Dependence of Hall Co-efficient on Temperature HEX-22

Introduction

Dielectric or electrical insulating material are understood as the material in which electrostic field can persist for long times. Layers of such substance are commonly inserted into capacitors to improve their perfomance, and the term dielectric refers specifically to this application.879.

An electric field polarizes the molecules of dielectric producing concentrations of charge on its surface that create an electric field opposed (antiparallel) to that of capacitor. This reduces the electric potential. Considered in reverse, this means that, with a dielectric, a given electric potential causes the capacitor to accumulate a larger charge.

Applications Now it is important to recognize that for the same electric field Ex, the Hall voltage for p type carriers will have opposite sign from that for n carriers. (That is, the Hall coefficient R has a different sign.) Thus, the Hall field Ey will not be able to compensate for the magnetic force on both types of carriers and there will be a transverse motion of carriers; however, the net transverse transfer of charge will remain zero since there is no current through the 3, 4 contacts; this statement is expressed as

$$e(v_y^{+}n - v_y^{-}n) = 0$$

while

$$e(v_x^{+}n - v_x^{-}p) = J_x \quad \text{and} \quad e(\mu^{+}p + \mu^{-}n) = \sigma$$

where the mobility is always a positive number; however, ωx+ has the opposite sign from ωx-, but

$$v_y = \frac{s}{t} = \left(\frac{1}{2}\frac{F}{m^{*}}t^{2}\right)\frac{1}{t}$$

where

$$F^{+} = e[(v_x^{+} \times H) - E_y]$$

$$F^{-} = -e[(v_x^{-} \times H) - E_y]$$

thus

$$v_y^{+} = \frac{1}{2}\frac{e}{m_h^{*}}t[(\mu^{-}E_x H) - E_y] = \mu^{+}(\mu^{+}E_x H - E_y)$$

$$v_y^{-} = \frac{1}{2}\frac{e}{m_e^{*}}t[(\mu^{-}E_x H) - E_y] = \mu^{-}(\mu^{-}E_x H + E_y)$$

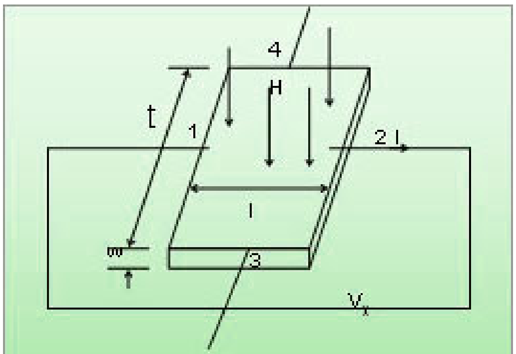

Fig 1:Schematic arrangement for the measure-ment of the Hall effect of a crystal

and thus

$$v_y^{+} = \frac{1}{2}\frac{e}{m_h} t[(\mu^{+} E_z H) - E_y] = \mu^{+}(\mu^{+} E_z H - E_y)$$

$$v_y^{-} = \frac{1}{2}\frac{e}{m_e} t[(\mu^{-} E_z H) - E_y] = \mu^{-}(\mu^{-} E_z H + E_y)$$

and thus

$$\mu^{+} p(\mu^{+} E_z H - E_y) - \mu^{-} n(\mu^{-} E_z H + E_y) = 0$$

$$E_y = E_z H \frac{(\mu_h^2 p - \mu_e^2 n)}{\mu_h p + \mu_e n}$$

and for the Hall coefficient RH

$$R_H = \frac{E_y}{J_z H} = \frac{E_y}{\sigma E_z H} = \frac{\mu_h^2 p - \mu_e^2 n}{e(\mu_h p + \mu_e n)^2} \quad \text{..(5)}$$

Equation 5 correctly reduces to Eq. 1 when only one type of carrier is present.

Since the mobilities µh are not constants but functions of T, the Hall coefficient given by Eq. 5 is also a function of T and it may become zero and even change sign. In general µe > µh so that inversion may happen only if p > *v*; thus "Hall coefficient inversion" is characteristic of only "p-type" semiconductors

At the point of zero Hall Coefficient, it is possible to determine the ratio of mobilities b=µe/µh in a simple manner.

(Ref: Experiments in Modern Physics by A.C. Melissinos)

The Set-up consists of the following

Hall probe (Ge : p type)

- Oven
- Temperature sensor
- Hall Effect Set-up, DHE-22
- Electromagnet, EMU-50V
- Constant Current Power Supply, DPS-50
- Digital Gaussmeter, DGM-102

Hall Probe (Ge : p-type)

Ge single crystal with four spring type pressure contact is mounted on a glass-epoxy strips. Four leads are provided for connections with the probe current and Hall voltage measuring devices.

Oven
It is a small oven which could be easily mounted over the crystal or removed if required.

Technical details

- Size : 35 x 25 x 5 mm (internal size)
- Temperature Range : Ambient to 100° C
- Power requirement : 12 W

Temperature Sensor
Temperature is measured with Cromel-Alumel thermocouple with its junction at a distance of 1 mm from the crystal

Hall Effect Set-up, Model: DHE-22

The set-up, DHE-22 consists of two sub set-ups, each consisting of further two units.

a) Measurement of Probe Current & Hall Voltage

This unit consists of a digital millivoltmeter and constant current power supply. The Hall voltage and probe current can be read on the same digital panel meter through a selector switch

(a) Digital Millivoltmeter

Intersil 3½ digit single chip ICL 7107 have been used. Since the use of internal reference causes the degradation in performance due to internal heating an external reference have 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 (100mV minimum)
Accuracy : ±0.1% of reading ± 1 digit
Line regulation : 0.05% for 10% variation

(b) 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 : 10mA
Accuracy : ±0.2% of the reading ±1 digit
Load regulated : 0.03% for 0 to full load

b) Measurement of Thermo emf and Heater current

The unit consists of a digital millivoltmeter and constant current power supply. The thermo emf of thermocouple and heater current can be read on the same DPM through a selector switch.

(a) Digital Millivoltmeter

Intersil 3½ digit single chip ICL 7107 have been used. Since the use of internal reference causes the degradation in performance due to internal heating an external reference have been used. Digital Voltmeter is much more convenient to use,
because the input voltage of either polarity can be measured.

Specification

Range : 0 - 20 mV
Resolution : 10 mV equivalent to 0.25ºC in terms of thermo emf
Accuracy : ±0.1% of reading ± 1 digit

(b) Constant Current Power Supply

The supply is highly regulated and practical ripple free source.

Specifications

Current : 0 - 1A
Accuracy : ±0.2% of the reading ± 1 digit
Line regulation : 0.1% for 10% variation
Load regulation : 0.1% for 0 to full load

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