Arab Academy for Science & Technology & Maritime Transport
(AASTMT – Cairo Branch)
College of Engineering & technology
Electronics & Communication Engineering Department
Course : Solid State Electronics
Course Code : EC210

Sheet #8

TextBook
'Principles of Electronic Materials and Devices', Third Edition, S.O. Kasap © McGraw-Hill, 2006

Constants:
$\varepsilon_o = 8.85 \times 10^{-12}\,\text{Fm}^{-1}$
Charge of electron $(q) = 1.6 \times 10^{-19}\,\text{C}$
Mass of electron $(m_e) = 9.1 \times 10^{-31}\,\text{kg}$
Plank's Constant $(h) = 6.63 \times 10^{-34}\,\text{Js}$
Boltzmann's Constant (k)=8.6173324×10^{-5}eV.K^{-1}= $1.3806488 \times 10^{-23}$ J.K^{-1}

Choose the correct answer justifying your choice:

1. Doping silicon with Aluminum results in …………..
(a) n-type semiconductor (b) p-type semiconductor
(c) intrinsic semiconductor (d) non-conducting material

2. Doping silicon with phosphorous results in …………..
(a) n-type semiconductor (b) p-type semiconductor
(c) intrinsic semiconductor (d) non-conducting material

3. In an intrinsic semiconductor ……………………..
(a) There is no allowed energy levels between E_c and E_v.
(b) There is an allowed energy level which is little above E_v.
(c) There is an allowed energy level which is little below E_c.
(d) There is an allowed energy level which is near the middle between E_c and E_v .

4. In an n-type semiconductor ……………………..
(a) There is no allowed energy levels between E_c and E_v.
(b) There is an allowed energy level which is little above E_v.
(c) There is an allowed energy level which is little below E_c.
(d) There is an allowed energy level which is near the middle between E_c and E_v .

5. In a p-type semiconductor ……………………..
(a) There is no allowed energy levels between E_c and E_v.
(b) There is an allowed energy level which is little above E_v.
(c) There is an allowed energy level which is little below E_c.
(d) There is an allowed energy level which is near the middle between E_c and E_v .

6. The electron and hole concentrations are equal to zero ……………
(a) in an intrinsic semiconductor. (b) in an extrinsic semiconductor.
(c) in a semiconductor at 0 K temperature. (d) in a semiconductor at very high temperature.

7. In an intrinsic semiconductor, if *n* and *p* are the electron and hole concentrations…...

(a) *n* must be zero (b) *p* must be zero

(c) *n* and *p* must be equal (d) *n* and *p* must not be equal

8. In an n-type semiconductor, if *n* and *p* are the electron and hole concentrations, …...

(a) *n* must be zero (b) *p* must be zero

(c) *n* is smaller than *p* (d) *n* is larger than *p*

9. In a p-type semiconductor, if *n* and *p* are the electron and hole concentrations, …...

(a) *n* must be zero (b) *p* must be zero

(c) *n* is smaller than *p* (d) *n* is larger than *p*

<u>Solve the following problems</u>

[1] For intrinsic silicon at room temperature, given that the intrinsic concentration is 1x1010 cm-3, the mean time between scatterings is 2x10-13 sec for electrons, and1x10-13 sec for holes, the conductivity effective mass for electrons is 0.26mo, and 0.386mo for holes, where mo is the rest mass for the electrons. Find:

a. Electron and hole mobilities
b. Total conductivity.
c. The current density if the silicon has a length of 1um, and an applied voltage of 10V.
d. The total current if the cross section area is $100um^2$.

Hint: use MKS system

[2] Example 5.3 p.392.

[3] For a p-type silicon slice with:
- Cross section area = 10 $um^{\mathbf{2}}$, length= 100um, mobility = 600 $cm^{\mathbf{2}}V^{\mathbf{-1}}sec^{\mathbf{-1}}$, temperature = 27$^oC$.
- Boron (Acceptor, N_A) doping gradient with a linear dependence on distance, with $N_{\mathbf{A}}$(at x=0um) = $5x10^{\mathbf{16}}$ $cm^{\mathbf{-3}}$, and $N_{\mathbf{A}}$(at x= 100um) =$10^{17}cm^{\mathbf{-3}}$.

Find the total diffusion current.

Note: Use k= 1.3806488×10^{-23} $J.K^{-1}$.

[4] Plot the Fermi-Dirac distribution if Fermi-Level is located at 0.56 eV for T=0K,1000K.

[5] For silicon at T=300K, given that the value of N_c =$2.8x10^{19}$ cm^{-3} and N_v=$1.04x10^{19}$ cm^{-3}, find:

a) The electron concentration for an n-type doped semiconductor if E_F is located at 146 meV below E_C.
b) The hole concentration for a p-type doped semiconductor if E_F is located at 0.31eV above $E_{v.}$

[6] For a Si material of dimensions 1um x 1um x 1um, find the maximum allowed number of electrons in the conduction band which can be present between E1=1eV and E2=2eV at T= 200K, 300K and 400K. Assume meff = 0.92mo.

[7] Calculate the Density of States for a 2D material, following the same procedure used in 3D material.