INSTRUCTION MANUAL

➢ **Experiment:** TO DETERMINE THE RESISTIVITY OF A SEMICONDUCTOR WITH TEMPERATURE BY FOUR-PROBE METHOD & TO DETERMINE ITS BAND-GAP.

➢ **Various parts of the Instrument:**

- Constant Current Power Supply.
- Four-Probe with sample (Ge with non-conducting base) arrangement inside the oven along with four connectors.
- Heater, Thermometer for temperature measurement.

Designed & Manufactured by:

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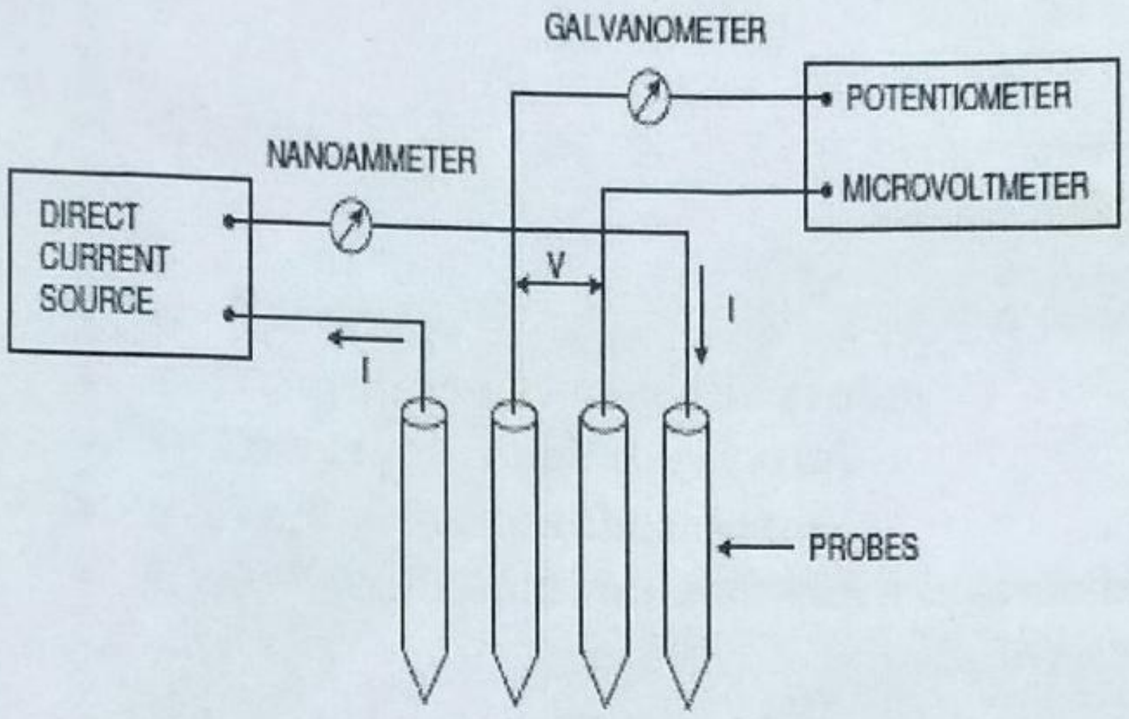
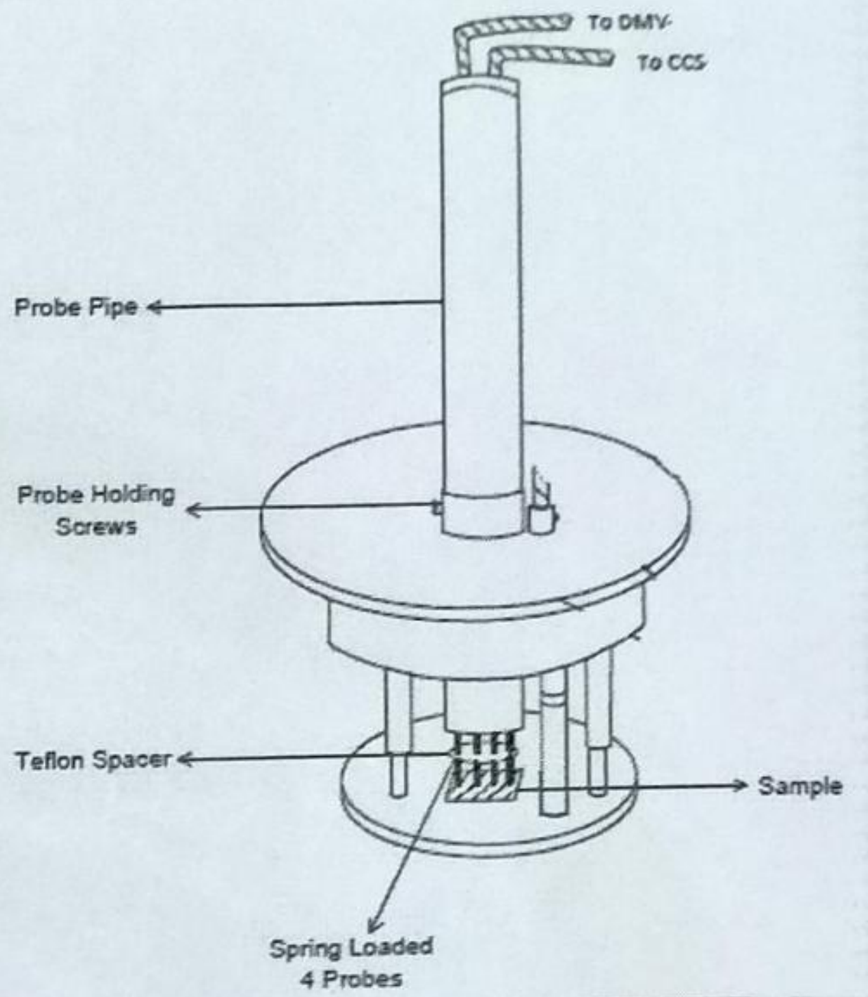
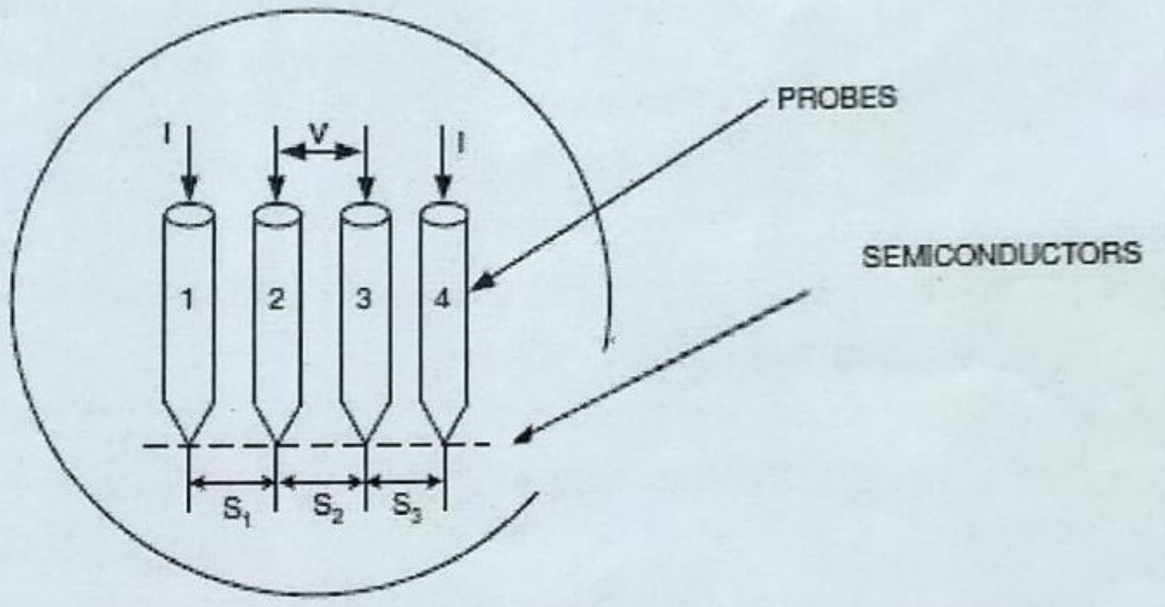


