Original Article
Bulletin of Pure and Applied Sciences.
Chemistry , Vol.44 C, No.1
January-June 2025: P.10-15

http://www.bpasjournals.com/chemistry
Print version ISSN 0970 4620
Online version ISSN 2320 320X

Anamalous Behaviour in Tungsten

[1]Atri Deo Tripathi*, [1]Mandeep Singh and [2]Khevan Chhabra

Author's Affiliations: [1,2]R & D Division, Osaw Industrial Products Pvt. Ltd., Ambala Cantt, Haryana 133001, India

***Corresponding Author:** R & D Division, Osaw Industrial Products Pvt. Ltd., Ambala Cantt, Haryana 133001, India,
E-mail: atri34tmu@gmail.com

ABSTRACT

In the current program, the Hall Effect in tungsten experiment has been conducted using a permanently installed tungsten strip, socket pairs for accessing the Hall voltage, $U_{H,}$ and a rotating potentiometer for zero point correction. All item were kept in a holder. U-core and pole pieces were used for attaching two coils (500 turns). The device shows the Hall voltage U_H on a tungsten strip with current I in a magnetic field B that is acting perpendicular to the current direction. The relation between the magnetic flux density and the Hall voltage has been confirmed, identified the charge carriers' polarity and computed the charge carrier concentration (n) and Hall constant (R_H).

Keywords: Tungsten, Gaussmeter, Hall Effect, Hall voltage, Magnetic field

Received on 12.02.2025, Revised on 22.04.2025, Accepted on 12.05.2025

How to cite this article: Tripathi A.D., Singh M. and Chhabra K. (2025). Anamalous Behaviour in Tungsten. *Bulletin of Pure and Applied Sciences-Chemistry,* 44C (1), 10-15.

INTRODUCTION

When a conductor carrying current is exposed to a magnetic field right angle to the current, a phenomenon known as the Hall Effect takes place, which causes a voltage to be produced at a right angle to the current direction (Popovic, R. S. (2004).

The concentration and mobility of charge carriers in tungsten are measured by a phenomenon known as the Hall Effect. It demonstrates that tungsten is primarily a hole conductor, which means that its principal charge carriers are holes.

The electrons are moved from the battery's positive pole to its negative pole using an average drift velocity. Along the z-direction, a magnetic field is produced perpendicular to the electric current I. The electrons then arrive at one side of the material, while some divert in the direction of x. The electrons accumulated on this side of the substance because they were not gathered by a wire. Because there is no negative charge to balance the positive ions there, a positive charge builds up on the other side of the substance. An electric field is produced in the x-direction as a result of the potential difference that exists between the two sides. The electrons are subjected to a force from this electric field, also known as the Hall field, which attempts to counteract the magnetic force.

The type of charge carrier can be identified by the sign of the Hall coefficient. The Hall Effect is referred to as the "Normal Hall effect" if the sign is negative, and electrons are the charge bearers. In contrast, the Hall Effect is referred to as the "Anomalous Hall effect" when the charge carriers are holes and the value of the Hall coefficient is positive (**Wahidullah E. et.al. (2021)**.

EXPERIMENTAL

Item used for experiment is given as under:

Power supply for electromagnet (0-40 V, 10 Amps.), Power supply (Constant current source 0-30 V, 20 Amps), Gauss meter with Hall Probe, Hall-Apparatus in Tungsten on mount (Thickness: 6 x 10^{-5} m of Tungsten strip), Microvoltmeter for measuring Hall voltage $V_{H,}$ two magnetic core with 500 turns coils.

The tungston strip assembly is placed in between flat portion of pole pieces. The Gaussmeter used for measuring magnetic flux and micro-volt meter for voltage measurement.

Procedure: Calibration of Magnetic field as a function of current

1. As illustrated in figure 1, fit the 500 turn coils and the U-core of the two pole components.
2. Set the electromagnet's pole components apart to match the Hall apparatus's support plate thickness, adjust the Gauss meter probe to protect the poles from sticking under the influence of large magnetic field. This means air gap between the poles pieces is maintained of same width as needed for Hall apparatus panel with Tungsten strip mount.
3. Connect the coils with 0-40V, 10A supply and place the magnetic field sensor (Hall-Probe) between the poles pieces as shown.
4. To neutralize the iron core of electromagnet from the Residual Magnesium pass about 1A AC current through the coils for about 30 seconds, then reduce the current to Zero steadily.
5. Switch on the power supply and Gauss meter.
6. Record the magnetic flux density, by varying current in steps of 1 A DC, as in Table-1. Then draw the graph between current and the field, as shown in figure-3.

