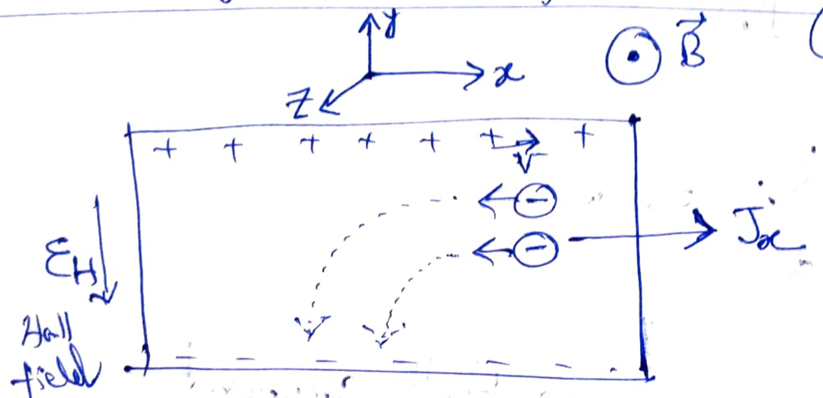
Note 14)

Hall effect

Hall effect in free electron model

(Case of single carrier)



$\vec{B} = B_z \hat{z}$ applied magnetic field.

Electric current flowing through the material in x-direction is J_x.

Electron velocity v_x $\Rightarrow$ Lorentz force

$$F_L = e v_x B$$

Now the field created by the surface charges produces a force which opposes this Lorentz force. The accumulation process continues until the Hall force completely cancels the Lorentz force.

Steady state $\quad F_H = F_L$

$$-e\mathcal{E}_H = -e v_x B \qquad \mathcal{E}_H = v_x B$$

magnitude of Hall field

Current density

$$J_x = N(-e)v_x \longrightarrow \boxed{v_x = \frac{J_x}{-Ne}}$$

$$\therefore \mathcal{E}_H = -\frac{1}{Ne} J_x B$$

$$= R_H J_x B$$

$$R_H \equiv -\frac{1}{Ne} \Rightarrow \text{Hall constant.}$$

$$\boxed{R_H = \frac{\mathcal{E}_H}{J_x B}}$$

In Semiconductors

Define, $R_e \equiv -\frac{1}{n_e e}$

$$R_h = \frac{1}{n_h e}$$

$$R = \frac{R_e \sigma_e^2 + R_h \sigma_h^2}{(\sigma_e + \sigma_h)^2}$$

$\sigma_e = \frac{n_e e^2 \tau_e}{m_e^*}$, $\sigma_h = \frac{n_h e^2 \tau_h}{m_h^*}$ are conductivities of electron & hole.

Nanomaterial

- Material with external dimention (any) in nanoscale or having internal or surface structure in the nanoscale.

d
nanomaterials.

nanoscale $\Rightarrow$ length scale ranging ~~from~~

$1\,nm \lesssim d \lesssim 100\,nm$

Nano-materials

- nanoparticle
- nanofiber
- nanotube (actually hollow nanofiber)
- nanoplate/nanosheet
- nanorod (solid nanofiber)
- nanoribbon (Actually nanosheet with very different larger dimensions (b & d)

Applications

Nanoscale diagnostics

||

Bioimaging & spectroscopy

Manufacturing process

→ paints, filters, insulation & lubricants additives.

Healthcare

e.g. Nanozymes

- nanomaterials with enzyme-like characteristics.

- biosensing, bioimaging, tumor diagnosis
- photo-thermal therapy.