Hall Effect in Semiconductors

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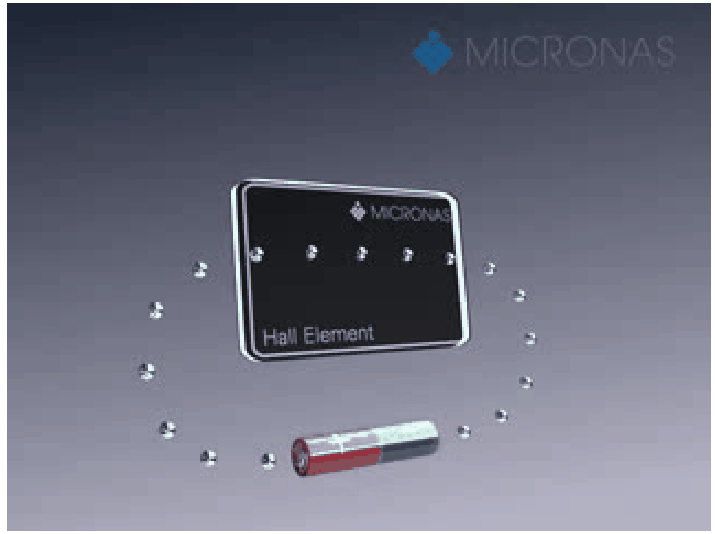
Introduction

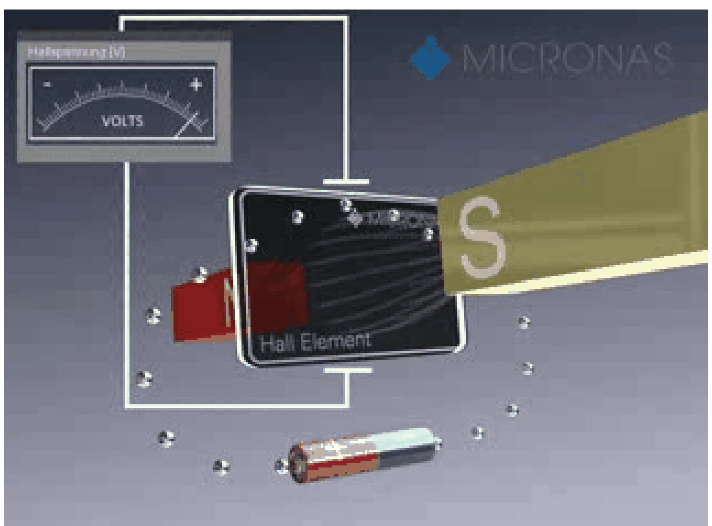
- Edwin Hall (in 1879) observed that;

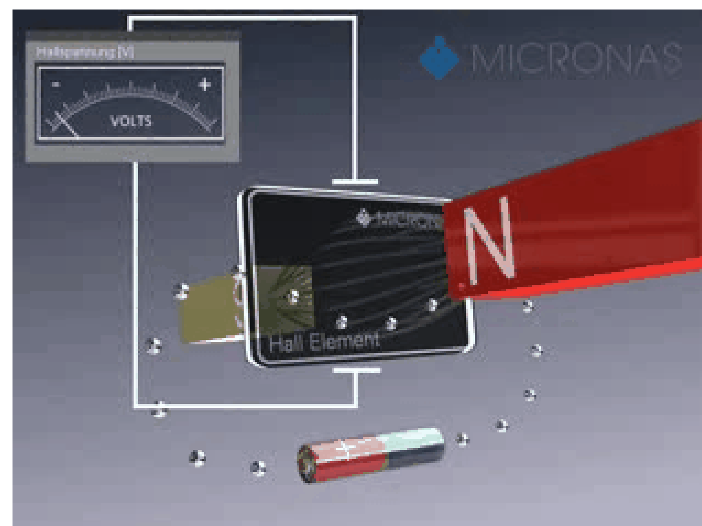
  In a conducting material, when a magnetic field is applied perpendicular to the direction of current flowing through the conductor, an electric field induces in a direction transverse to the direction of both magnetic field and current flow.

