ECSE-2210 Microelectronics Technology
Class Activity 24 – Solution

1. Explain why MS diodes switch very rapidly (compared to p-n diodes) from the forward-bias on-state to the reverse-bias off-state.
   In a p-n junction the excess minority carriers stored in the quasi neutral region must be removed before the device can be switched from the forward bias on to reverse bias off state. In a MS junction there is very little minority carrier injection and storage within the semiconductor because the diffusion component of the current is extremely small.

2. Consider a Tungsten/n-Si Schottky barrier diode with a barrier height, Φ_B, of 0.67eV. If Richardson's constant A^* is 120 A/ (cm^2 K^2), calculate the reverse saturation current, I_S. Also, calculate the current, I, for a forward bias of 0.3 V. Assume a cross sectional junction area of $A = 1$ cm^2.

   $I_S = AA^* T^2 \exp(-\Phi_B / kT)$
   $= 1 \times 120 \times 300^2 \times \exp(-0.67/0.0259)$
   $= 6.29 \times 10^{-5}$A

   $I = I_S \exp(0.3/kT)$
   $= 6.29 \times 10^{-5}$ A $\exp(0.3 / 0.0259)$
   $= 6.7$ A

3. Consider a p-n junction diode with a cross sectional area $A = 1$ cm^2 and the following parameters.

p-side	n-side
$N_A = 10^{18}$ cm^{-3}	$N_D = 10^{16}$ cm^{-3}
$L_n = 16$ μm	$L_P = 10$ μm
$D_n = 25$ cm^2/s	$D_p = 10$ cm^2/s

   Calculate the reverse saturation current. Also calculate the forward current, I, when the device is biased at 0.3V. (Note: Compare this to the Schottky diode case).
   For the p-n junction
   $n_{p0} = 10^2$ cm^{-3} and $p_{n0} = 10^4$ cm^{-3}

   $I_o = 1.6 \times 10^{-19}$ C $\times$ 25 cm^2/s $\times$ 10^2 cm^{-3} / (16×10^{-4} cm) + 1.6×10^{-19} C $\times$ 10 cm^2/s $\times$ 10^4 cm^{-3} / (10×10^{-4} cm)
   $= 1.6 \times 10^{-11}$ A

   $I = 1.6 \times 10^{-11}$ A $\exp(0.3/kT)$
   $= 1.76 \times 10^{-6}$ A

   On comparing the two diodes, the MS junction diode has a higher current when compared to the p-n junction diode.