[1] (a) A silicon semiconductor is in the shape of a rectangular bar with a cross-sectional area of 100 μm^2, a length of 0.1 cm, and is doped with 5×10^{16} cm^{-3} arsenic atoms. The temperature is T = 300 K. Determine the current if 5V is applied across the length. (b) Repeat part (a) if the length is reduced to 0.01 cm. (c) Calculate the average drift velocity of electrons in parts (a) and (b).

[2] A perfectly compensated semiconductor is one in which the donor and acceptor impurity concentrations are exactly equal. Assuming complete ionization, determine the conductivity of silicon at T = 300 K in which the impurity concentrations are (a) $N_a = N_d = 10^{16}$ cm^{-3} and (b) $N_a = N_d = 10^{18}$ cm^{-3}.

[3] Consider silicon at T = 300 K. assume the electron mobility is $\mu_n = 1350$ $cm^2/V\text{-}s$. The kinetic energy of an electron in the conduction band is $(1/2)m_n^* v_d^2$, where m_n is the effective mass ($m_n = 1.08\ m_o$) and v_d is the drift velocity. Determine the kinetic energy of an electron in the conduction band if the applied electric field is (a) 10 V/cm and (b) 1 kV/cm.

[4] Assume that the mobility of electrons in silicon at T = 300 K is $\mu_n = 1300$ $cm^2/V\text{-}s$. Also assume that the mobility is limited by lattice scattering and varies as $T^{-3/2}$. Determine the electron mobility at (a) T = 200 K and (b) T = 400 K.

[5] The electron concentration in silicon decreases linearly from 10^{16} cm^{-3} to 10^{15} cm^{-3} over a distance of 0.10 cm. The cross-sectional area of the sample is 0.05 cm^2. The electron diffusion coefficient is 25 cm^2/s. Calculate the electron diffusion current.

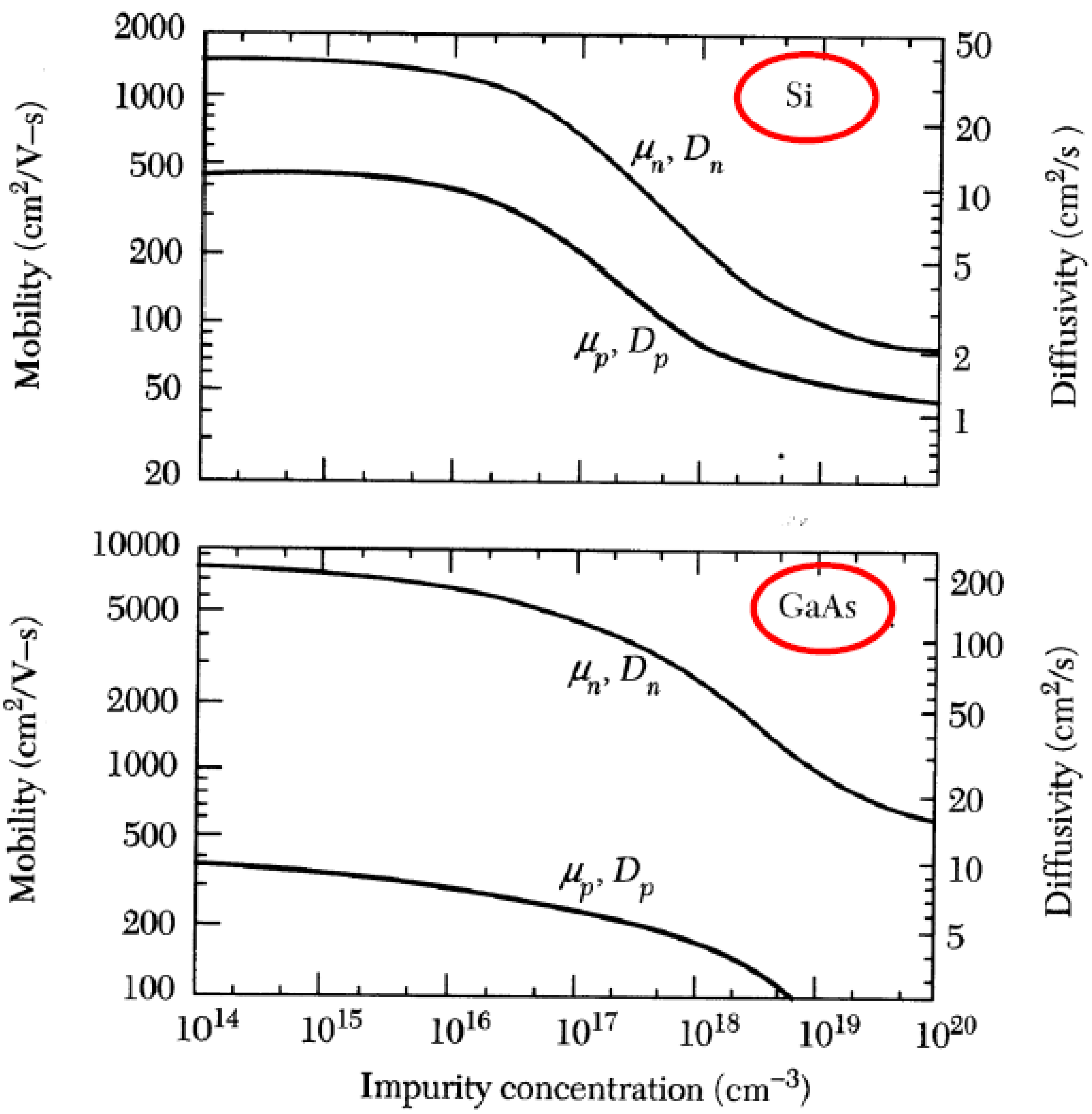
[6] The hole concentration is given by $p = 10^{15} \exp(-x/Lp)$ cm^{-3} for x = 0 and the electron concentration is given by $5 \times 10^{14} \exp(+x/Ln)$ cm^{-3} for $x \leq 0$. The values of Lp and Ln are 5×10^{-4} cm and 10^{-3} cm respectively. The hole and electron diffusion coefficients are 10 cm^2/s and 25 cm^2/s, respectively. The total current density is defined as the sum of the hole