Circuit



Four-probe arrangement



Sample with probes

➢ **Theory:** Many conventional methods for measuring resistivity are unsatisfactory for semiconductors because metal-semiconductor contacts are usually rectifying in nature. Also there is generally minority carrier injection by one of the current carrying contacts. An excess concentration of minority carriers will affect the potential of other contacts and modulate the resistance of the material. The method described here overcomes the difficulties mentioned above and also offers several other advantages. It permits measurements of resistivity in samples having a wide variety of shapes, including the resistivity of small volumes within bigger pieces of semiconductor. In this manner the resistivity of both sides of p-n junction can be determined with good accuracy before the material is into bars for marking devices. This method of measurement is also applicable to silicon and other semiconductor materials.

➢ Working Formula:

- Resistivity $\rho = \frac{\rho_0}{f\left(\frac{w}{s}\right)}\ \Omega$ meter ----------(1)

- Where $\rho_0 = \frac{V}{I}\ (2\pi\ s)$----------(2)

- w– Thickness of crystal.
- s– Separation between the probes.
- i – Current through the crystal.
- v – Voltage across the crystal.
- f(w/s) – function, value of which is available in the data table.

- Band gap $E_g = 2k\frac{\ln(\rho)}{(1/T)}$ eV----------(3)

➢ Where

- k – The Boltzman's Constant.
- T – Temperature of the sample in K

➢ Procedure:

- Connect Plugs of Crystal (in our case Ge) (Four probe setup) with Constant Current Power supply sockets for the milli-voltmeter & the milli-Ammeter.
- Switch ON the AC mains of Constant current supply. LED will glow. Adjust the current at desired value (say4 mA approx). Note the corresponding mV reading in the milli-Voltmeter. Keep Switch at suitable range.
- Place the four probe arrangement in the oven and Insert Thermometer in the given Hole at the top.
- Plug Oven in AC mains. Switch ON the Supply by rotating HEAT CONTROL switch in clock wise direction. LED will indicate it's ON position.
- Let the oven heat, note the reading in milli-Voltmeter and temperature 0C in thermometer.
- Take milli-voltmeter reading for temperature upto 2000C. while the milli-Ammetre reading remains at constant value.

**** In each case of measurement temperature should be constant for at least five (5) minutes. PID control should be attached with the oven.**

➢ Observation Table: -

- Current (I) = 4 mA (Constant)
- Distance between Probes (s) = 2mm
- Thickness of the Crystal (w) = .73mm
- Function value f(w/s) = 4

S.N	Temperature (^{0}C)	Voltage (mV)	Temperature (T in K)	$\rho_0 = \frac{V}{I}$ (2π s)	ρ (Ω m)	$T^{-1} \times 10^{-3}$	ln(ρ)
1.	30	297	303	0.9719	24.30	3.3	1.386
2.	50	290	323	0.9490	23.73	3.1	1.375
3.							
4.							
5.							
6.	90	225	363	0.7363	18.41	2.75	1.265
7.	-	-	-	-	-	-	-

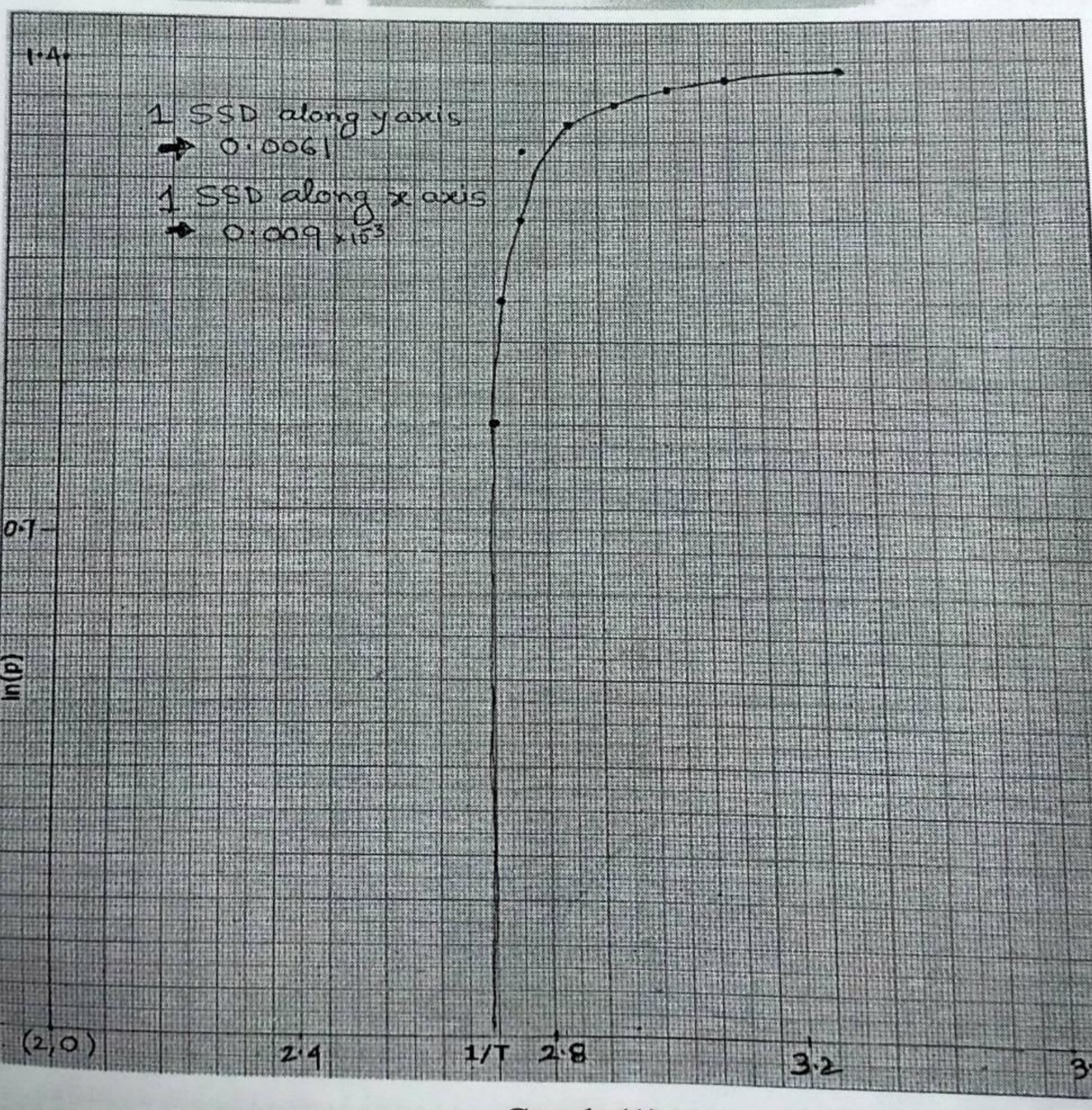
Table (1)

