Hall Effect

Lab 5

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Contents

Aim

1. To measure the Hall effect in a semiconductor, and hence derive certain electrical properties of the semiconductor.

Theory

The Hall effect is the production of a voltage difference (the Hall voltage) across an electrical conductor that is transverse to an electric current in the conductor and to an applied magnetic field perpendicular to the current.

When a current-carrying semiconductor is kept in a magnetic field, the charge carriers of the semiconductor experience a force in a direction perpendicular to both the magnetic field and the current. At equilibrium, a voltage appears at the semiconductor edges, whose field applies the same force as the Lorentz force.

Method

1. Measure the thickness of the sample as t and resistance as R
2. Make connections such that you can pass current and measure the voltage perpendicular to each other in the sample.
3. Connect and place the Electromagnet such that the resulting magnetic field is perpendicular to both current and voltage axes.
4. Place a gauss meter between Electromagnet and sample
5. Calibrate Gauss meter
6. Pass current through the Electromagnet such that the gauss meter reads $1.5k$ gauss. Record it as B
7. Pass current through the sample from about 1mA to 15 mA.
8. Measure the corresponding voltage.
9. Plot and fit the graph to $y = mx$, with m giving us mean value of V_H/I
10. Use m to find the following-
    1. $R_H = mt/B$
    2. $n = 1/R_H e$
    3. $r = Rt$
    4. $\mu = R_H/r$
    5. $\theta_H = \tan^-(\mu B)$

Observation

Quantity	Value
t	$5 \cdot 10^{-4} m$
B	0.1464T
R	0.870Ω

V (mV)	I (mA)	V (mV)	I (mA)
0.86	8.1	16.7	165.5
1.93	18.3	17.14	171.2

V (mV)	I (mA)	V (mV)	I (mA)
3.02	28.5	-1.91	-17.8
4.06	38.2	-3.42	-32.1
5.00	47.1	-4.46	-42.1
6.00	56.9	-5.16	-48.6
7.35	69.6	-7.06	-67.1
7.99	75.8	-8.55	-81.6
9.42	89.8	-9.28	-88.8
10.16	97.3	-10.45	-100.6
11.11	106.8	-11.84	-114.9
12.00	116.0	-12.97	-126.8
13.16	128.0	-15.56	-153.9
14.71	144.2	-17.07	-170.1
15.60	153.8		

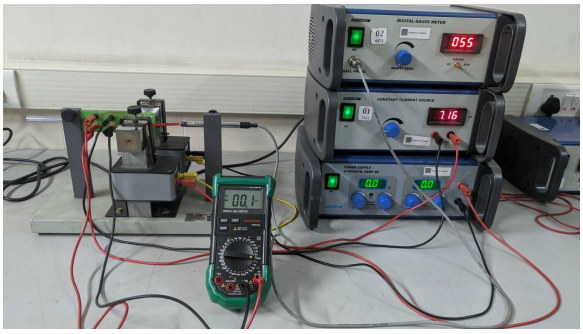

Figure 1: Hall Effect Experimental Setup

Results

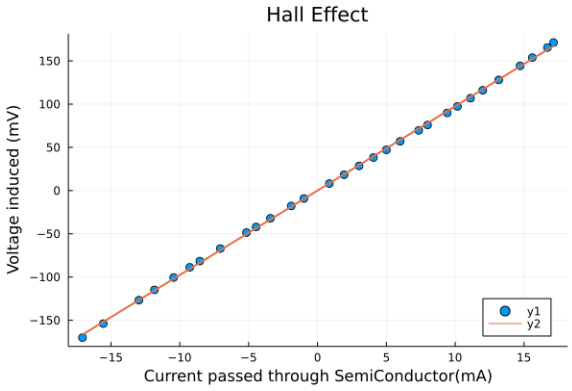

Figure 2: Plot

1. Mean of $V_H/I = 9.76 \pm 0.3\%\Omega$
2. Hall Coefficient $R_H = 0.0333 \pm 2.368\%\Omega mT^{-1}$

3. Volume density of carriers $n = 1.88 \cdot 10^{20} \pm 2.368\%$
4. Resistivity $r = 4.35 \cdot 10^{-}4 \pm 2.11\%\Omega m$
5. Mobility $\mu = 76.6 \pm 4.478\% m^2 V^{-1} s^{-1}$
6. Hall angle $\theta_H = 1.48 rad$

References

1. Wikipedia contributors. "Hall effect." Wikipedia, The Free Encyclopedia. Wikipedia, The Free Encyclopedia, 26 Mar. 2022. Web. 18 Apr. 2022.
2. Hall Effect Lab Manual