Electronic Devices

Tutorial-2: Carrier Transport and Excess Charge Carriers

Q. 1

Consider a Si sample which is doped with donor atoms having concentration of $10^{16}/cm^3$. The length and the cross sectional area of the sample is 5 μm and 100 μm^2 respectively. A voltage of magnitude 15 V is applied to the semiconductor at 300 K. Find out the drift current as contributed by the majority charge carrier of the given semiconductor

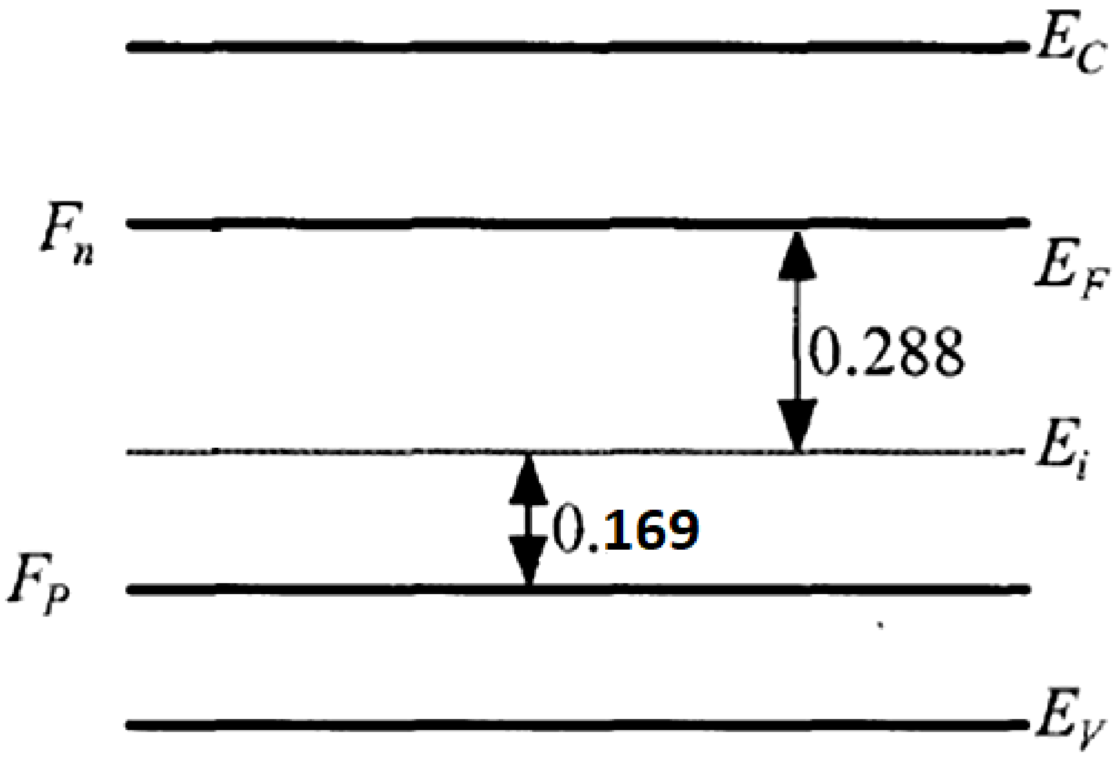
$\mathbf{1.6 \times 10^{-2} A}$

Q.2

An n-type Si sample with $N_d = 10^{15}$ cm^{-3} is steadily illuminated such that $g_{op} = 10^{19}$ EHP/cm^3-s. If $\tau_n = \tau_p = 1$ μs for this excitation, calculate the separation in the quasi-Fermi levels, $(F_n - F_p)$. Draw a band diagram.

Sol.

The Band diagram



Q. 3

In a semiconductor, the intrinsic carrier concentrations and the resistivity at room temperature are $1.5 \times 10^{16}/\mathrm{m}^3$ and $2 \times 10^5 \Omega$-m respectively. If the semiconductor is now doped with $10^{20}/\mathrm{m}^3$ donor dopant atoms. Calculate the following for the extrinsic semiconductor:

(a) Minority carrier concentration
(b) Conductivity

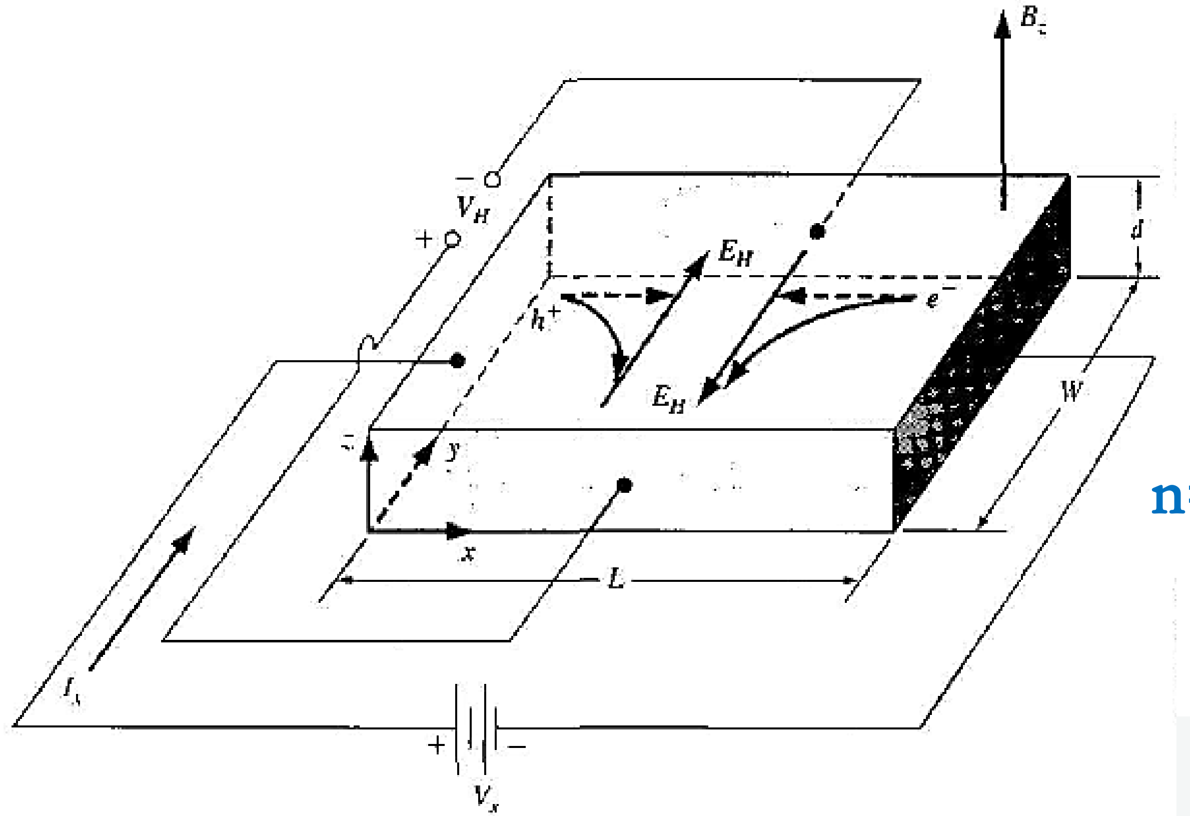
Assume that the mobilities of electron and holes are same.

$$p_0 = \mathbf{2.25 \times 10^{12}/m^3}$$

$$\sigma = \mathbf{1.6 \times 10^{-2}/\,\Omega\text{-m}}$$

Q. 4

To determine the majority carrier concentration and mobility. Consider the given hall parameters and geometry shown in Figure. Let L = 10^{-1} cm, W = 10^{-2} cm, d = 10^{-3} cm. Also assume that I_x = 1.0 mA, V_x = 12.5 V, B_z = 500 gauss = 5×10^{-2} Tesla and V_H = −6.25 mV.



n= $5 \times 10^{21}/m^3 = 5 \times 10^{15}/cm^3$

$\mu_n = 1000\ cm^2V^{-1}s^{-1}$

Q. 5

The total current in a semiconductor is constant and is composed of electron drift current and hole diffusion current. The electron concentration is constant and is equal to 10^{16}cm^{-3}. The hole concentration is given by :

$$p(x) = 10^{15}\exp(-\frac{x}{L})cm^{-3}$$

Where L = 12µm. The hole diffusion coefficient is D_p=12cm^2/s and the electron mobility is equal to 1000cm^2/V-s. The total current density = 4.8 A/cm^2. Calculate:

(a) The hole diffusion current density in terms of x
(b) The electron current density in terms of x

$$J_{diff,p} = -1.6\, exp(-\frac{x}{L})\ \mathrm{A/\ cm^2}$$

$$J_{drift,e} = 4.8 - 1.6\, exp(-\frac{x}{L})\ A/cm^2$$