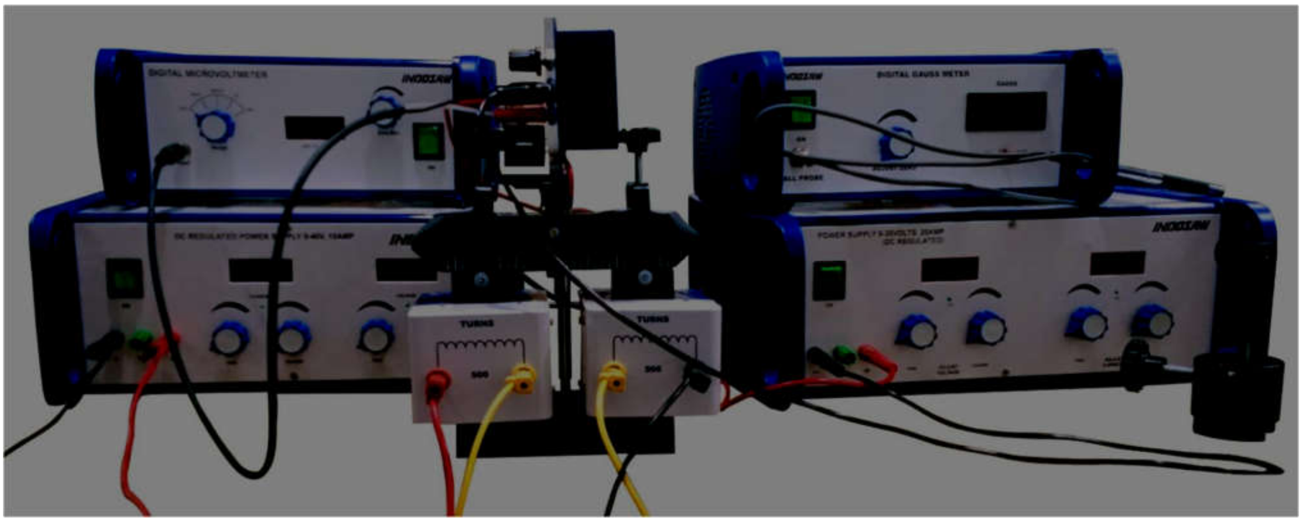

Figure 1: hall Effect in metal apparatus

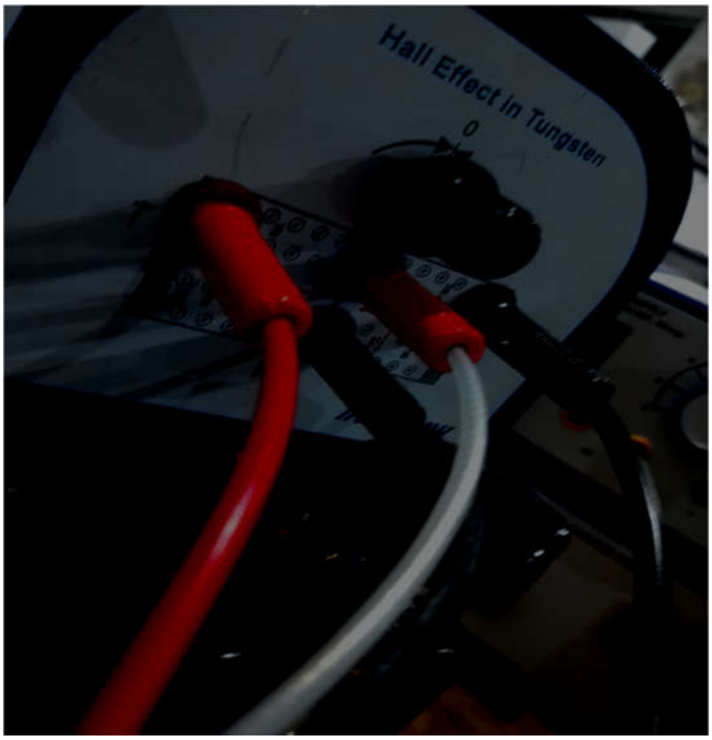

Figure 2: Connection of voltage and current in Assembly

RESULTS AND DISCUSSION

When a metallic conductor strip carrying current is positioned in a magnetic field B perpendicular to the direction of current flow I, a transverse electrical field E_H and a potential difference (Hall effect) are created (Hao et.al.2015).

For the Hall voltage U_H, the following formula is valid.

