EXPERIMENT NO: ~~13~~ 9 (a)

OBJECT: TO ESTIMATE THE BAND GAP ENERGY (E_G) OF Ge CRYSTAL FROM RESISTIVITY VERSES TEMPERATURE MEASUREMENTS USING FOUR PROBE TECHNIQUE .

INTRODUCTION:

Many conventional methods for measuring resistivity are unsatisfactory for semiconductors because metal-semiconductor contacts are usually rectifying in nature. Also, there is generally some minority carrier injection by one of the current carrying contacts. An excess concentration of minority carriers affects of potential of other contacts and modulates the resistance of the material.

Four probe method overcomes the difficulties mentioned above and also offers several other advantages. It permits measurements of resistivity in samples having a wide variety of shapes. It is not always convenient to produce a specimen of known dimensions for a conductivity measurement. This method is used to measure, conveniently and accurately, the conductivity of ingots or slices, both thick and thin of semiconductor crystals.

THEORY:

The probe basically employs four spring loaded equi-spaced needles which make contact with a plane shaped surface on the specimen as shown in figure (1). A stabilized current is passed through the outer pair of probes, 1 and 4 and the voltage V, between the inner two, 2 and 3 is measured by a voltmeter which draws negligible current.

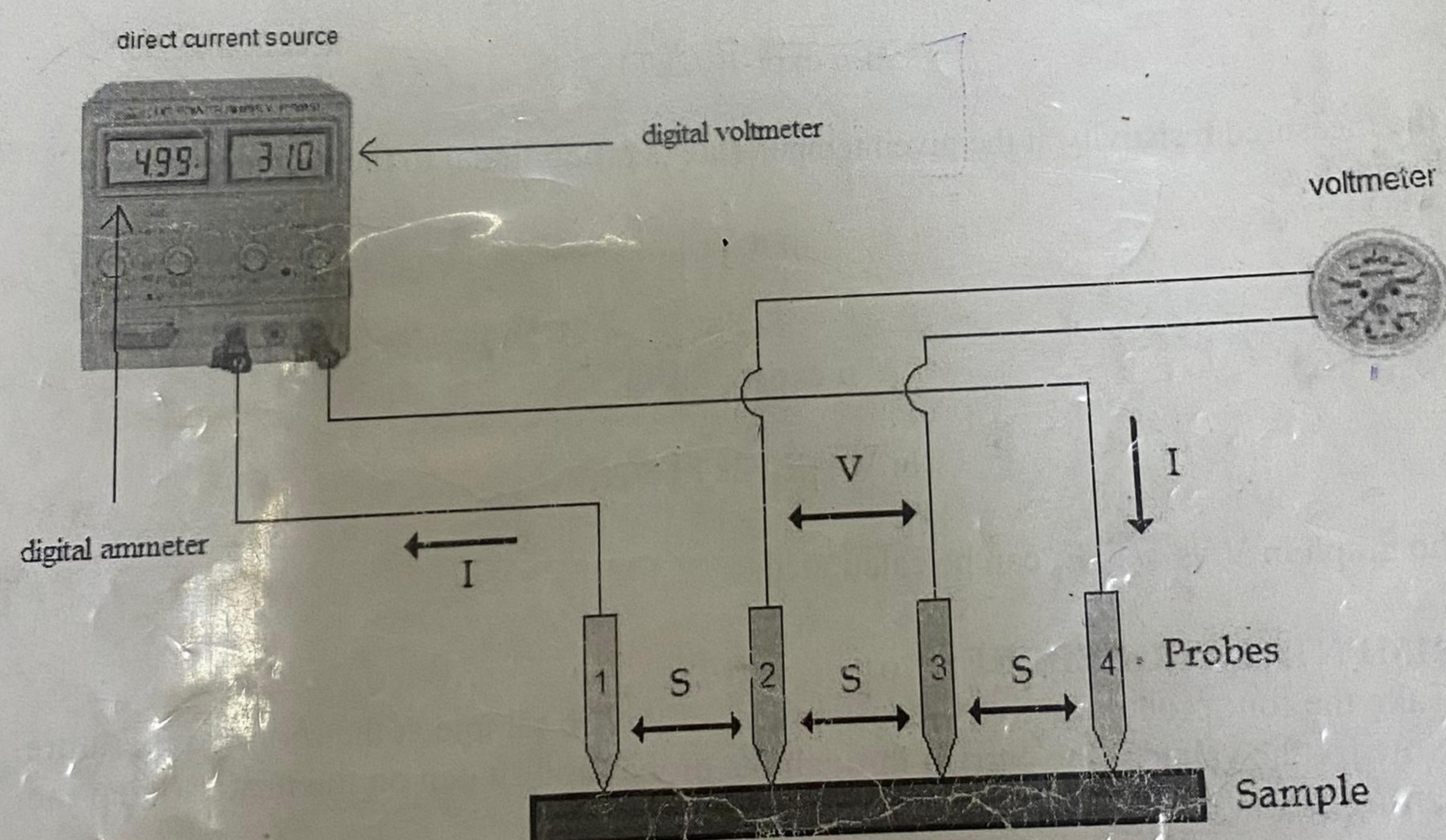

Figure (1): Schematic diagram of Four probe setup

We know that for the four probe setup at a given temperature T

$$\rho_o = 2\pi s(V/I) \qquad (1)$$

Where "s" denotes inter probe spacing.