➢ Plotting of Graph:

Temperature (T in K)	ρ (Ω m)	$T^{-1} \times 10^{-3}$	ln(ρ)

Table (2)

➢ Finally plot the graph in (1/T) x 10^{-3} along X axis & ln(ρ) along Y axis as shown in graph (1)



Graph (1)

- Find the slop of the curve $= 1.065 \times 10^3$
- Use equation (3) to find E_g.
  - $E_g = 7$ eV (Approx).

- **Result:** So the energy band gap of the semiconductor (Germanium) is given by $E_g = 7$ eV (Approx).

** The experiment maybe repeated for other values of the current also.

- Value of the function f (w/s) for various value of (w/s) from the following table;

w/s	f(w/s)
0.100	13.863
0.141	9.704
0.200	6.931
0.333	6.931
0.333	4.159
0.500	2.780
1.000	1.504
1.414	1.223
2.000	1.094
3.000	1.0228
5.000	1.0070
10.000	1.00045

Table (3)

*If any (w/s) value is not found in the table then plots a graph in these (w/s) and f (w/s
alues. From graph the desired values of f (w/s) corresponding to any value of (w/s) can b
und out.

➢ *Online Demo :* https://youtu.be/8GxTzt33Uk4

WARRANTY

1) We guarantee the instrument against all manufacturing defects during 12 months from the date of sale by.

2) The guarantee covers manufacturing defects in respect of indigenous components and material limited to the warranty extended to us by the original manufacturer and defect will be rectified as far as lies within our control.

3) The guarantee will become **INVALID.**

a) If the instrument is not operated as per instruction given in the instruction manual.
b) If the agreed payment terms and other conditions of sale are not followed.
c) If the customer resells the instrument to another party.
d) Provided no attempt have been made to service and modify the instrument.

4) The non-working of the instrument is to be communicated to us immediately giving full details of the complaints and defects noticed specifically mentioning the type and sr. no. of the instrument, date of purchase etc.

5) The repair work will be carried out, provided the instrument is dispatched securely packed and insured with the courier. To and fro charges will be to the account of the customer.

DISPATCH PROCEDURE FOR SERVICE

Should it become necessary to send back the instrument to factory please observe the following procedure:

1) Before dispatching the instrument please write to us giving full details of the fault noticed.

2) After receipt of your letter our repairs dept. will advise you whether it is necessary to send the instrument back to us for repairs or the adjustment is possible in your premises.

3) Dispatch the instrument (only on the receipt of our advice) securely packed in original packing duly insured and freight paid along with accessories and a copy of the details noticed to us at our office address.