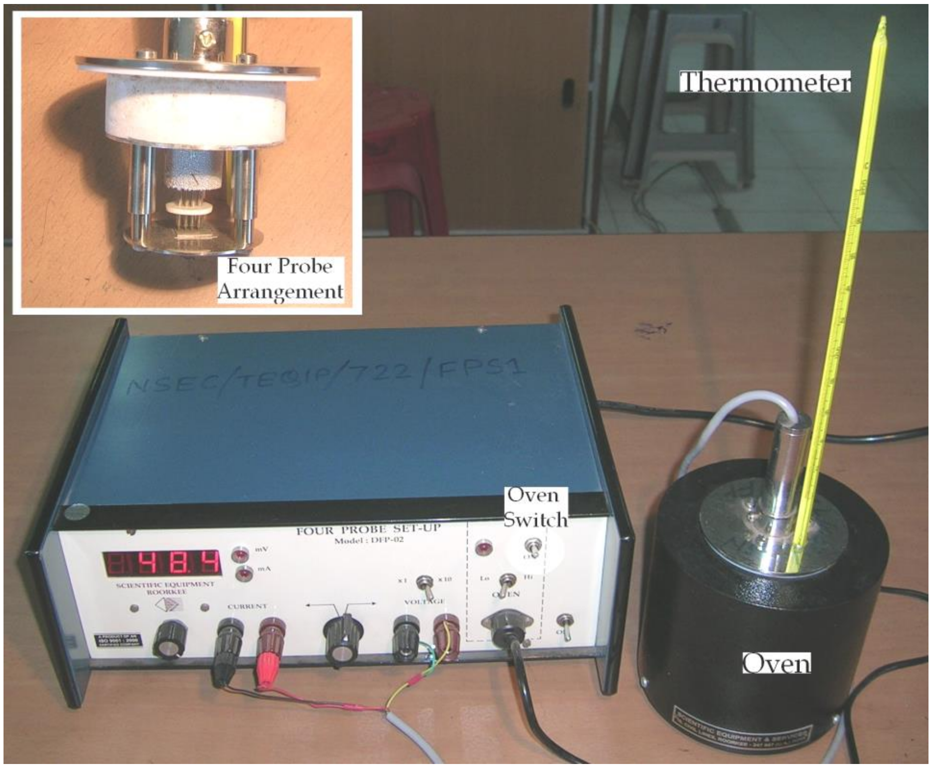
Instrument No. – BG- **Date:**

DETERMINATION OF THE BAND GAP OF A SEMICONDUCTOR BY FOUR PROBE METHOD



APPARATUS :

Ge single crystal (n type with thickness (w) = 0.05 cm.), four probe arrangement [distance between probes (S) = 0.2 cm.], oven and thermometer.

THEORY:

In figure four probes are spaced S1, S2, S3 and S4 apart. Current *I* is passed through the outer probes (1 & 4) and the floating potential *V* is measured approx the inner pairs of probes 2 & 3.

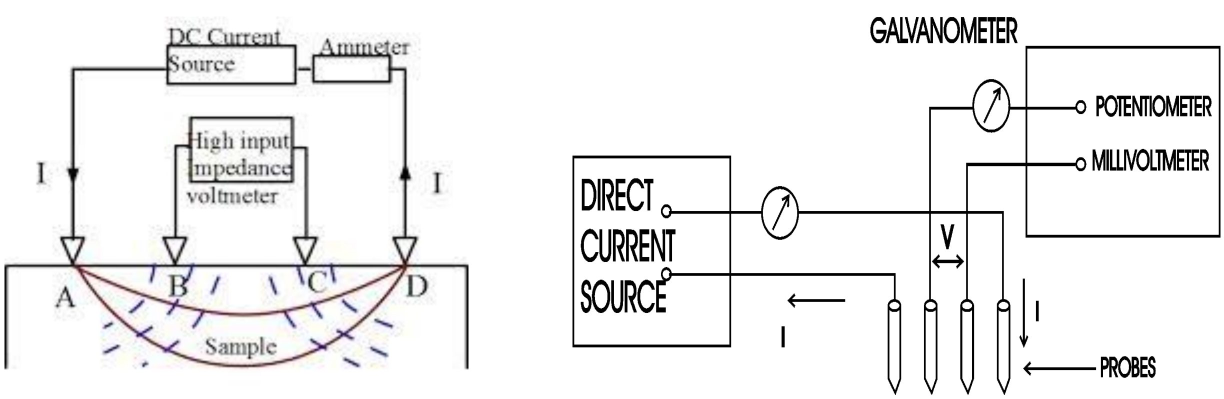


Figure : Circuit Used For Resistivity Measurements.

