<u>Study of Magnetoresistance</u>

AIM: *To study the magneto resistance of given semiconductor material.*

APPARATUS: Hall probe arrangement, which is a germanium/silicon crystal N or P type with four spring type pressure contact mounted on sun mica bakelite strip, electromagnet which is a U shaped soft iron yoke, constant current supply from 0 to 4A, digital gauss meter with hall probe (here the hall voltage is amplified and passes through milli voltmeter which is calibrated in gauss) and a wooden hall probe stand.

THEORY: It is noticed that the resistance of the sample changes when the magnetic field is turned on. The phenomenon, called magneto resistance, is due to the fact that the drift velocity of all carriers is not same. With the magnetic field on, the Hall voltage V is given as,

$$V = E_y t = |v \times H|$$

which compensates exactly the Lorentz force for carriers with the average velocity; slower carriers will be over compensated and faster one under compensated, resulting in trajectories that are not along the applied field. This results in an effective decrease of the mean free path and hence an increase in resistivity.

Here the above referred symbols are defines as: v = drift velocity; E = applied electric field; t = thickness of the crystal; H = Magnetic field

FORMULAE USED: Magneto resistance can be found by using formula

$$\Delta R/R = (R_m - R)/R$$

Where R = Sample resistance without magnetic field
R_m = Resistance at different magnetic field

CIRCUIT DIAGRAM:

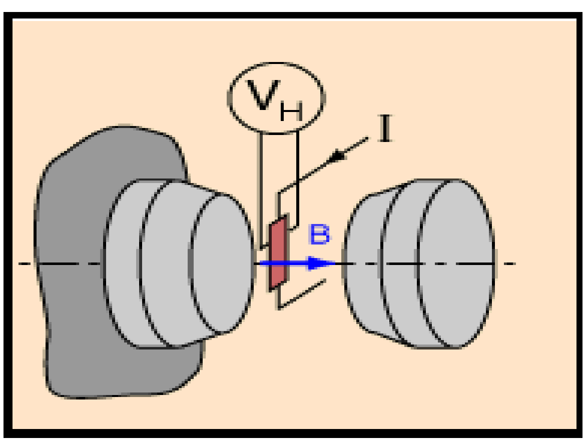

Fig: Four probe between magnetic pole pieces.

PROCEDURE:

1. Connect the electromagnet to the power supply and measure the magnetic field at different currents with the help of gauss meter (Table 1).
2. Connect the red color contact of the four probe to the voltage terminal and green colour contact of the four probe to the current terminal of magneto resistance board.
3. Switch ON the magneto resistance board.
4. Measure the resistance of the sample by varying the current and recording the corresponding voltage reading by placing the four probe outside the magnetic field using the magneto resistance board.
5. Adjust the current in magneto resistance board 3 mA. (constant for whole set of reading).
6. Put the meter selector switch towards mV. There may be some voltage reading even outside the magnetic field. This is due to imperfect alignment of the four contacts of the hall probe and is generally known as **Zero field potential**. If its value is comparable to the hall voltage then it should be adjusted to the minimum value (for hall probe for germanium only) else it should be subtracted from hall voltage reading.
7. Place the hall probe in the magnetic field.
8. Connect the constant current power supply with electromagnet.
9. Switch on the supply and adjust current to a desired value.
10. Rotate the probe till it becomes perpendicular to magnetic field (Hall voltage will be maximum here).
11. Measure voltage at different magnetic fields (Table 2).
12. Calculate the value of Δ**R/R.**

OBSERVATIONS:

Table 1: Calibration of Magnetic Field
L.C. of ammeter = ……A and L.C. of gauss meter = ………Gauss

S. No.	Current (A)	Magnetic Field (Gauss)
1		
2		
3		
4		
5		

Sample resistance without magnetic field R [at 3 mA] = ……Ω

Table 2: Measurement of Magneto-resistance
Probe Current **I = 3.0 mA** [constant for whole set of reading].

S. No.	Current (Amp)	Magnetic Field H (Gauss)	Voltage V_m(mV)	R_m =Vm/I (Ω)	ΔR/R	Log H	Log (ΔR/R)
1							
2							
3							
4							
5							

RESULTS:

Graph shows the nature of

(a) Magnetic field (H) Vs ΔR/R

(b) Log (H) Vs Log (ΔR/R**)**

CALCULATIONS:

Using the following formula:

ΔR/R = (Rm – R)/R

MAXIMUM PROBABLE ERROR

$$\frac{\Delta R}{R} = \frac{(R_m - R)}{R}$$

$\ln\left(\frac{\Delta R}{R}\right) = \ln\left(\frac{R_m - R}{R}\right)$**,** differentiate this and calculate maximum probable error by putting the suitable values of variables

PRECAUTIONS:

1. Start with controls set for zero current. When turning off, smoothly decrease current to zero and then turn off. High value of current should not be applied to the four probe and electromagnet.
2. Never suddenly interrupt or apply power to a large magnet. Large inductive voltage surges may damage the insulation.
3. Hall probe should be placed perpendicular to the magnetic field.
4. Hall probes should be connected to proper terminal (as per color code).
5. Do not touch exposed magnet coil contacts.
6. Do not leave the magnet current at a high setting for any length of time beyond the minimum needed for data acquisition.

SOURCES OF ERROR:

1. Hall probe may not be positioned properly between the magnetic pole pieces.
2. Hall probe may not be properly mounted.
3. The circuit may not be properly connected.

VIVA VOCE QUESTIONS:

1. Define a semiconductor.
2. Name the example of different types of semiconductors.
3. Define resistivity and whether it is different from specific resistance?
4. What is the unit of magnetic field being used in present experiment?
5. Which apparatus is used to measure magnetic field in this experiment?
6. Define magnetoresistance and how is it different from electrical resistance?

7. What is drift velocity and explain the relation between drift velocity and electric field?
8. How Hall voltage is associated with magnetic field mathematically?
9. Why zero field potential is calculated in this experiment?
10. What are the applications of magnetoresistance?

REFERENCES

1. Solid State Physics by S. L. Gupta and V. Kumar, K. Nath &Co. Publishers.
2. Solid State Physics by S.O. Pillai, New Age International Publishers.