CSE 112

HW 1 (Semiconductor)

1. 3.3
2. 3.4
3. 3.5
4. 3.6
5. 3.7
6. 3.8
7. 3.9

Section 3.2: Doped Semiconductors

3.3 For a p-type silicon in which the dopant concentration $N_A = 5 \times 10^{18}/\text{cm}^3$, find the hole and electron concentrations at $T = 300$ K.

3.4 For a silicon crystal doped with phosphorus, what must N_D be if at $T = 300$ K the hole concentration drops below the intrinsic level by a factor of 10^8?

3.5 In a phosphorus-doped silicon layer with impurity concentration of $10^{17}/\text{cm}^3$, find the hole and electron concentrations at 27°C and 125°C.

Section 3.3: Current Flow in Semiconductors

3.6 A young designer, aiming to develop intuition concerning conducting paths within an integrated circuit, examines the end-to-end resistance of a connecting bar 10-μm long, 3-μm wide, and 1 μm thick, made of various materials. The designer considers:

(a) intrinsic silicon
(b) n-doped silicon with $N_D = 5 \times 10^{16}/\text{cm}^3$
(c) n-doped silicon with $N_D = 5 \times 10^{18}/\text{cm}^3$
(d) p-doped silicon with $N_A = 5 \times 10^{16}/\text{cm}^3$
(e) aluminum with resistivity of 2.8 μΩ·cm

Find the resistance in each case. For intrinsic silicon, use the data in Table 3.1. For doped silicon, assume $\mu_n = 3\mu_p = 1200\ \text{cm}^2/\text{V} \cdot \text{s}$. (Recall that $R = \rho L/A$.)

3.7 Contrast the electron and hole drift velocities through a 10-μm layer of intrinsic silicon across which a voltage

of 3 V is imposed. Let $\mu_n = 1350\ \text{cm}^2/\text{V}\cdot\text{s}$ and $\mu_p = 480\ \text{cm}^2/\text{V}\cdot\text{s}$.

3.8 Find the current that flows in a silicon bar of 10-μm length having a 5-μm × 4-μm cross-section and having free-electron and hole densities of $10^4/\text{cm}^3$ and $10^{16}/\text{cm}^3$, respectively, when a 1 V is applied end-to-end. Use $\mu_n = 1200\ \text{cm}^2/\text{V}\cdot\text{s}$ and $\mu_p = 500\ \text{cm}^2/\text{V}\cdot\text{s}$.

3.9 In a 10-μm-long bar of donor-doped silicon, what donor concentration is needed to realize a current density of $2\ \text{mA}/\mu\text{m}^2$ in response to an applied voltage of 1 V? (*Note*: Although the carrier mobilities change with doping concentration, as a first approximation you may assume μ_n to be constant and use $1350\ \text{cm}^2/\text{V}\cdot\text{s}$, the value for intrinsic silicon.)