Edwin H. Hall
(1855-1938)

Introduction – Illustration

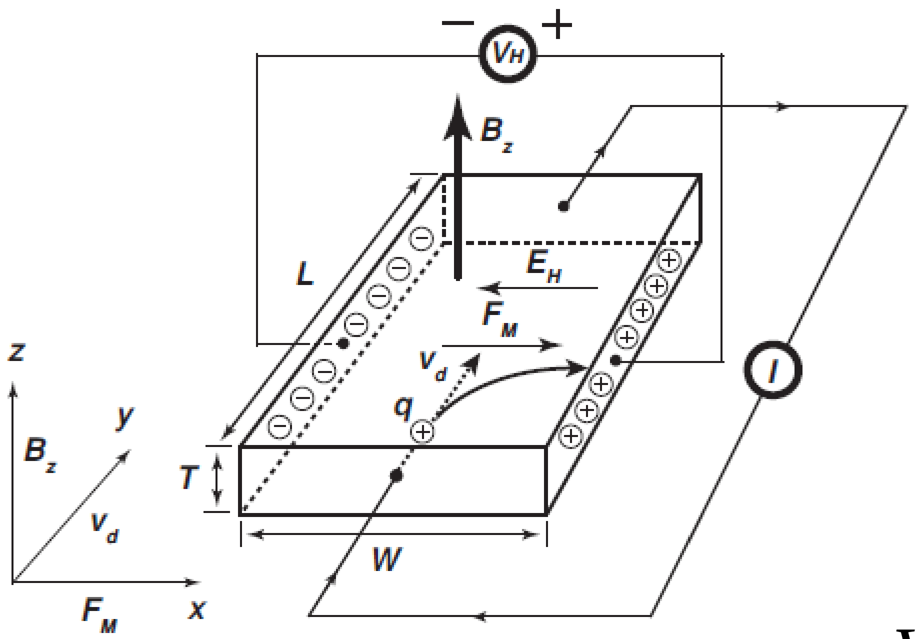






www.micronas.com/en/products/linear-hall-sensors

Hall Coefficient & Carrier concentration



$$\overrightarrow{F_M} = q(\overrightarrow{v_d} \times \overrightarrow{B_z}) = qv_d B_z$$

In equilibrium condition,

$$qv_d B_z = qE_H$$

Where

$$V_H = WE_H$$

$$I = nqv_d A$$

$$V_H = \left(\frac{1}{nq}\right)\frac{IB_z}{T} = R_H \frac{IB_z}{T}$$

$$R_H = \frac{1}{nq} \qquad n = \frac{1}{qR_H}$$

Hall Coefficient & Carrier concentration

Hall coefficient in Metals

Metal	$R_H(\times 10^{-11})$ $[m^3A^{-1}S^{-1}]$
Ag	- 9.0
Au	- 7.2
Cu	- 5.5
Al	- 3.5
Na	-25
Mg	- 9.4

