Assignment 4: Metal-semiconductor junctions

1. Show schematically a Schottky junction formation between a metal and p-type semiconductor. Sketch the energy band diagram under (a) equilibrium, (b) forward bias, and (c) reverse bias.

2. Consider a n-type Si sample with 10^{16} $donors\ cm^{-3}$. The two ends of the sample are labeled B and C. The electron affinity of Si is 4.01 eV and the work function of four potential metals for contacts at B and C are listed in table below For Si, take $E_g = 1.10\ eV$, $n_i = 10^{10}\ cm^{-3}$

Cs	**Li**	**Al**	**Au**
1.8	2.5	4.25	5.0

   and $E_{Fi} = 0.55\ eV$.

   (a) Ideally, which metals will result in a Schottky contact?

   (b) Ideally, which metals will result in an Ohmic contact?

   (c) Sketch the I-V characteristics when both B and C are Ohmic contacts.

   (d) Sketch the I-V characteristics when B is Ohmic and C is a Schottky junction.

   (e) Sketch the I-V characteristics when both B and C are Schottky contacts.

3. Consider a Schottky junction diode between W and n-Si, doped with 10^{16} $donors\ cm^{-3}$. The cross-sectional area is 0.1 mm^2. The electron affinity of Si is 4.01 eV and the work function of W is 4.55 eV. Take $N_c = 2.8 \times 10^{19}\ cm^{-3}$. Take $B_e = 110\ Acm^{-2}K^{-2}$.

   (a) What is the theoretical Schottky barrier height, ϕ_B, from the metal to the semiconductor?

(b) What is the built-in voltage?

(c) Calculate the reverse saturation current and the current when there is a forward bias of 0.2 V across the junction.

(d) The experimental Schottky barrier is actually 0.66 eV due to dangling bonds and other surface defects. How does the answer to (c) change when using this value?

4. A PtSi Schottky diode at $T = 300\ K$ is fabricated on n-Si by doping of $N_D = 10^{16}\ cm^{-3}$. The barrier height is $0.89\ V$. Determine the value of the forward bias voltage when current density is $2\ Acm^{-2}$. Take $B_e = 110\ Acm^{-2}K^{-2}$.

5. A Schottky diode is formed by depositing Au on n-type GaAs doped at $N_D = 5 \times 10^{16}\ cm^{-3}$. $T = 300\ K$.

   (a) Determine the contact potential.

   (b) Determine the forward bias voltage to obtain a current density of $5\ Acm^{-2}$.

   (c) What is the change in forward bias voltage needed to double the current density?

   GaAs parameters: $E_g = 1.43\ eV$. Take $N_c = 4.7 \times 10^{17}\ cm^{-3}$, $N_v = 7 \times 10^{18}\ cm^{-3}$, $B_e = 45\ Acm^{-2}K^{-2}$.
   Au parameters: Take $\phi_m = 5\ eV$.