diffusion current density at x = 0 and the electron diffusion current density at x = 0. Calculate the total current density.

[7] The electron concentration in silicon at T = 300 K is given by $n(x) = 10^{16} \exp(-x/18)$ cm^{-3} where x is measured in μm and is limited to $0 \leq x \leq 25$ μm. The electron diffusion coefficient is $D_n = 25$ cm^2/s, and the electron mobility is $\mu_n = 960$ $cm^2/V\text{-}s$. The total electron current density through the semiconductor is constant and equal to $J_n = -40$ A/cm^2. The electron current has both diffusion and drift current components. Determine the electric field as a function of x which must exist in the semiconductor.

[8] In n-type silicon, the Fermi energy level varies linearly with distance over a short range. At x = 0, $E_F - E_{Fi} = 0.4$ eV and, at x = 10-3 cm, $E_F - E_{Fi} = 0.15$ eV. (a) Write the expression for the electron concentration over the distance. (b) If the electron diffusion coefficient is $D_n = 25$ cm^2/s, calculate the electron diffusion current density at (i) x = 0 and (ii) $x = 5 \times 10^{-4}$ cm.

[9] In GaAs, the donor impurity concentration varies as $N_{d0} \exp(-x/L)$ for $0 \leq x \leq L$, where L = 0.1 μm and N_{d0} = 5 x 1016 cm^{-3}. Assume $\mu_n = 6000$ $cm^2/V\text{-}s$ and T = 300 K. (a) Derive the expression for the electron diffusion current density versus distance over the given range of x. (b) Determine the induced electric field that generates a drift current density that compensates the diffusion current density.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1000
500
200
100
50
20
Mobility (cm²/V–s)
50
20
10
5
2
1
Diffusivity (cm²/s)
Si
μn, Dn
μp, Dp
10000
5000
2000
1000
500
200
100
Mobility (cm²/V–s)
200
100
50
20
10
5
Diffusivity (cm²/s)
GaAs
μn, Dn
μp, Dp
10^14
10^15
10^16
10^17
10^18
10^19
10^20
Impurity concentration (cm^-3)