The potential difference V between probes 2 & 3 can be written as

$$V = \frac{I\rho_0}{2\pi s} \qquad \cdots(i)$$

Where ρ_0 is the resistivity of the material, I is the amount of current passing through the material. Therefore,

$$\rho_0 = 2\pi s \frac{V}{I} \qquad \cdots(ii)$$

Since the thickness of the crystal is very small compared to the probe distance a correction factor for it has to be applied.

$$\rho = \frac{\rho_0}{G_7} = \frac{\rho_0}{f\left(\frac{w}{s}\right)}$$

Now substituting the values,

$$\rho_0 = 2\times 3.14\times 0.2\times \frac{V}{I} = 1.256 \frac{V}{I}$$

and the correction factor G_7 i.e. $f\left(\frac{w}{s}\right)$ is 5.89

$$\rho = \frac{\rho_0}{5.89} = \frac{1.256}{5.89} \frac{V}{I}$$

$$\therefore \quad \rho = 0.213 \frac{V}{I} \qquad \cdots(iii)$$

Thus ρ may be calculated for various temperatures.

Now, if we plot $\log_{10}\rho$ vs. $\frac{1}{T}$, we get a curve which is linear at higher temperatures.

We know resistivity, $\rho = C\exp\left(\frac{E_g}{2KT}\right)$, where C is a constant. From this expression we can have: $\ln\rho = \left(\frac{E_g}{2K}\right)\frac{1}{T} + \ln C$

Therefore, width of the energy gap may be determined from the slope of the linear portion of the experimental curve: $\frac{\Delta \log_{10}\rho}{\Delta \frac{1}{T}} = \frac{\Delta \ln\rho}{2.303\times\Delta\frac{1}{T}} = \frac{1}{2.303}\times\frac{E_g}{2K}$

Thus we have

$$\boxed{E_g = 2.303\times 2K \frac{\Delta \log_{10}\rho}{\Delta\frac{1}{T}} \qquad \cdots(iv)}$$

Where K is Boltzman's Constant [K = 8.6 × 10^{-5} eV/Kelvin]

Procedure:

1. Switch on the circuit (***make sure that the oven is switched off***).
2. Align the voltmeter/ammeter display changer switch at ammeter position and fix the value of the probe current to any fixed value (**approx. 6 – 8 mA).**
3. Align the display changer switch to voltmeter position and note the temperature and record the corresponding voltage value.
4. Switch on the oven at **low heating mode.**
5. As the temperature starts to increase, record all the corresponding values of the voltage at the **interval of 10 °C up to 60 °C** and from thereon till **140 °C at the interval of 5 °C**.
6. Switch off **the oven** and then switch off **the circuit**.
7. Calculate all the terms in the table.
8. Plot a graph between $\mathbf{\log_{10}\rho}$ **vs** $\boldsymbol{T^{-1}}$.
9. Take the slope from the ***linear portion*** of the mean graph.
10. Complete the calculation to find out the value of the Band gap for the given semiconductor.

OBSERVATIONS:

Current I = ____ mA (constant)

Distance between probes (s) = 0.2 cm.

Thickness of the crystal (w) = 0.05 cm.

Sl no.	Temp (^oC)	Voltage Readings		Temperature (T in K)	ρ (Ωcm.)	T^{-1} (K^{-1})	$\log_{10}\rho$
		Raw data	Voltage (millivolts)				

RESULT: The band gap of the germanium sample is found out to be _______________ eV.
(The standard value of band gap for Ge semiconductor is 0.7 eV)

DISCUSSIONS: