

## VE320 Homework 7

Due Sep. 13, 11:40am

1.

(a) A Schottky barrier diode formed on n-type silicon has a doping concentration of  $N_d = 5 \times 10^{15} \text{ cm}^{-3}$  and a barrier height of  $\phi_{B0} = 0.65 \text{ V}$ . Determine the built-in potential barrier  $V_{bi}$ . (b) If the doping concentration changes to  $N_d = 10^{16} \text{ cm}^{-3}$ , determine the values of  $\phi_{B0}$  and  $V_{bi}$ . Do these values increase, decrease, or remain the same? (c) Repeat part (b) if the doping concentration is  $N_d = 10^{15} \text{ cm}^{-3}$ .

2.

(a) Consider a Schottky diode at  $T = 300 \text{ K}$  that is formed with tungsten on n-type silicon. Use Figure 9.5 to determine the barrier height. Assume a doping concentration of  $N_d = 10^{16} \text{ cm}^{-3}$  and assume a cross-sectional area  $A = 10^{-4} \text{ cm}^2$ . Determine the forward-bias voltage required to induce a current of (i)  $10 \mu\text{A}$ , (ii)  $100 \mu\text{A}$ , and (iii)  $1 \text{ mA}$ . (b) Repeat part (a) for a temperature of  $T = 350 \text{ K}$ . (Neglect the barrier lowering effect.)

3.

A pn junction diode and a Schottky diode each have cross-sectional areas of  $A = 8 \times 10^{-4} \text{ cm}^2$ . The reverse saturation current densities at  $T = 300 \text{ K}$  for the pn junction diode and Schottky diode are  $8 \times 10^{-13} \text{ A/cm}^2$  and  $6 \times 10^{-9} \text{ A/cm}^2$ , respectively. Determine the required forward-bias voltage in each diode to yields currents of (a)  $150 \mu\text{A}$ , (b)  $700 \mu\text{A}$ , and (c)  $1.2 \text{ mA}$ .

4.

(a) The contact resistance of an ohmic contact is  $R_c = 5 \times 10^{-5} \Omega\text{-cm}^2$ . The cross-sectional area of the junction is  $10^{-5} \text{ cm}^2$ . Determine the voltage across the junction if the current is (i)  $I = 1 \text{ mA}$  and (ii)  $I = 100 \mu\text{A}$ . (b) Repeat part (a) if the cross-sectional area is  $10^{-6} \text{ cm}^2$ .

5.

A metal, with a work function  $\phi_m = 4.2 \text{ V}$ , is deposited on an n-type silicon semiconductor with  $\chi_s = 4.0 \text{ V}$  and  $E_g = 1.12 \text{ eV}$ . Assume no interface states exist at the junction. Let  $T = 300 \text{ K}$ . (a) Sketch the energy-band diagram for zero bias for the case when no space charge region exists at the junction. (b) Determine  $N_d$  so that the condition in part (a) is satisfied. (c) What is the potential barrier height seen by electrons in the metal moving into the semiconductor?

6.

A metal–semiconductor junction is formed between a metal with a work function of  $4.3 \text{ eV}$  and p-type silicon with an electron affinity of  $4.0 \text{ eV}$ . The acceptor doping concentration in the silicon is  $N_a = 5 \times 10^{16} \text{ cm}^{-3}$ . Assume  $T = 300 \text{ K}$ . (a) Sketch the thermal equilibrium energy-band diagram. (b) Determine the height of the Schottky barrier. (c) Sketch the energy-band diagram with an applied reverse-biased voltage of  $V_R = 3 \text{ V}$ . (d) Sketch the energy-band diagram with an applied forward-bias voltage of  $V_a = 0.25 \text{ V}$ .