VE320 Homework 6

Due: 26/06/2019 10:00 am

1.

A silicon pn junction in thermal equilibrium at $T = 300$ K is doped such that $E_F - E_{Fi} = 0.365$ eV in the n region and $E_{Fi} - E_F = 0.330$ eV in the p region. (*a*) Sketch the energy-band diagram for the pn junction. (*b*) Find the impurity doping concentration in each region. (*c*) Determine V_{bi}.

2.

(*a*) Consider a uniformly doped silicon pn junction at $T = 300$ K. At zero bias, 25 percent of the total space charge region is in the n-region. The built-in potential barrier is $V_{bi} = 0.710$ V. Determine (*i*) N_a, (*ii*) N_d, (*iii*) x_n, (*iv*) x_p, and (*v*) $|\mathrm{E}_{\max}|$. (*b*) Repeat part (*a*) for a GaAs pn junction with $V_{bi} = 1.180$ V.

3.

An "isotype" step junction is one in which the same impurity type doping changes from one concentration value to another value. An n-n isotype doping profile is shown in Figure P7.12. (*a*) Sketch the thermal equilibrium energy-band diagram of the isotype junction. (*b*) Using the energy-band diagram, determine the built-in potential barrier. (*c*) Discuss the charge distribution through the junction.

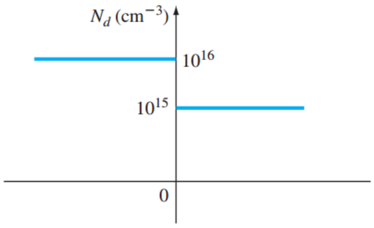

Figure P7.12 | Figure for Problem 7.12.

4.

An abrupt silicon pn junction at $T = 300$ K has impurity doping concentrations of $N_a = 5 \times 10^{16}$ cm^{-3} and $N_d = 10^{15}$ cm^{-3}. Calculate (*a*) V_{bi}, (*b*) W at (*i*) $V_R = 0$ and (*ii*) $V_R = 5$ V, and (*c*) $|\mathrm{E}_{\max}|$ at (*i*) $V_R = 0$ and (*ii*) $V_R = 5$.

5.

An ideal one-sided silicon p$^+$n junction at $T = 300$ K is uniformly doped on both sides of the metallurgical junction. It is found that the doping relation is $N_a = 80\, N_d$ and the built-in potential barrier is $V_{bi} = 0.740$ V. A reverse-biased voltage of $V_R = 10$ V is applied. Determine (*a*) N_a, N_d; (*b*) x_p, x_n; (*c*) $|\mathrm{E}_{\max}|$; and (*d*) C_j'.

6.

A silicon pn junction at $T = 300$ K has the doping profile shown in Figure P7.28. Calculate (*a*) V_{bi}, (*b*) x_n and x_p at zero bias, and (*c*) the applied bias required so that $x_n = 30\ \mu$m.

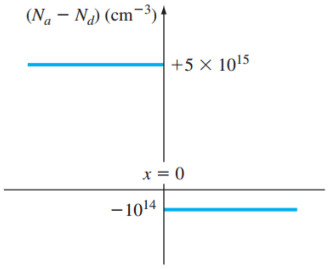

Figure P7.28 | Figure for Problem 7.28.

7.

Consider a silicon n^+p junction diode. The critical electric field for breakdown in silicon is approximately $E_{crit} = 4 \times 10^5$ V/cm. Determine the maximum p-type doping concentration such that the breakdown voltage is (*a*) 40 V and (*b*) 20 V.

8.

(*a*) The doping concentrations in a silicon pn junction are $N_d = 5 \times 10^{15}$ cm^{-3} and $N_a = 5 \times 10^{16}$ cm^{-3}. The minority carrier concentration at either space charge edge is to be no larger than 10 percent of the respective majority carrier concentration. (*i*) Determine the maximum forward-bias voltage that can be applied to the junction and still meet the required specifications. (*ii*) Is the n-region or p-region concentration the factor that limits the forward-bias voltage? (*b*) Repeat part (*a*) if the doping concentrations are $N_d = 3 \times 10^{16}$ cm^{-3} and $N_a = 7 \times 10^{15}$ cm^{-3}.

9.

A one-sided p^+n silicon diode has doping concentrations of $N_a = 5 \times 10^{17}$ cm^{-3} and $N_d = 8 \times 10^{15}$ cm^{-3}. The minority carrier lifetimes are $\tau_{n0} = 10^{-7}$ s and $\tau_{p0} = 8 \times 10^{-8}$ s. The cross-sectional area is $A = 2 \times 10^{-4}$ cm^2. Calculate the (*a*) reverse-biased saturation current, and (*b*) the forward-bias current at (*i*) $V_a = 0.45$ V, (*ii*) $V_a = 0.55$ V, and (*iii*) $V_a = 0.65$ V.

10.

Can you explain in your own words how a depletion region is formed after a p-type semiconductor is in contact with an n-type semiconductor?

11.

A silicon p^+n junction has doping concentrations of $N_a = 2 \times 10^{17}$ cm^{-3} and $N_d = 2 \times 10^{15}$ cm^{-3}. The cross-sectional area is 10^{-5} cm^2. Calculate (a) V_{bi} and (b) the junction capacitance at reverse bias V_R (i) $V_R = 1$V, (ii) $V_R = 3$V, and (iii) $V_R = 5$ V. (c) plot $1/C^2$ versus V_R and identify how the slope and intercept at the voltage axis are related to N_d and V_{bi}, repectively.