4.10 Position of the Fermi Level

In intrinsic semiconductor the Fermi level lies in the middle of the forbidden gap. This result is obtained on the assumption that the effective masses of electron and hole are equal. As they will not be equal the Fermi level lies in the vicinity of the center of the forbidden gap Fig. 4.15, with increase in temperature the Fermi level in an intrinsic semiconductor may get not displaced and may be regarded as staying the middle of the band gap.

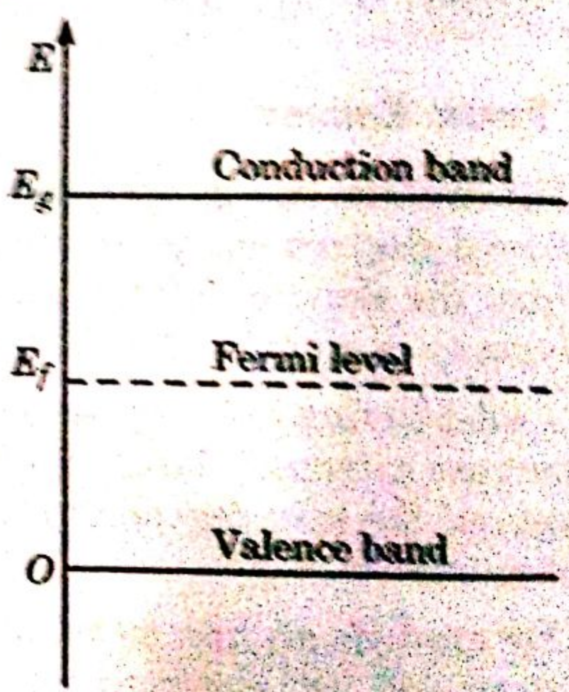

Fig. 4.15. Position of Fermic level

4.11 Fermi-Dirac Statics

Electrons in solid have to obey Fermi-Dirac Statics. When the temperature is above the absolute zero, at thermal equilibrium, the electrons do not simply fill the lowest energy states first. The Fermi-Dirac statics gives the distribution of probability of an electron to have an energy E at temperature T:

$$f_e(E) = \frac{1}{\exp\left[\frac{E - E_F}{K_b T}\right] + 1}$$

E_F = Fermi level energy

K_b = Botzmann's Constant

This distribution is called the Fermi-Dirac distribution and is plotted in Fig. 4.16 for various values of temperature.

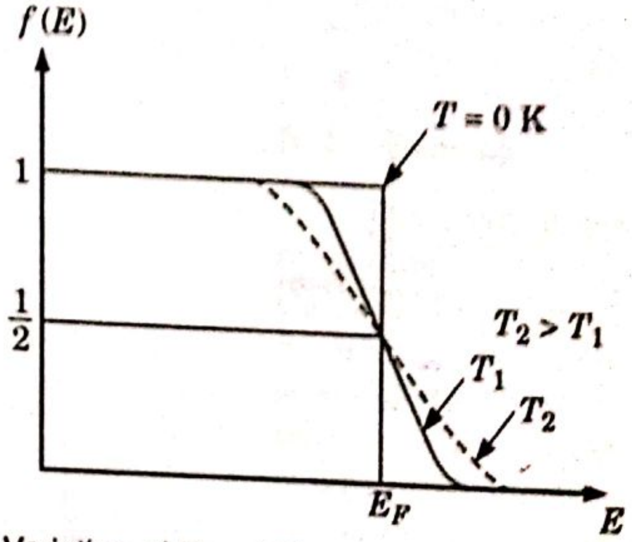

Fig. 4.16. Variation of Fermi-Dirac distribution with temperature.

In particular, we have $T = 0$ K : for $E > E_F$, $f_e(E) = 0$

for $E \leq E_F$, $f_e(E) = 1$

This means that all the electrons in the crystal have their energy below E_F. At a temperature $T > 0$ K the transition from unity to zero is less sharp. Nevertheless for all temperatures, $f_e(F) = ½$ when $E = E_F$.

To determine the Fermi energy we must know the concept of density of states. The knowledge of the Fermi-Dirac distribution which tells the probability of presence of an electron with energy E, and the density of states. Which tells how many electrons are allowed with an energy E, permits the determination of the distribution of electrons in the energy bands.