MASS ACTION LAW

In an Intrinsic semiconductors number of free electrons $n = n_i$ No of holes $p = p_i$ Since the crystal is electrically neutral, $n_i p_i = n_i^2$ Regardless of individual magnitudes of n and p, the product is always Constant, Therefore

$$np = n_i^2$$

$$N_i = AT^{(3/2)}\, e^{(-E_{GO}/2KT)}$$

This is called **Mass Action Law**

Continuity equation

Continuity equation is a differential equation that describes the conservative transport of some kind of quantity. Since mass, energy, momentum, and other natural quantities are conserved, a vast variety of physics may be described with continuity equations.

This equation may be derived by considering the fluxes into an infinitesimal box. This general equation may be used to derive any continuity equation, ranging from as simple as the volume continuity equation to as complicated as the Navier–Stokes equations. This equation also generalizes the advection equation.

Derivation

In electromagnetic theory, the **continuity equation** can either be regarded as an empirical law expressing (local) charge conservation, or can be derived as a consequence of two of Maxwell's equations. It states that the divergence of the current density is equal to the negative rate of change of the charge density.

HALL EFFECT

The Hall effect is observed when a magnetic field is applied at right angles to a rectangular sample of material carrying an electric current. A voltage appears across the sample that is due to an electric field that is at right angles to both the current and the applied magnetic field. The Hall effect can be easily understood by looking at the Lorentz force on the current carrying electrons. The orientation of the fields and the sample are shown in Figure 1.

An external voltage is applied to the crystal and creates an internal electric field (E_x). The electric field that causes the carriers to move through the conductive sample is called the drift field and is in the x-direction in Figure 1. The resultant drift current (J_x) flows in the x-direction in response to the drift field. The carriers move with an average velocity given by the balance between the force accelerating the charge and the viscous friction produced by the collisions (electrical resistance). The drift velocity appears in the cross product term of the Lorentz force as shown in equation 1. The transverse (y) component of the Lorentz force causes charge densities to accumulate on the transverse surfaces of the sample.

Therefore, an electric field in the y-direction results that *just* balances the Lorentz force because there is no continuous current in the y-direction (Only a transient as the charge densities accumulate on the surface). The equilibrium potential difference between the transverse sides of the sample is called the Hall voltage.

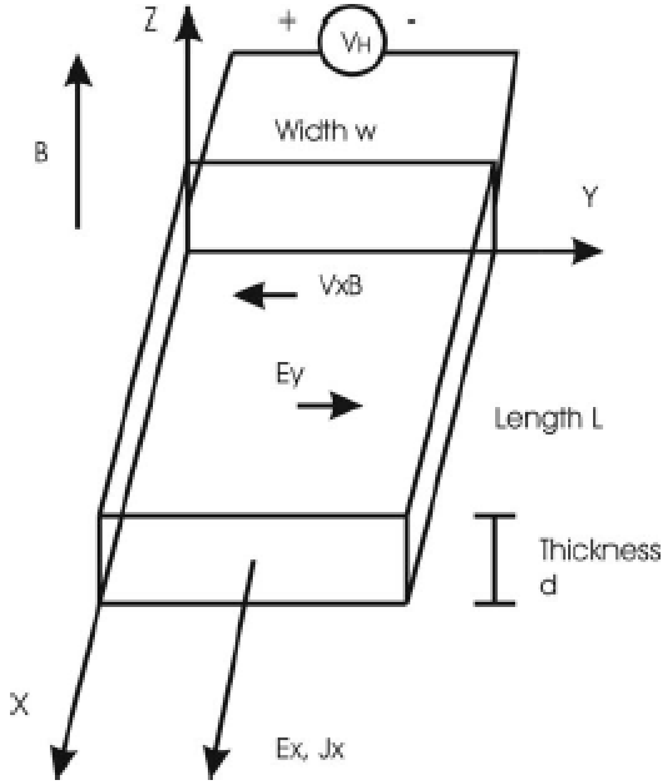

Figure 1
(Signs shown for the case of positive charge carriers)

A good measurement of the Hall voltage requires that there be no current in the y-direction. This means that the transverse voltage must be measured under a condition termed "no load". In the laboratory you can approximate the "no load" condition by using a very high input resistance voltmeter.

THEORY

The vector Lorentz force is given by:

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}) \tag{1}$$

where **F** is the force on the carriers of current, *q* is the charge of the current carriers, **E** is the electric field acting on the carriers, and **B** is the magnetic field inside the sample. The charge may be positive or negative depending on the material (conduction via electrons or "holes").

The applied electric field **E** is chosen to be in the x-direction. The motion of the carriers is specified by the drift velocity **v**. The magnetic field is chosen to be in the z-direction (Fig. 1).

The drift velocity is the result of the action of the electric field in the x-direction. The total current is the product of the current density and the sample's transverse area *A* ($I = J_x A$; $A = wt$). The drift current J_x is given by;

$$J_x = nqv_x \tag{2}$$

where *n* is the number density or concentration of carriers. The carrier density n is typically only a small fraction of the total density of electrons in the material. From your measurement of the Hall effect, you will measure the carrier density.

In the y-direction assuming a no load condition the free charges will move under the influence of the magnetic field to the boundaries creating an electric field in the y-direction that is sufficient to balance the magnetic force.

$$E_y = v_x B_z \tag{3}$$

The Hall voltage is the integral of the Hall field (E_y=E_H) across the sample width *w*.

$$V_H = E_H w \tag{4}$$

In terms of the magnetic field and