,(0.213) = (81.5/2)\,0.213 = 8.6798\ \Omega cm$; $1/T = 1/313 = 3.1949\times10^{-3}\ K$
   $\log_{10}\rho = \log_{10} 8.6798 = 0.9385\ \Omega cm.$

4. $\rho = V/I\,(0.213) = (81.0/2)\,0.213 = 8.6265\ \Omega cm$; $1/T = 1/318 = 3.1447\times10^{-3}\ K$
   $\log_{10}\rho = \log_{10} 8.6265 = 0.9358\ \Omega cm$

5. $\rho = V/I\,(0.213) = (80.1/2)\,0.213 = 8.5307\ \Omega cm$; $1/T = 1/323 = 3.0960 \times 10^{-3}\ K$

$\log_{10} \rho = \log_{10} 8.5307 = 0.9308\ \Omega cm.$

6. $\rho = V/I\,(0.213) = (79.0/2)\,0.213 = 8.4135\ \Omega cm$; $1/T = 1/328 = 3.0488 \times 10^{-3}\ K$

$\log_{10} \rho = \log_{10} 8.4135 = 0.9250\ \Omega cm.$

7. $\rho = V/I\,(0.213) = (76.3/2)\,0.213 = 8.1260\ \Omega cm$; $1/T = 1/333 = 3.0030 \times 10^{-3}\ K$

$\log_{10} \rho = \log_{10} 8.1260 = 0.9099\ \Omega cm.$

8. $\rho = V/I\,(0.213) = (73.0/2)\,0.213 = 7.7745\ \Omega cm$; $1/T = 1/338 = 2.9586 \times 10^{-3}\ K$

$\log_{10} \rho = \log_{10} 7.7745 = 0.8907\ \Omega cm.$

9. $\rho = V/I\,(0.213) = (68.3/2)\,0.213 = 7.2633\ \Omega cm$; $1/T = 1/343 = 2.9155 \times 10^{-3}\ K$

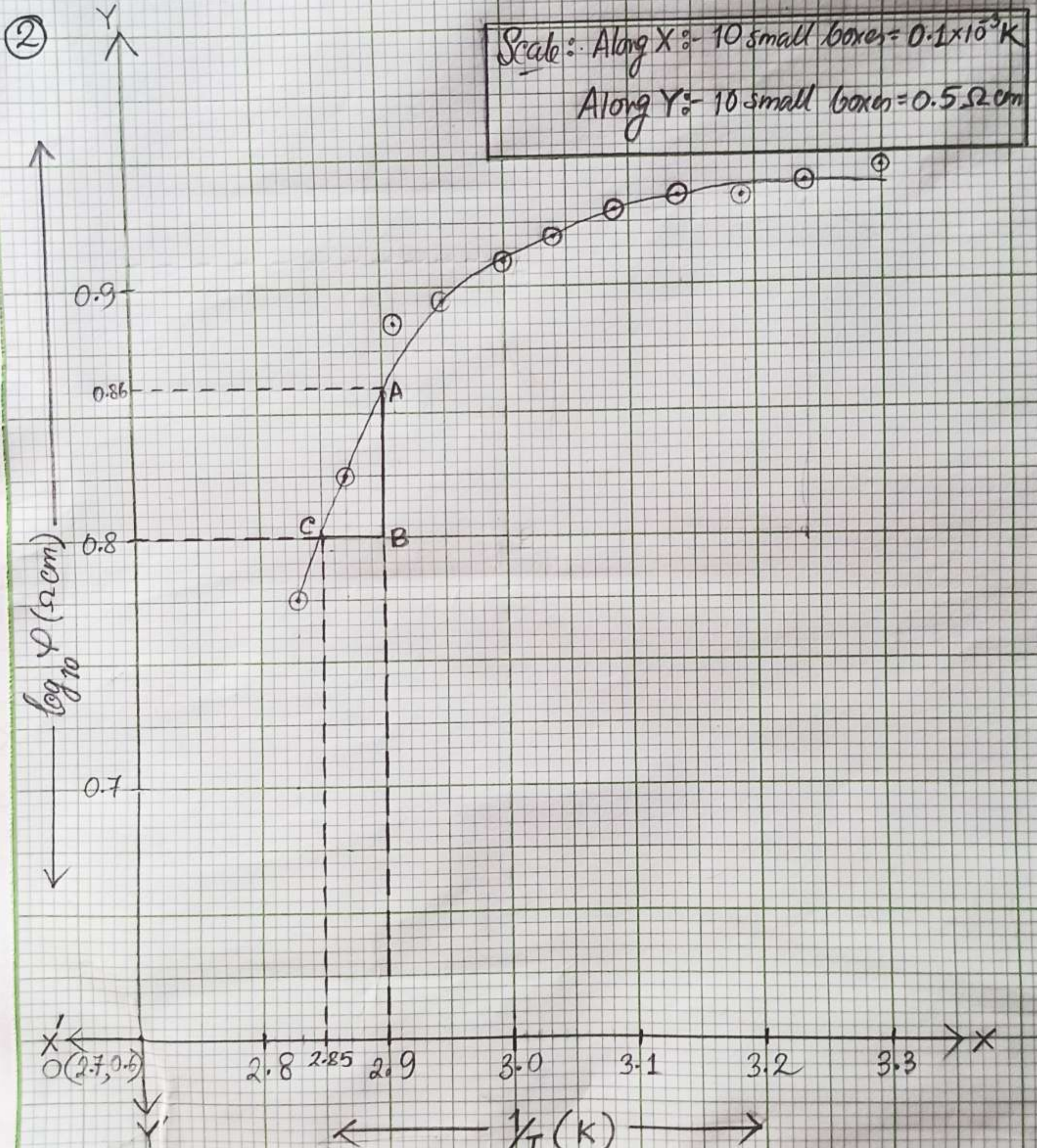
$\log_{10} \rho = \log_{10} 7.2633 = 0.8821\ \Omega cm.$

10. $\rho = V/I\,(0.213) = (63.0/2)\,0.213 = 6.7095\ \Omega cm$; $1/T = 1/348 = 2.8736 \times 10^{-3}\ K$

$\log_{10} \rho = \log_{10} 6.7095 = 0.8267\ \Omega cm.$

11. $\rho = V/I\,(0.213) = (56.5/2)\,0.213 = 6.0173\ \Omega cm$; $1/T = 1/353 = 2.8329 \times 10^{-3}\ K$

$\log_{10} \rho = \log_{10} 6.0173 = 0.7794\ \Omega cm.$



(Graph of $\log_{10} \rho$ vs $1/T$)

③ GRAPH :-

From the graph :-

AB = 0.86 Ωcm to 0.8 Ωcm
BC = 2.9 K to 2.85 K.

$$\therefore \text{Slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0.86 - 0.8}{2.9 - 2.85} = \frac{0.06}{0.05} = 1.2\ \Omega\,\text{cm}$$

$$\therefore E_g\ (\text{Germanium}) = 0.396 \times \cancel{0.85}\ 1.2 = 0.4752\ \text{eV}$$

④ ⓘ The Energy Band Gap of semi-conductor material is = 0.4752 eV

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