Ve320 Introduction of Semiconductor Device
Homework 2
Due Date: June. 06

Ex 2.1

The bandgap energy in a semiconductor is usually a slight function of temperature. In some cases, the bandgap energy versus temperature can be modeled by

$$E_g = E_g(0) - \frac{\alpha T^2}{(\beta + T)}$$

where $Eg(0)$ is the value of the bandgap energy at $T = 0\,K$. For silicon, the parameter values are $Eg(0) = 1.170\,eV$, $\alpha = 4.73 \times 10^{-4}\,eV/K$, and $\beta = 636\,K$. Plot Eg versus T over the range $0 \leq T \leq 600\,K$. In particular, note the value at $T = 300\,K$.

Ex 2.2

Fig.1 shows the parabolic E versus k relationship in the valence band for a hole in two particular semiconductor materials. Determine the effective mass (in units of the free electron mass) of the two holes.

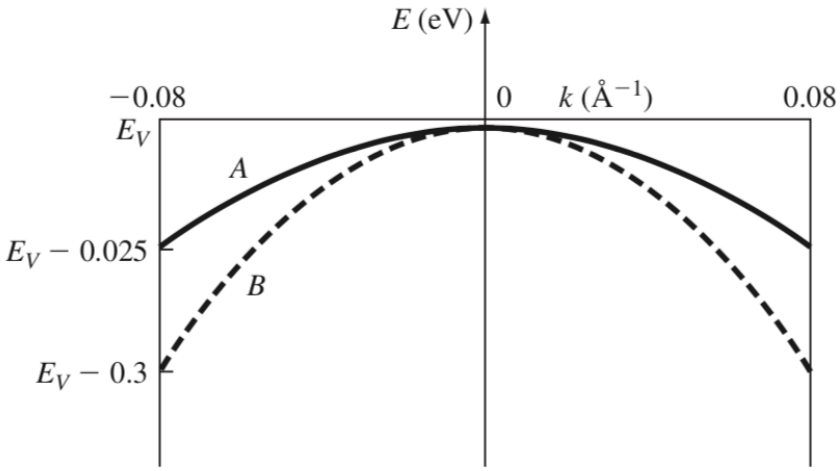

Figure 1. Figure for Ex 2.2.

Ex 2.3

Show that, Eq. (a) can be derived from Eq. (b).

$$g(E) = \frac{4\pi(2m)^{3/2}}{h^3}\sqrt{E} \qquad (a)$$

$$g_T(k)dk = \frac{\pi k^2 dk}{\pi^3} \cdot a^3 \qquad (b)$$

Ex 2.4

The probability that a state at $E_c + kT$ is occupied by an electron is equal to the probability that a state at $E_v - kT$ is empty. Determine the position of the Fermi energy level as a function of E_c and E_v.

Ex 2.5

Calculate the energy range (in eV) between $f_F = 0.95$ and $f_F = 0.05$ for $E_F = 5.0\ eV$ at (a) $T = 200\ K$ and (b) $T = 400\ K$.

Ex 2.6

Calculate E_{Fi} with respect to the center of the bandgap in silicon for $T = 200$, 400 and $600\ K$.

Ex 2.7

If the density of states function in the conduction band of a particular semiconductor is a constant equal to K, derive the expression for the thermal-equilibrium concentration of electrons in the conduction band, assuming Fermi–Dirac statistics and assuming the Boltzmann approximation is valid.

Ex 2.8

The value of p_0 in silicon at $T = 300\ K$ is $2 \times 10^{16}\ cm^{-3}$. (a) Determine $E_F - E_v$. (b) Calculate the value of $E_c - E_F$. (c) What is the value of n_0? (d) Determine $E_{Fi} - E_F$.

Ex 2.9

Silicon at $T = 300\ K$ is doped with boron atoms such that the concentration of holes is $p_0 = 5 \times 10^{15}\ cm^{-3}$. (a) Find $E_F - E_v$. (b) Determine $E_c - E_F$. (c) Determine n_0. (d) Which carrier is the majority carrier? (e) Determine $E_{Fi} - E_F$.

Ex 2.10

(a) Determine the values of n_0 and p_0 in silicon at $T = 300\ K$ if $E_F - E_v = 0.25\ eV$. (b) Assuming the value of p_0 in part (a) remains constant, determine the values of $E_F - E_v$ and n_0 at $T = 400\ K$.