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Experiment No: 3

1) Aim: To determine the resistivity of semiconductor by four probe method

2) Apparatus Required: Probe arrangement, sample, oven 0-200°C, constant current generator, oven power supply and digital panel meter

3) Theory: A semiconductor has electrical conductivity intermediate in magnitude between that of conductor and insulator. According to band theory, the energy levels of semiconductors can be grouped into two bands, valence band and the conduction band. In the presence of an external electric field it is electrons in the valence band that can move freely, thereby responsible for the electrical conductivity. In case of intrinsic semiconductors, the fermi level lies in between the conduction band minimum & valence band maximum. Since conduction band lies above fermi level at 0K, when no thermal excitations are available, the conduction band remains unoccupied. So conduction is not possible at 0K and resistance is infinite. As temp increases, the occupancy of conduction band goes up.

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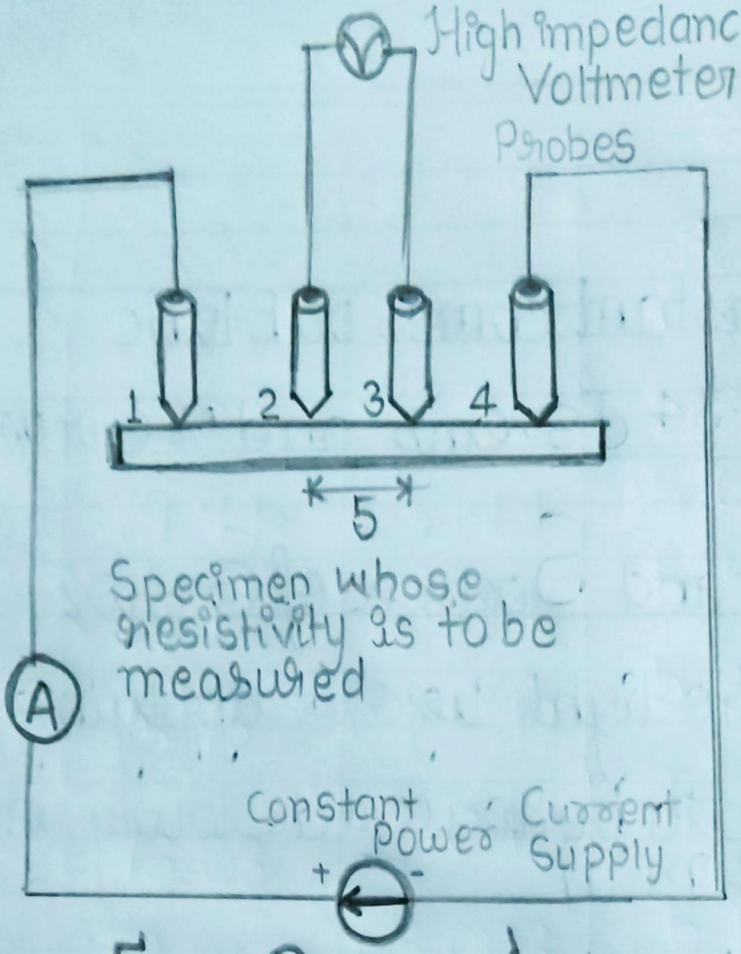

Four Probes Arrangement.

Observations:

Material = Germanium

ρ = 0.2cm.

Current = 3mA

$f(W/S) = 5.89$

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4. Formula used:

$$\rho = \frac{\rho_0}{f\left[\frac{W}{S}\right]}$$

ρ = resistivity of material.
W = thickness of slice
S = spacing b/w the probes in meter.

$$\rho_0 = \frac{V}{I} \times 2\pi S$$

V = potential difference b/w inner probes in volts
I = current through outer pair of probes in ampere

Resistivity is the reciprocal of conductivity & its temperature dependence is given by

$$\rho = A \exp\left[\frac{E_g}{2kT}\right]$$

E_g = Bandgap of material
T = Temperature in Kelvin
k = Boltzmann Constant, $k = 8.6 \times 10^{-5}$ eV/K.

