21.03.2006., Zagreb

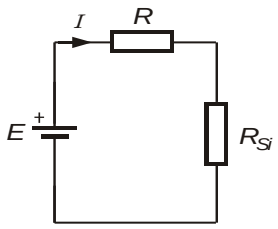
3.domaća zadaća iz Elektroničkih komponenata

1. Otpornik R = 2 kΩ i komadić silicija dužine l = 400 μm, presjeka S = 8000 μm^2 serijski su spojeni na izvor napona E = 4,5 V. Silicij je dopiran s $N_A = 10^{15}$ cm^{-3}, a pokretljivosti nosilaca su μ_n = 1386 cm^2/Vs i μ_p = 452 cm^2/Vs. T = 300 K. Izračunajte snagu na otporniku, komadiću silicija i snagu izvora.
2. *PN* spoj dopiran s $N_A = 4\cdot10^{16}$ cm^{-3} i $N_D = 9\cdot10^{16}$ cm^{-3} priključen je na izvor napona U. Maksimalna jakost električnog polja u barijeri je E_{maks} = −250 kV/cm, a temperatura T = 300 K. Izračunajte iznos priključenog napona U.

Rješenja

1. $R_{Si} = \rho \cdot \frac{l}{S}, \qquad \rho = \frac{1}{\sigma}, \qquad \sigma = q \cdot (n \cdot \mu_n + p \cdot \mu_p)$

$$\left.\begin{array}{l} N_A = 10^{15}\,cm^{-3} \\ N_D = 0 \\ n_i(300\,K) = 1{,}38 \cdot 10^{10}\,cm^{-3} \end{array}\right\} \quad N_A >> n_i \;\rightarrow\; p >> n \quad \Rightarrow \quad \left\{\begin{array}{l} q \cdot n \cdot \mu_n << q \cdot p \cdot \mu_p \;\rightarrow\; \sigma = q \cdot p \cdot \mu_p \\ \\ p = N_A = 10^{15}\,cm^{-3} \end{array}\right.$$



$$\sigma = q \cdot p \cdot \mu_p = 72{,}32 \;\frac{mS}{cm}$$

$$\rho = \frac{1}{\sigma} = 13{,}83 \;\Omega cm$$

$$R_{Si} = \rho \cdot \frac{l}{S} = 13{,}83 \cdot \frac{400 \cdot 10^{-4}}{8000 \cdot 10^{-8}} = 6{,}914 \;k\Omega$$

$$R_{uk} = R + R_{Si} = 8{,}914 \;k\Omega$$

$$I = \frac{E}{R_{uk}} = 504{,}8 \;\mu A$$

$$\boxed{P_R = I^2 \cdot R = 509{,}7 \;\mu W}$$

$$\boxed{P_{Si} = I^2 \cdot R_{Si} = 1{,}762 \;mW}$$

$$\boxed{P_E = E \cdot I = 2{,}272 \;mW}$$

Provjera: $P_E = P_R + P_{Si} = 2{,}272 \;mW$

2. $E_{maks} = -\frac{2 \cdot U_{TOT}}{d_B}$, $\qquad d_B = \sqrt{\frac{2 \cdot \varepsilon_0 \cdot \varepsilon_r}{q} \cdot \left(\frac{1}{N_D} + \frac{1}{N_A} \right) \cdot U_{TOT}}$

$$E_{maks}^{\ 2} = \frac{4 \cdot U_{TOT}^{\ 2}}{d_B^{\ 2}} = \frac{4 \cdot U_{TOT}^{\ 2}}{\frac{2 \cdot \varepsilon_0 \cdot \varepsilon_r}{q} \cdot \left(\frac{N_A + N_D}{N_A \cdot N_D} \right) \cdot U_{TOT}}$$

$$U_{TOT} = \frac{E_{maks}^{\ 2} \cdot \varepsilon_0 \cdot \varepsilon_r \cdot (N_A + N_D)}{2 \cdot q \cdot N_A \cdot N_D} = \frac{\left(-250 \cdot 10^3 \right)^2 \cdot 8{,}854 \cdot 10^{-14} \cdot 11{,}9 \cdot \left(4 \cdot 10^{16} + 9 \cdot 10^{16} \right)}{2 \cdot 1{,}6 \cdot 10^{-19} \cdot 4 \cdot 10^{16} \cdot 9 \cdot 10^{16}} = 7{,}431\ V$$

$U = U_K - U_{TOT}$, $\qquad U_K = U_T \cdot \ln \frac{n_{0n} \cdot p_{0p}}{n_i^{\ 2}}$, $\qquad U_T = \frac{T}{11605}$

$n_i = 1{,}38 \cdot 10^{10} cm^{-3} \quad \rightarrow \quad N_A, N_D >> n_i \quad \Rightarrow \quad \begin{matrix} n_{0n} = N_D \\ p_{0p} = N_A \end{matrix}$

$$U_K = \frac{300}{11605} \cdot \ln \frac{9 \cdot 10^{16} \cdot 4 \cdot 10^{16}}{\left(1{,}38 \cdot 10^{10} \right)^2} = 790{,}3\ mV$$

$$\boxed{U = U_K - U_{TOT} = -6{,}641\ V}$$