$U_H = U_H = 1.B.I/ne.d$

where,

e = 1.602X 10^{-19} C: Charge elementary
B: density of magnetic flux
I: current flowing across the metal wire
d: The band-shaped conductor's thickness
n: charge carrier concentration

The moving charge carriers' displacement in the magnetic field is what causes the Hall voltage U_H. The Hall coefficient is R_H given by

$R_H = 1/ne$

Because the charge carriers are mostly in charge of the current, their polarity determines the sign of the Hall constant R_H. One characteristic of the so-called "anomalous" Hall effect is the presence of primarily positive charge carriers. Both the material and the temperature affect the Hall constant. While R_H is relatively modest for metals, it grows noticeably larger for semiconductors.

The Hall voltage's direction can be used to determine the charge carriers' polarity. Through experimental measurement of the Hall voltage U_H as a function of the magnetic field B for different currents I, the concentration of the charge carriers n can be ascertained

Table 1:

S No.	Ib(A)	B(T)
0	0	0
1	0.5	0.103
2	1	0.215
3	1.5	0.328
4	2	0.434
5	2.5	0.532
6	3	0.606
7	3.5	0.658
8	4	0.696
9	4.5	0.724
10	5	0.743
11	5.5	0.76
12	6	0.775
13	6.5	0.789
14	7	0.8
15	7.5	0.81
16	8	0.82
17	8.5	0.83

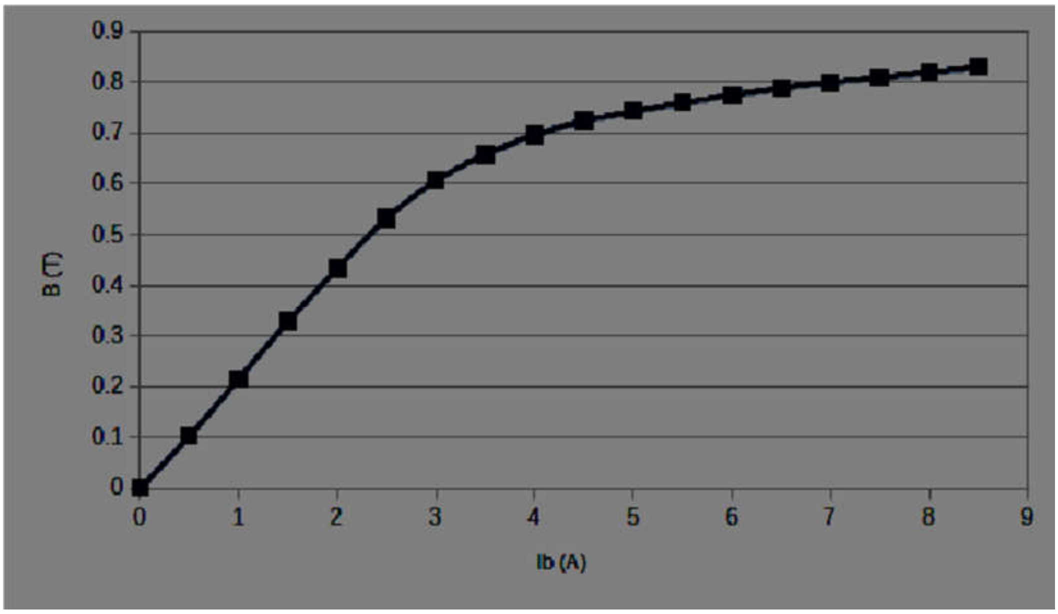

Figure 3: Graph between Magnetic Field (B) (T) Vs Current (A)

Variation of V_H with Magnetic Field B

1. In order to maintain the smallest possible air gap where the tungsten is positioned, fit the tungsten sample as shown in Fig. 1 into the electromagnet, whose pole pieces are positioned directly against the panel. Please note that Flat side of the Pole pieces are used during experiment.
2. Connect the (30V, 20A) power supply to the Tungsten sample to the ports provided at the ends of the sample as shown in Fig.2.
3. Now, connect the micro-voltmeter to the hall voltage ports provided in the middle of the sample.
4. Short the micro-voltmeter connecting leads with each other and set the microvoltmeter to

zero by using zero setting knob provided on the micro-voltmeter.

5. Now pass a transverse current I_T of about 15A from the sample using a (30V, 20A) power supply, at this point the micro-voltmeter will show certain reading, again set it to zero by using a zero setting knob(Black knob) provided at the top of the sample.
6. Now connect the (40V,10A) power supply to the coils for generating magnetic fields after switching on the power supply if the microvoltmeter shows any value, make it to zero by using a zero setting knob provided at the top of the sample.
7. Now your set up is ready for experiment , increase the magnetic field current gradually by keeping the constant current fixed at 10,15 or 20 A and note down the Hall voltage from microvoltmeter and read the corresponding magnetic field strength from the Gaussmeter calibration Table 1.