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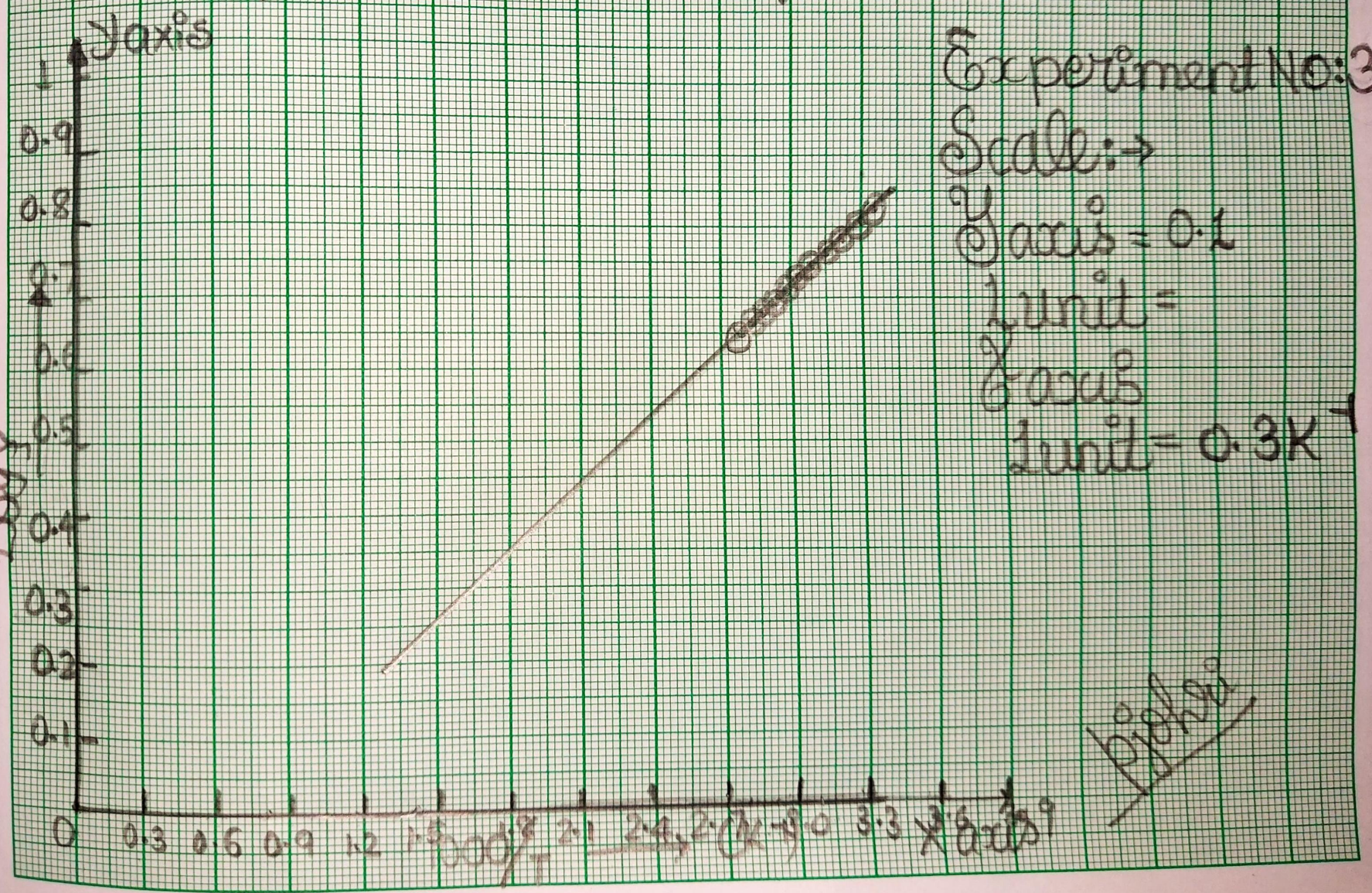
Observation Table

Sr. No	Temp (K)	Voltage across inner probes	1000/T (K)	Resistivity (ρ)	Log ρ
1	303	84.65	3.3	6.02	0.779
2	308	82.22	3.246	5.847	0.766
3	313	79.94	3.194	5.685	0.754
4	318	77.78	3.144	5.531	0.742
5	323	75.75	3.095	5.387	0.731
6	328	73.83	3.048	5.25	0.720
7	333	72.01	3.003	5.121	0.709
8	338	70.3	2.958	4.999	0.698
9	343	68.67	2.915	4.883	0.688
10	348	67.12	2.873	4.773	0.678
11	353	65.65	2.832	4.668	0.669
12	358	64.25	2.793	4.569	0.659


Yaxis
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
log Q
0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3.0
3.3
3.6
3.9
1000/T
Experiment No:3
Scale:→
Yaxis = 0.1
unit
Xaxis
unit = 0.3K⁻¹
Right

Calculations

$$\text{Slope} = \frac{0.75 - 0.69}{3.18 - 2.92}$$

$$= 0.23$$

Energy Band Gap $E_g = 2.3026 \times 2 \times K_a \times \text{Slope} \times 10^3$ (eV)

$= 2.3026 \times 2 \times 8.6 \times 10^{-5} \times 0.23 \times 10^3$ (eV)

$= 9.11 \times 10^{-2}$ eV

$= 0.0911$ eV Ans

Average Resistivity

$= 5.22775$ ohm cm

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5) Procedure:

1. Select the semiconductor material from the combo box
2. Select the source current from the slider
3. Select the range of oven from the combobox
4. Select the temperature from the slider
5. Click on the Run button to start heating the oven in a particular interval from the default 25°C to the temp. that we set already
6. Click on set button to display the temp that we set in the oven
7. Click on the measure button to measure the present temperature in the oven display
8. Select the range of voltmeter.
9. Measure voltage using voltmeter
10. Calculate the Resistivity of semiconductor in eV for the given temperature.

6) Result:

The band energy (Eg) gap for the given semiconductor = 0.0911 eV Ans.

7) Precautions and Sources of Error:

1) Current should be constant while performing the experiment.

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2) The top of the sample should be cleaned very carefully to remove any coating formed on it.

3) The surface on which the probes rest should be flat

4) The four probes should lie in a straight line.

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