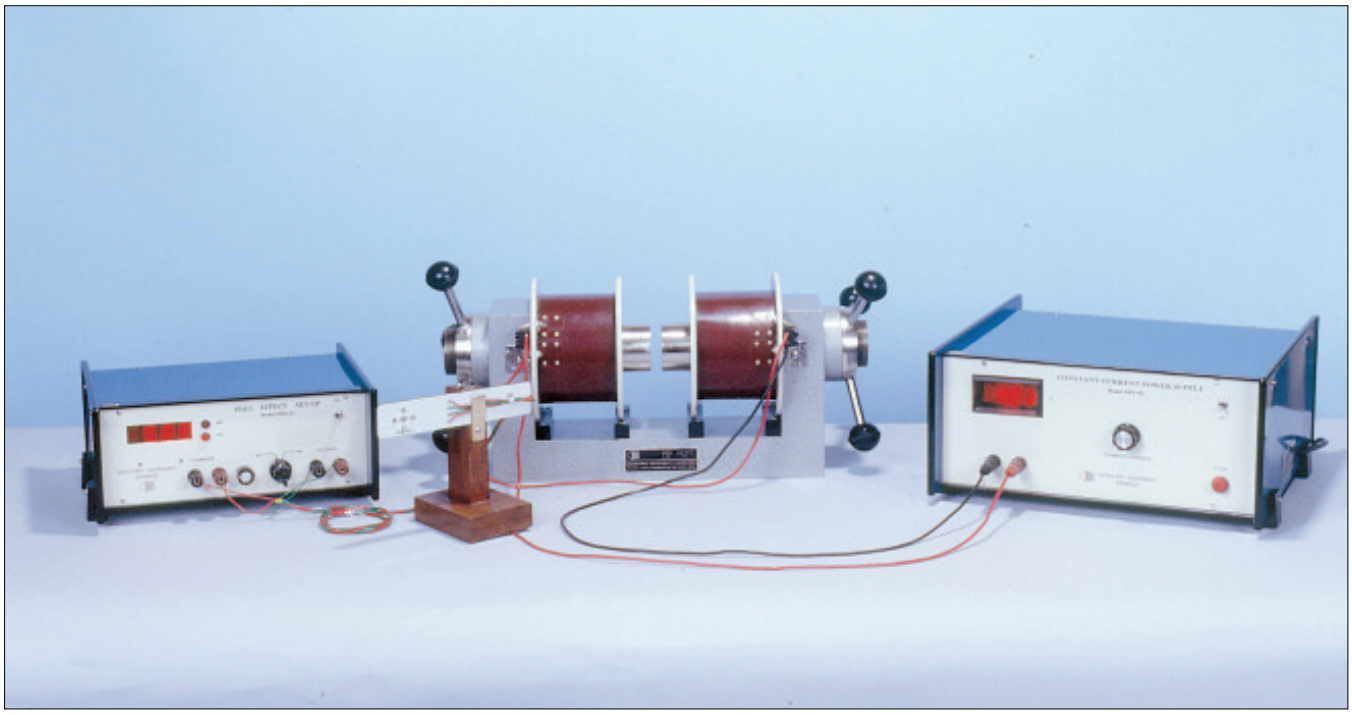
Hall Effect Experiment



Introduction

The resistivity measurements of semiconductors can not reveal whether one or two types of carriers are present; nor distinguish between them. However, this information can be obtained from Hall Coefficient measurements, which are also basic tools for the determination of carrier density and mobilities in conjuction with resistivity measurement.

Theory

As you are undoubtedly aware, a static magnetic field has no effect on charges unless they are in motion. When the charges flow, a magnetic field directed perpendicular to the direction of flow produces a mutually perpendicular force on the charges. When this happens, electrons and holes will be separated by opposite forces. They will in turn produce an electric field ($\bar{E}_h$) which depends on the cross product of the magnetic intensity, $\bar{H}$, and the current density, $\bar{J}$.

$$\bar{E}_h = R\bar{J} \times \bar{H}$$

Where R is called the Hall Coefficient

Now, let us consider a bar of semiconductor, having dimension, x, y and z. Let $\bar{J}$ is directed along X and $\bar{H}$ along Z then $\bar{E}_h$ will be along Y.

Then we could write

$$R = \frac{V_h/y}{JH} = \frac{V_h.z}{IH}$$

Where V_h is the Hall voltage appearing between the two surfaces perpendicular to y and $I=\bar{J}yz$

Silicon Valley Science Labs
12262 Goleta Avenue, Suite 210, Saratoga, CA 95070 USA
Phone: +1 408-230-9381
Fax: +1 408-517-0557
info@svslabs.com
www.svslabs.com

Hall Effect experiment consists of the following:

1. (a) Hall Probe (Ge Crystal); (b) Hall Probe (InAs)
2. Hall Effect Set-up (Digital), DHE-21
3. Electromagnet, EMU-75 or EMU-50V
4. Constant Current Power Supply, DPS-175 or DPS-50
5. Digital Gaussmeter, DGM-102

Hall Probes

(a) Hall Probe (Ge Crystal)

Ge single crystal with four spring-type pressure contacts is mounted on a sunmica-decorated bakelite strip. Four leads are provided for connections with measuring devices.

TECHNICAL DETAILS

Material: Ge single crystal n or p-type as desired

Resistivity: 8-10Ω.cm

Contacts: Spring type (solid silver)

Zero-field potential: <1mV (adjustable)

Hall Voltage: 25-35mV/10mA/KG

It is designed to give a clear idea to the students about Hall Probe and is recommended for class room experiment. A minor drawback of this probe is that it may require zero adjustment.

(b) Hall Probe (InAs)

Indium Arsenide crystal with 4 soldered contacts is mounted on a PCB strip and covered with a protective layer. The Hall Element is mounted in a pen-type case and a 4-core cable is provided for connections with the measuring device and current source.

TECHNICAL DETAILS

Contacts: Soldered

Rated Control Current: 4mA

Zero Field Potential: <4mV

Linearity (0-20KG): ±0.5% or better

Hall Voltage: 60-70mV/4mA/KG

The crystal alongwith its four contacts is visible through the protective layer. This is mainly used as a transducer for the measurement of magnetic field.

Hall Effect Set-up (Digital), DHE-21

DHE-21 is a high performance instrument of outstanding flexibility. The set-up consists of a digital millivoltmeter and a constant current power supply. The Hall voltage and probe current can be read on the same digital panel meter through a selector switch.

(i) Digital Millivoltmeter

Intersil 3½ digit single chip A/D Converter ICL 7107 have been used. It has high accuracy like, auto zero to less than 10µV, zero drift of less than 1µV/°C, input bias current of 10pA max. and roll over error of less than one count. Since the use of internal reference causes the degradation in performance due to internal heating, an external reference has been used. Digital voltmeter is much more convenient to use in Hall experiment, because the input voltage of either polarity can be measured.

SPECIFICATIONS

Range: 0-200mV (100µV minimum)

Accuracy: ±0.1% of reading ±1 digit

(ii) Constant Current Power Supply

This power supply, specially designed for Hall Probe, provides 100% protection against crystal burn-out due to excessive current. The supply is a highly regulated and practically ripple free dc source.

SPECIFICATIONS

Current: 0-20mA

Resolution: 10µA

Accuracy: ±0.2% of the reading ±1 digit

Load regulation: 0.03% for 0 to full load

Line regulation: 0.05% for 10% variation

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