The Hall Effect

≈RAD EMILIANI ANTONIO≈

20.11.2021

Summary

→ The aim of the laboratory

→ observe the Hall voltage generated across a semiconductor when a magnetic field $\vec{B}$ is applied perpendicular to an electric current of intensity I that travels trough that semiconductor

→ experiment that allows determining the sign of the charge carriers in a conductor or semiconductor such as a flat strip of copper.

→ The Hall Effect can be used to choose betwee two possibilities:

⇒ A magnetic field with the magnetic induction B is set up at right angles to the strip. This field exerts the Lorentz force: $\vec{F} = q \cdot \vec{v} \times \vec{B}$ (1)

→ The carriers tend to drift to the left side, producing a Hall potential difference, V_{xy}, between the sides x and y

→ the sign of the charge carriers is determined by V_{xy}.

→ if the carriers are positive, x will be at a higher positive potential than y

→ if the charge carriers are negative, the x side becomes negative and the y side remains positive

→ If the potential difference is U_H the Hall Effect produces an electric field of intensity $E_H = \frac{U_H}{d}$ (2)

→ x and y will build up ⇒ Hall voltage will increase to a value for which the electrostatic force equals the Lorentz force $\frac{eU_H}{d} = evB$ (3)

→ The Hall induced voltage can be measured by using the circuit

$I = nevad$ (4)

n - density of charge carriers

a, d - width and thickness of the strip.

and the speed becomes $v = \frac{I}{naed}$ (5)

The Hall voltage can be deduced as

$$U_H = vBd = \frac{1}{ne}\frac{IB}{a} = R_H\frac{IB}{a}, \quad (6)$$

R_H - Hall constant

$$R_H = \frac{A}{e}\frac{p\mu_p^2 - n\mu_n^2}{(p\mu_p - n\mu_n)^2} \quad (7)$$

$\mu = \frac{v}{E}$ - mobility of the charge carriers, $E = 1\ V/m$

→ materials with only one type of charge carriers

$\sigma = ne\mu$ - electric conductivity

$R_H = A/ne$

$$\mu = \frac{R_H \cdot \sigma}{A}$$

In electrical techniques, the Hall effect is used:

→ to determine the strenght (H), induction (B) of magnetic field

→ to determine the losses in Fe

→ in measuring the electric power and phase shift in alternative circuits.

I [A]	B [T]	I_s [mA]	$\frac{I_s B}{a}$ [AT/m]	U [div]	U_H m[V]	R_H [Vm/AT]	n [e^-/m^3]	σ $[\Omega m]^{-1}$	μ [m^2/Vs]
1.5	0.2	2	0,26		4,4				
		4	0,53		8,9				
		6	0,8		13,3				
		8	1,06		18,4				
2	0.25	2	0,33		5,7	$20\cdot10^{-3}$	$0{,}031\cdot10^{21}$	10	$200\cdot10^{-3}$
		4	0,66		11,4				
		6	1		17,6				
		8	1,33		23,1				
2.5	0.28	2	0,37		6,9				
		4	0,74		14,4				
		6	1,12		21,0				
		8	1,49		27,2				

$$\frac{I_s B}{a} =$$

$a = 1{,}5\ mm$

$$\frac{I_s \cdot B}{a} = \frac{2 \cdot 0{,}12}{1{,}5} = 0{,}26$$

$$\frac{I_s \cdot B}{a} = \frac{4 \cdot 0{,}12}{1{,}5} = 0{,}53$$

$$-\text{''}- = \frac{6 \cdot 0{,}12}{1{,}5} = 0{,}8$$

$$= \frac{8 \cdot 0{,}12}{1{,}5} = 1{,}06$$

$$= \frac{2 \cdot 0{,}25}{1{,}5} = 0{,}33$$

$$= \frac{4 \cdot 0{,}25}{1{,}5} = 0{,}66$$

$$= \frac{6 \cdot 0{,}25}{1{,}5} = 1$$

$$= 1{,}33$$

$$\frac{2 \cdot 0{,}28}{1{,}5} = 0{,}37 \qquad = 1{,}12$$

$$\frac{4 \cdot 0{,}28}{1{,}5} = 0{,}71 \qquad = 1{,}49$$

$$tg\alpha = \frac{V_B - V_A}{B - A} = \frac{22{,}5 - 12{,}5}{1{,}2 - 0{,}7} = \frac{10}{0{,}5} = 20$$

$$tg\alpha \equiv R_H$$

$$R_H = 20 \cdot 10^{-3} \left[\frac{V \cdot m}{AT}\right]$$

$$n = \frac{1}{e \cdot R_H} \quad > e = 1{,}6 \cdot 10^{-19}\ C$$

$$n = \frac{1}{1{,}6 \cdot 10^{-19} \cdot 20 \cdot 10^{-3}} = \frac{1}{32 \cdot 10^{-21}} = 0{,}031 \cdot 10^{21}$$

$$\sigma = \frac{c}{R \cdot a \cdot b}, \quad R = 400\ \Omega, \quad a = 1{,}5\ mm, \quad b = 2\ mm$$

$c = 12\ mm$

$$= \frac{12}{400 \cdot 0{,}015 \cdot 0{,}002} = \frac{12}{0{,}012} = 10$$

$$\mu_H = R_H \cdot \sigma = 20 \cdot 10^{-3} \cdot 10 = 200 \cdot 10^{-3}$$

LAB 4

The Hall Effect