Important note:

8. Significant zero-point changes may result from air circulation when the transverse current is turned on. To lessen these fluctuations, conduct this experiment while maintaining the fan. Tungsten's increased electric resistance causes thermal effects and, consequently, zero-point fluctuations, which are higher than those of silver. To find the Hall voltage,do atleast five observations.

Determination of hall Cofficient, R_H

Table 2:

B(T)	U_H (microvolts) at I_T=20A
0.20	7.5
0.38	15
0.52	20.2
0.64	24.9F
0.70	28
0.73	30
0.76	32
0.79	32.8
0.81	34

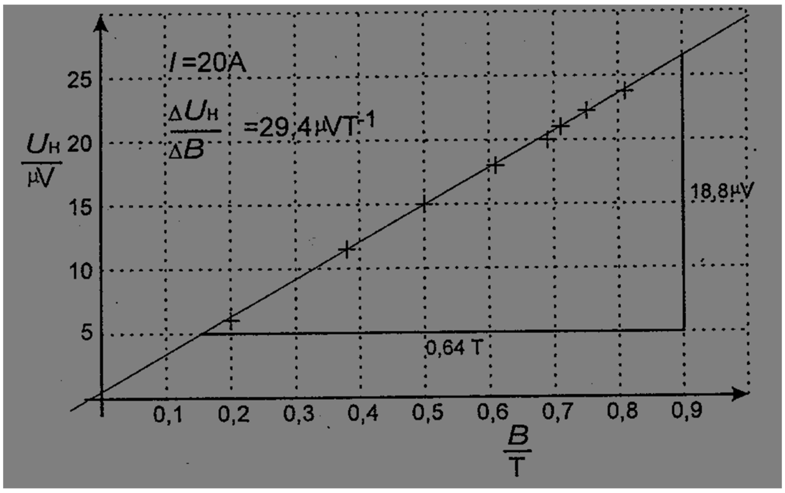

Figure 4: Graph between Magnetic field (B) Vs Hall Voltage (U_H)

Table 2 shows UH at a transverse current I of 20A as a function of the magnetic flux density B. It is plotted in Fig.4, the value of the slope (D U_H /DB) is given for calculating the Hall constant.

U_H = IB/neh(where h is the thickness of the specimen=6 x 10^{-5} m)
Hall coefficient R_H =DU_H .h/DB.I= 29.4x 10^{-6} VT^{-1} X 6x 10^{-5} m/20 A =1.05*10^{-10} m^3 C
Literature value n = 5.29 x 10^{28} m^{-3}.

Polarity of charge carriers

As the Hall constant is +ve, it justify that in Tungsten current conduction is due to Holes (anomalous Hall effect).

Charge density:

$n = 1/eR_{H}$,

with elementary charge e = 1.602*10^{-19} C follows the concentration of charge Carriers:

n (I = 20 A) = 5.9* 10^{28} 1/m^3

CONCLUSION

Hall voltage in tungsten has been carried out in the laboratory by using two coils, Gaussmeter, Power supply (10 A, 20 A) and tungsten strip. The hall voltage is positive showing that i in Tungsten current conduction is due to Holes. This is anomalous Hall effect *(Xie et al., 2018)* because mostly metals have negative hall voltage. To study the relation of V_H, I_T, the Hall effect apparatus for Silver (normal hall effect) is better suited to calculate the Hall coefficient *(Kaneda & Mizuki, 1972)*.

Acknowledgement

Authors are grateful to Mr.Ajay Sagar, Managing Director, Osaw Industrial Products Pvt. Ltd. Ambala Cantt-133001, for providing laboratory facilities during course of this investigation.

REFERENCES

1. Hao, Q., Chen, W., & Xiao, G. (2015). Beta (β) tungsten thin films: Structure, electron transport, and giant spin Hall effect. Applied Physics Letters, 106 (18), 182403.
2. Kaneda, T., & Mizuki, E. (1972). Hall Effect of Silver Ions in Rb Ag 4 I 5 Single Crystals. Physical Review Letters, 29 (14), 937.
3. Popovic, R. S. (2004). Hall effect devices (2, illustrated ed.).CRC Press. ISBN 978-0-7503-0855-7.
4. Wahidullah E. , Abdul W.Q. , Nasratullah M., Zabiullah Z.(2021), Investigation of the Effect of Hall, Hall Constant and Density on Conductors (Silver, Copper and Tungsten), International Journal of Trend in Scientific Research and Development, 5(5), 1609-1615
5. Xie, T., Dreyer, M., Bowen, D., Hinkel, D., Butera, R. E., Krafft, C., & Mayergoyz, I. (2018). On local sensing of spin Hall effect in tungsten films by using STM-based measurements. IEEE Transactions on Nanotechnology, 17 (5), 914–919.

****