Carrier concentration

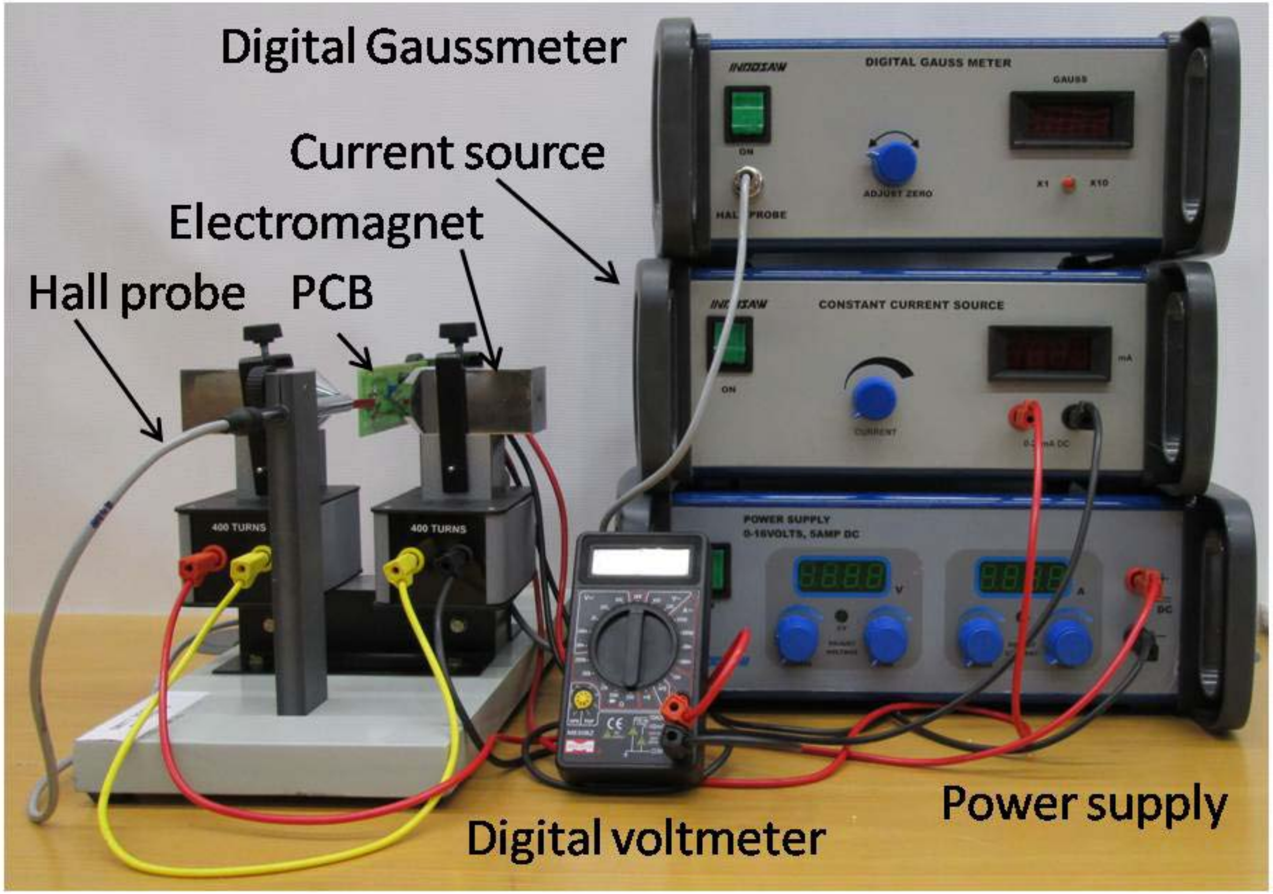
Material	n (m^{-3})
Ag	5.58×10^{28}
Au	5.90×10^{28}
Cu	8.45×10^{28}
Si	1.50×10^{16}
Ge	2.10×10^{18}
GaAs	1.10×10^{13}

* S. O. Kasap, McGraw-Hill, (2006), pp. 145. ** Adrian C. Melissinos, Academic Press, (2003), pp. 63.