This equation (1) is valid only for materials whose dimensions are large compared with the probe spacing S. If this is not the case, for example, when measurements are made on thin slices or small disc of materials, then a correction factor G (b/s) is introduced.

Here:

s = distance between two probes = 0.233 cm

b = thickness of the crystal = 0.04 cm

So, the correction factor, G (b/s) = 8

And the resistivity will be given by

$$\rho_c = \rho_o / G(b/s)$$

For semiconductors the variation of high temperature (>room temperature) resistivity is inversely proportional to the intrinsic charge carrier concentration variation. The intrinsic charge carrier concentration varies with temperature as

$$n_i \,\alpha\, \exp(-E_g/2kT)$$

And the measured resistivity at the given temperature is proportional to the voltage drop developed.

$$\rho \,\alpha\, V.$$

So,

$$V \,\alpha\, \exp(E_g/2kT)$$

$$\ln V = (E_g/2kT) + A$$

From the graph ln V vs 1/T, E_g can be calculated.

EXPERIMENTAL PROCEDURE:

1. Take the four probe resistivity measurement of the Ge sample at the room temperature.
2. Now fix the value of the current through the probes and switch on the heater (keep the setting as low).
3. Measure the variation in voltage as the function of increase temperature.
4. From a graph for 1/T vs ln V.

CALCULATION:

1. From the probe measurement graph measure the room temperature resistivity of Ge.
2. From the temperature variation graph calculate the Band gab of Ge (in eV).

NOTE:

1. K= Boltzmann's Constant
   $=1.3807 \times 10^{-23}$ J/K

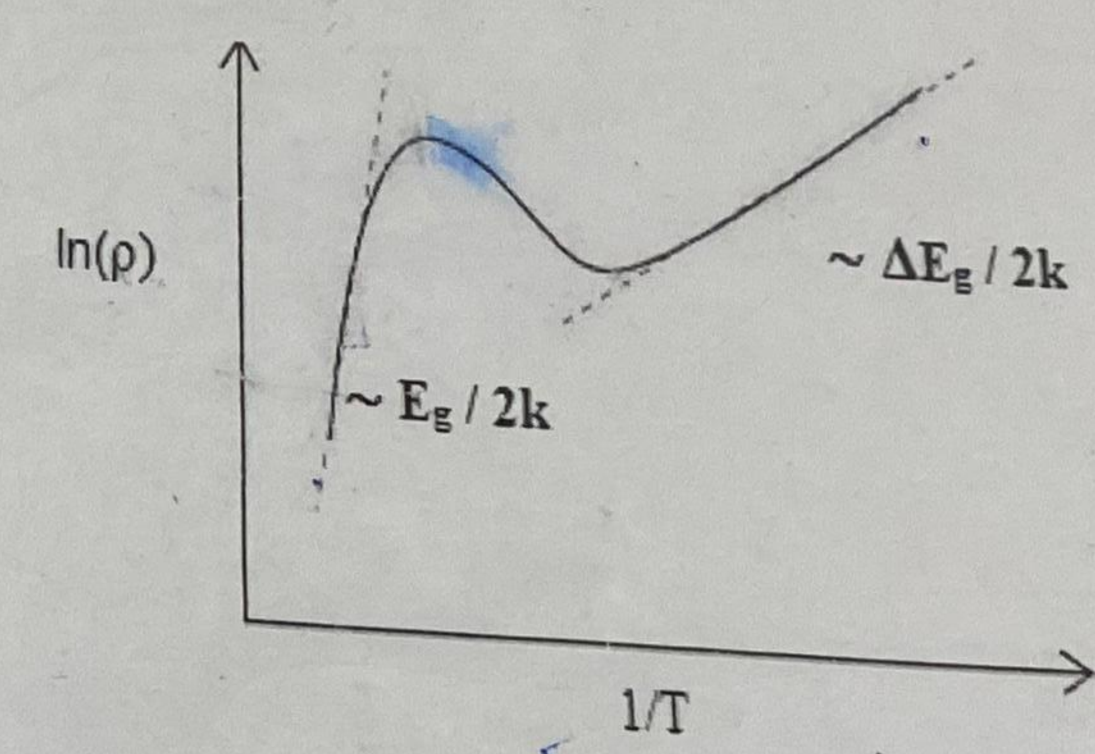

Figure (2): Temperature variation of resistivity for semiconductor.

I. Resistivity determination:

S. No.	I	V

II. Temperature

I= ______ mA

S. No.	T	V	Ln V	1/T