Setting equations (1) and (2) to be equal, we obtain

$e^{\frac{2\mu}{k_B T}} = (\frac{m_h}{m_e})^{\frac{3}{2}} e^{\frac{E_g}{k_B T}}$

$\Rightarrow \mu = \frac{1}{2}E_g + \frac{3}{4}k_B T ln(\frac{m_h}{m_e})$.

For $m_h = m_e$, $\mu = \frac{1}{2}E_g$ and thus the fermi level is in the middle of the forbidden energy gap.

THE EFFECTIVE MASS AND CURVATURE

When a free electron is subjected from electric field $\vec{E}$, it experiences an acceleration given by $a = \frac{-e\vec{E}}{m}$. However, when electric field is applied to a crystal, few electrons if any have $a = \frac{-e\vec{E}}{m}$. This is because the crystal electrons are so tightly bound to the atoms that they can not be accelerated at all. For an electron which is not bound to any atoms, Newton's second law gives $ma = -eE+$ Force due to neighbouring ion cores and the electrons.

The sum of these other forces is not known quantitatively and thus ignoring them, the initial expression can be written as $m^*\vec{a} = -eE$ where m^* is the effective mass.

Considering the wave energy relation $E = \frac{\hbar^2 k^2}{2m}$, the curvature is defined as $\frac{d^2E}{dk^2} = \frac{1}{m}$. Then the coefficient of k^2 determines the curvature of E versus k. For an electron in a I-D lattice we assume that the electron moves with a group velocity given by $V_g = \frac{1}{\hbar}\frac{dE}{dk}$ and the external force acting on the electron is given as $F = \hbar\frac{dk}{dt}$.

Hence $\frac{dV_g}{dt} = \frac{1}{\hbar}\frac{d^2E}{dkdt}$.

$\frac{dV_g}{dt} = \frac{1}{\hbar}\frac{d^2E}{dk^2}\frac{dk}{dt}$

But $\frac{dk}{dt} = \frac{F}{\hbar}$.

$\Rightarrow \frac{dV_g}{dt} = \frac{1}{\hbar^2}(\frac{d^2E}{dk^2})F$.

$F = \frac{\hbar^2}{\frac{d^2E}{dk^2}}\frac{dV_g}{dt}$.

Identifying $\frac{\hbar^2}{\frac{d^2E}{dk^2}}$ as the mass, then the above equation is identical to Newton's second law.

Thus the effective mass m^* is given by

$m^* = \hbar^2(\frac{d^2E}{dk^2})^{-1}$, where $\frac{d^2E}{dk^2}$ defines the curvature.

THERMO ELECTRIC EFFECTS

For a semi-conductor maintained at constant temperature while allowing an electric field to pass through drives an electric current density j_q. If the current is carried only by electrons, then the charge flux is given by $j_q = n(-e)(-\mu_e)E = ne\mu_e E$, where μ_e is the electon mobility. The average energy transported by an electron expressed in terms of the fermi level μ is given by $(E_c - \mu) + \frac{3}{2}k_B T$, where E_c is the energy at the conduction band edge.

Thus the energy flux, j_U that accompany the charge flux is

$j_U = n(E_c - \mu + \frac{3}{2}k_B T)(-\mu_e)E.$

THE PELTIER COEFFICIENT, π

The peltier coefficient, π is defined by the relation $j_U = \pi j_q$ i.e $\pi = \frac{j_U}{j_q}$ and gives the energy carried per unit charge. Thus from the expressions of j_q and j_U, we obtain for electrons

$\pi_e = -\frac{(E_c - \mu + \frac{3}{2}k_B T)}{e}.$

It is negative because the energy flux is opposite to the charge flux. In case of holes, $j_q = pe\mu_h E$ and $j_u = p(\mu - E_v + \frac{3}{2}k_B T)\mu_h E$,

where E_v is the energy at the valence band edge, μ_h is the hole mobility and p is the hole carrier concentration.

Thus $\pi_h = \frac{(\mu - E_v + \frac{3}{2}k_B T)}{e}$ and is positive.

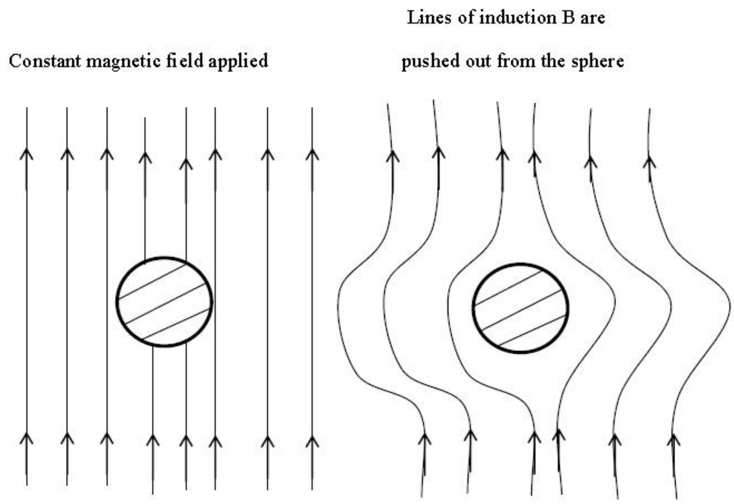
The absolute thermoelectric power Q is defined by $E = Q_{grad}T$, where E is the electric field created by the temperature gradient ∇T. π and Q are related by the relation $\pi = QT$ which is referred to as the kelvin relation of the irreversible thermodynamics.

SUPERCONDUCTIVITY

This phenomenon refers to when electrical resistivity of a metal or alloy drops suddenly to zero when it is cooled to a low temperature. In otherwords at a critical temperature the specimen undergoes phase transition from a state of normal resistivity to a state of superconductivity. When in a superconducting state, electrical resistivity is zero or even close to zero but persisting electrical currents have been seen to flow without change in superconductivity rings.

Magnetic Properties of Superconductors

A bulk superconductor in a weak magnetic field will act as a perfect diamagnet with zero magnetic induction in the interior. When a specimen is put in a magnetic field and then cooled through the transition temperature for superconductivity the magnetic flux originally present is pushed out of the specimen.



The above effect is called Meissner effect. This is due to electric currents or screening current flowing on the surface of a superconductor in such a way as to generate a field equal and