Applications

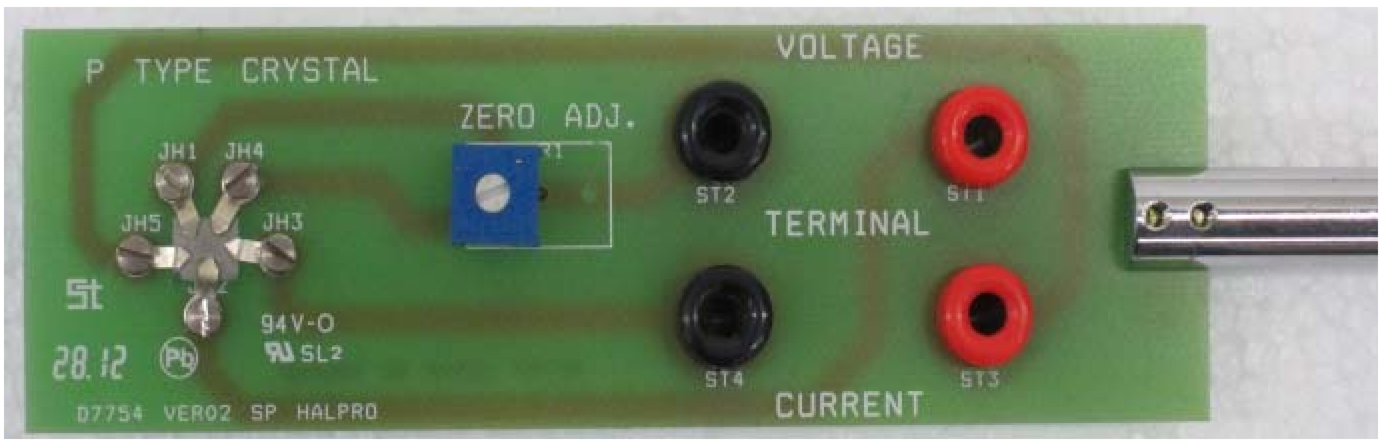
- Hall effect is a fundamental principle in magnetic field sensing.
- Hall probe/Gauss meter
- Proximity sensors
- Magnetically actuated electronic switches
  - Position and alignment detectors
  - Speed controller
  - Ignition systems

