

Assignment 4 Experiment 4

Resistivity Determination for a Semiconductor Wafer using Four Probe Method

Aim

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

Apparatus Required

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

Formula

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

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

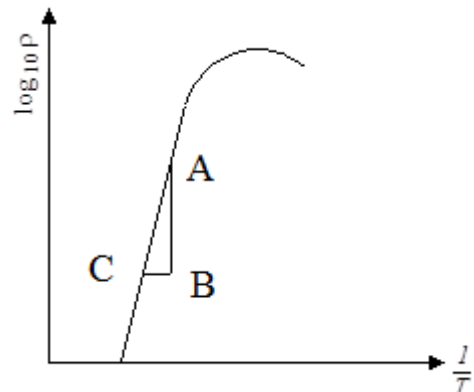
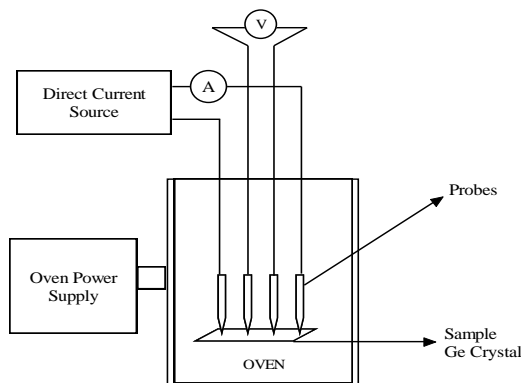
Here, s is distance between probes and W is the thickness of semi-conducting crystal. V and I are the voltage and current across and through the crystal chip.

Graph

Plot a graph in $\left(\frac{10^3}{T}\right)$ and $\log_{10} \rho$ as shown in Fig. Find the slope of the curve $\frac{AB}{BC} = \frac{\log_{10} \rho}{10^3/T}$.

So the energy band gap of semiconductor (Germanium) is given by

$$E_g = 2k \times \frac{2.3026 \times \log_{10} \rho}{1/T}$$
$$= 2 \times 8.6 \times 10^{-5} \times 2.3026 \times \frac{AB}{BC} \times 1000 eV = 0.396 \times \frac{AB}{BC} eV$$



Observations:

Distance between probes(s) = 0.33 mm,

Thickness of the crystal chip (W) = 0.5 mm

Current (I) = 2.00 mA

Table 1.1(b) To determine the resistivity of the semi-conductor for various temperatures:

Current (I) = 2 mA

S.No.	Temperature		Voltage (V)	Resistivity $\rho = V/I$ (0.213) (ohm. cm)	$1/T$ (10^{-3})	$\text{Log}_{10} \rho$ (Ohm cm)
	in °C	in K	(mV)		(K)	
1	30	303	83.2	?	?	?
				?	?	?
2	35	308	81.6	?	?	?
3	40	313	81.5	?	?	?
4	45	318	81	?	?	?
5	50	323	80.1	?	?	?
6	55	328	79.0	?	?	?
7	60	333	76.3	?	?	?
8	65	338	73	?	?	?
9	70	343	68.2	?	?	?
10	75	348	63	?	?	?
11	80	353	56.5	?	?	?

Assignment Question:

1. By using the readings in the tabular column (V and I), calculate the resistivity (ρ), $1/T$ and $\text{Log}_{10} \rho$, enter the values in four decimal points in the tabular column in your observation note book.
2. Draw the graph between $1/T$ (K) along the X axis and $\text{Log}_{10} \rho$ (Ohm. Cm) along the Y axis. From the graph find out the slope (AB/BC)
3. Substitute the slope value in the formula and find out the energy band gap of the material.

4. Write the result in the following order

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

Finally, submit the scanned copy of your observation note book in GCR on (or) before THREE working days from the date of experiment.