VE320 Homework 6

Due Nov. 19, 23:59 pm

(In the following problems, assume $A^* = 120$ A/K^2-cm^2 for silicon and $A^* = 1.12$ A/K^2-cm^2 for gallium arsenide Schottky diodes unless otherwise stated.)

1.

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

2.

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

3.

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

4.

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

5.

A metal, with a work function $\phi_m = 4.2$ V, is deposited on an n-type silicon semiconductor with $\chi_s = 4.0$ V and $E_g = 1.12$ eV. Assume no interface states exist at the junction. Let $T = 300$ 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 eV and p-type silicon with an electron affinity of 4.0 eV. The acceptor doping concentration in the silicon is $N_a = 5 \times 10^{16}$ cm^{-3}. Assume $T = 300$ 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 $V_R = 3$ V. (*d*) Sketch the energy-band diagram with an applied forward-bias voltage of $V_a = 0.25$ V.