Setup & Experiments

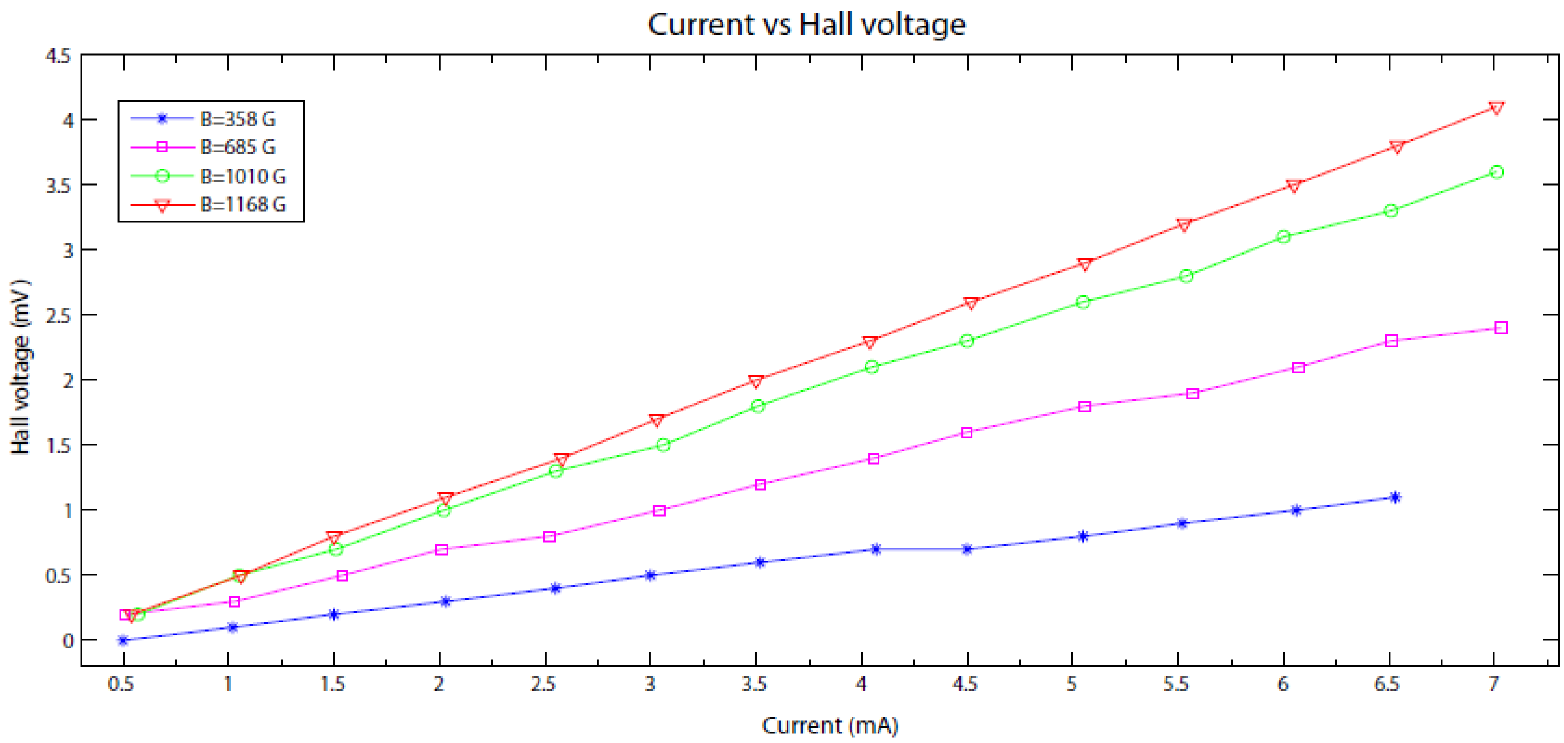


Setup & Experiment

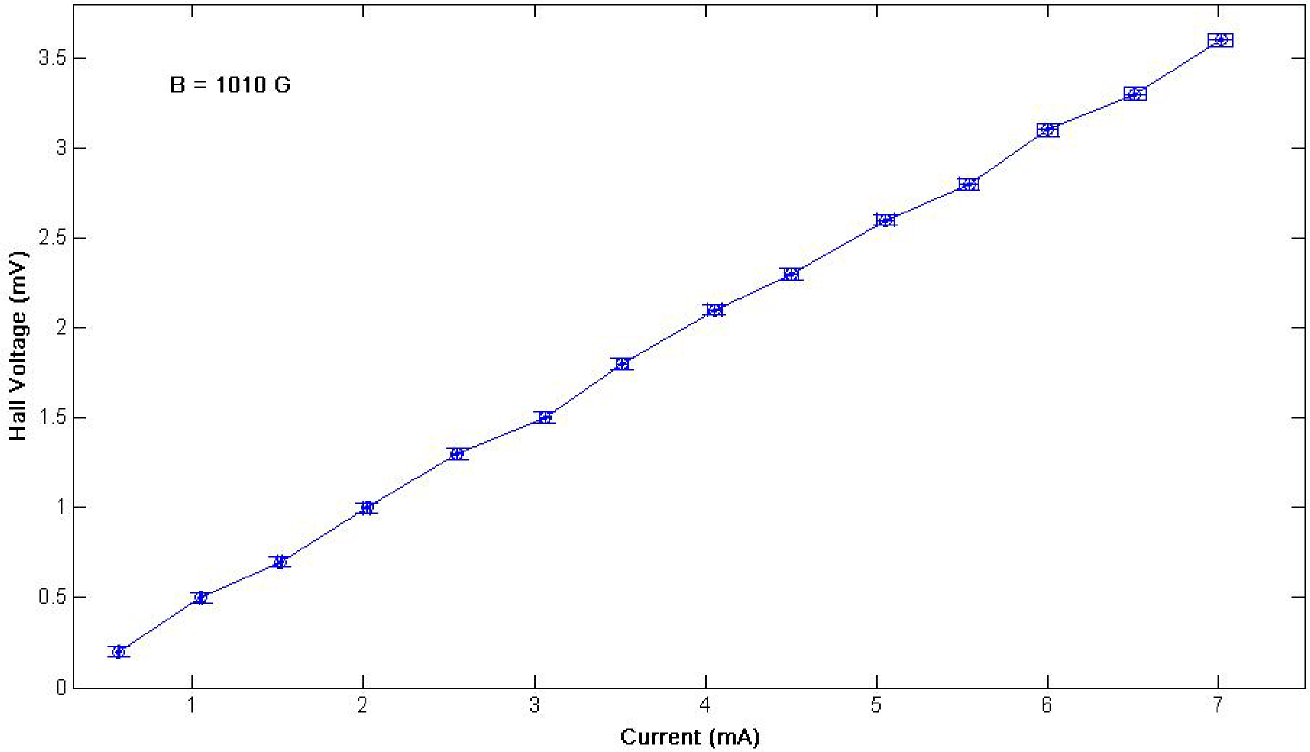
- Printed Circuit Board



Current vs Hall voltage plots



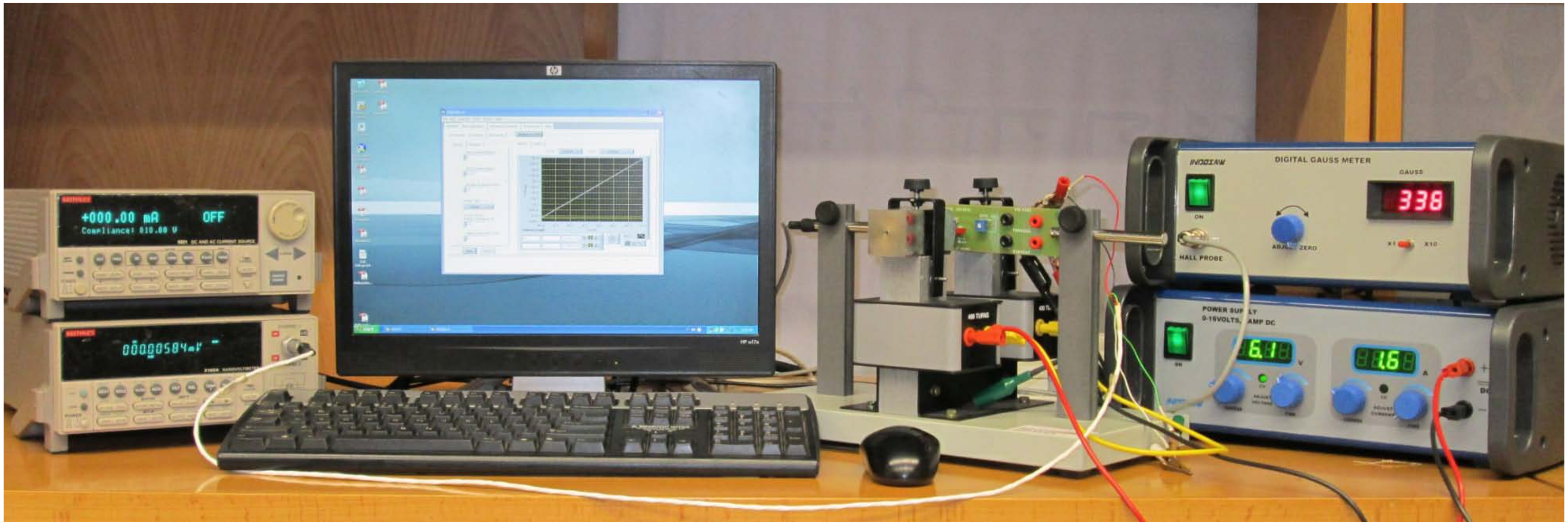
