Home Problem Set #7 Due : October 13, 2014

1. Calculate the number of electrons in the conduction band for silicon at T = 300 K. (Assume $m^*_e / m_0 = 1$.)

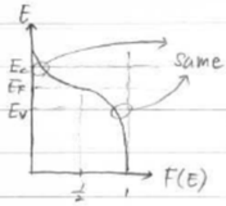
$$N_e = 4.84 \times 10^{15} \left(\frac{m_e^*}{m_0}\right)^{3/2} T^{3/2} \exp\left[-\frac{E_g}{2k_BT}\right], \text{ for Si}, \; T=300\,K, \; \frac{m_e^*}{m_0} = 1$$

$$= 4.84 \times 10^{15} \times 1 \times 300^{3/2} \cdot \exp\left(-\frac{1.12}{2 \times 8.616 \times 10^{-5} \times 300}\right) \text{ Appendix 4}$$

$$= 9.81 \times 10^{9} \text{ (개/cm}^3\text{)}$$

2. Calculate the Fermi energy of an intrinsic semiconductor at $T \neq 0$ K. (*Hint* : Give a mathematical expression for the fact that the probability of finding an electron at the top of the valence band plus the probability of finding an electron at the bottom of the conduction band must be 1.) Let $N_e = N_p$ and $m^*_e = m_h^*$.

Fermi function : $F(E) = \dfrac{1}{\exp\left(\frac{E-E_F}{k_BT}\right)+1}$



same : probability of finding electron (at the top of valence band + at the bottom of conduction band) = 1

$E_c = 0$ (기준점으로 생각), $E_v = -E_g$

$\therefore F(E_c) = F(0) = \dfrac{1}{\exp(-E_F/k_BT)+1}$, $F(E_v) = \dfrac{1}{\exp\left(\frac{-E_g-E_F}{k_BT}\right)+1}$

$F(E_c) + F(E_v) = 1$ $\therefore \dfrac{1}{\exp(-E_F/k_BT)+1} + \dfrac{1}{\exp((-E_g-E_F)/k_BT)+1} = 1$

$$\rightarrow \frac{2+\exp(-E_F/k_BT)+\exp((-E_g-E_F)/k_BT)}{\left\{\exp\left(-\frac{E_F}{k_BT}\right)+1\right\}\cdot\left\{\exp\left(\frac{-E_g-E_F}{k_BT}\right)+1\right\}} = \frac{2+\exp\left(-\frac{E_F}{k_BT}\right)+\exp\left(\frac{-E_g-E_F}{k_BT}\right)}{\exp\left(\frac{-E_g-2E_F}{k_BT}\right)+\exp\left(-\frac{E_F}{k_BT}\right)+\exp\left(\frac{-E_g-E_F}{k_BT}\right)} = 1$$

분모는 우변으로 넘겨 정리하면, $\exp\left(\frac{-E_g-2E_F}{k_BT}\right) = 1$ $\therefore -E_g - 2E_F = 0$, $\therefore E_F = -\frac{1}{2}E_g$