Current vs Hall voltage plot



$$R_H = slope\left(\frac{B}{T}\right) \cong (0.00265 \pm 0.00002) m^3 C^{-1}$$

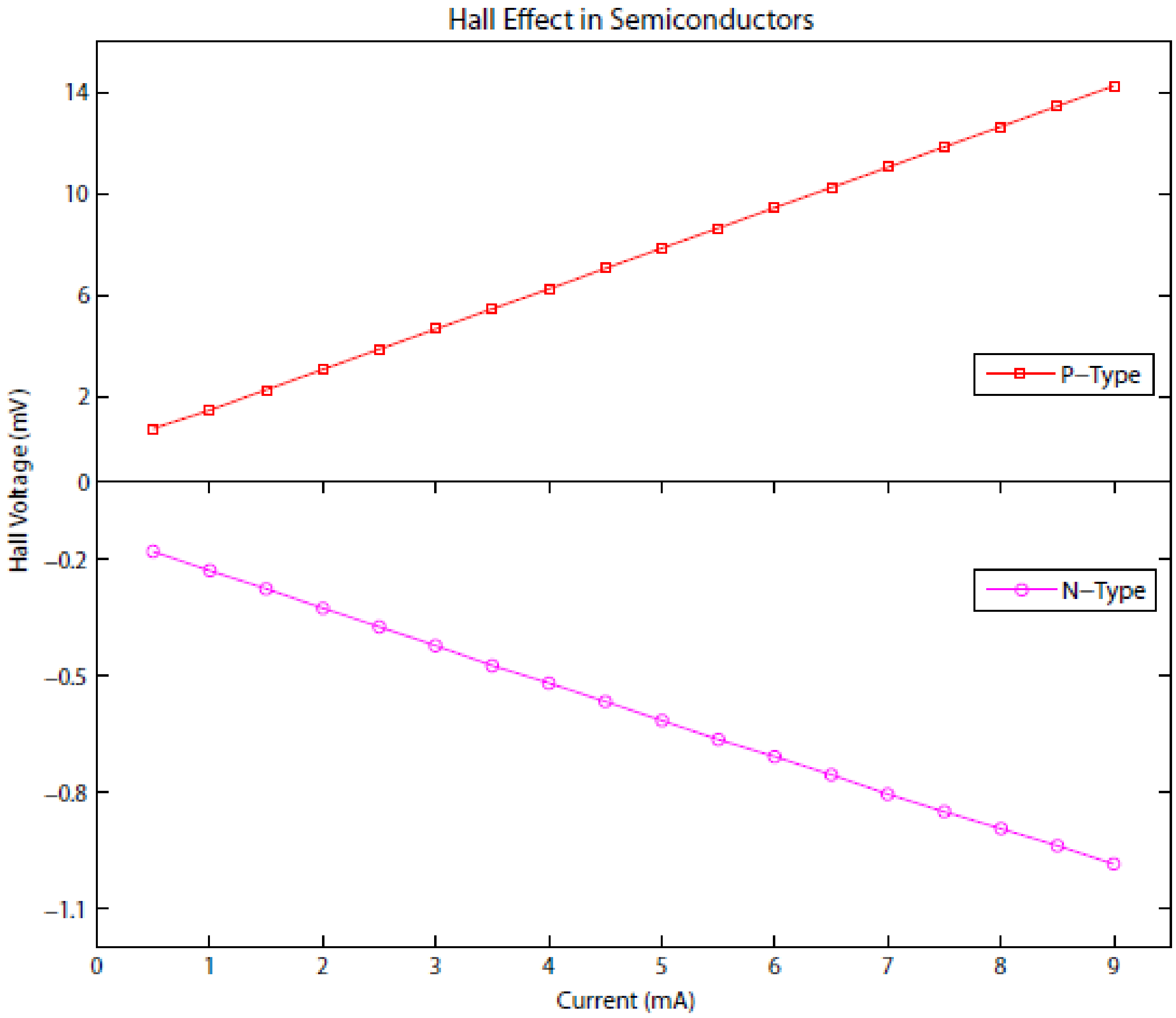
$$n = (2.43 \pm 0.02) \times 10^{21} m^{-3}$$

Hall Effect measurements with computer control



- Keithley 6221 DC & AC Current source
- Keithley 2182 nano-volt meter
- Kl6220.vi software package

Hall Effect measurements with computer control



Thank you for your attention