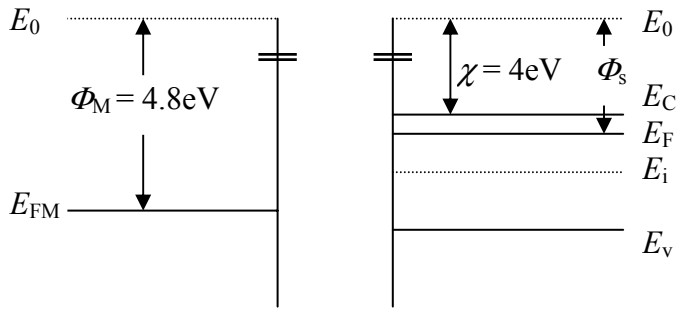
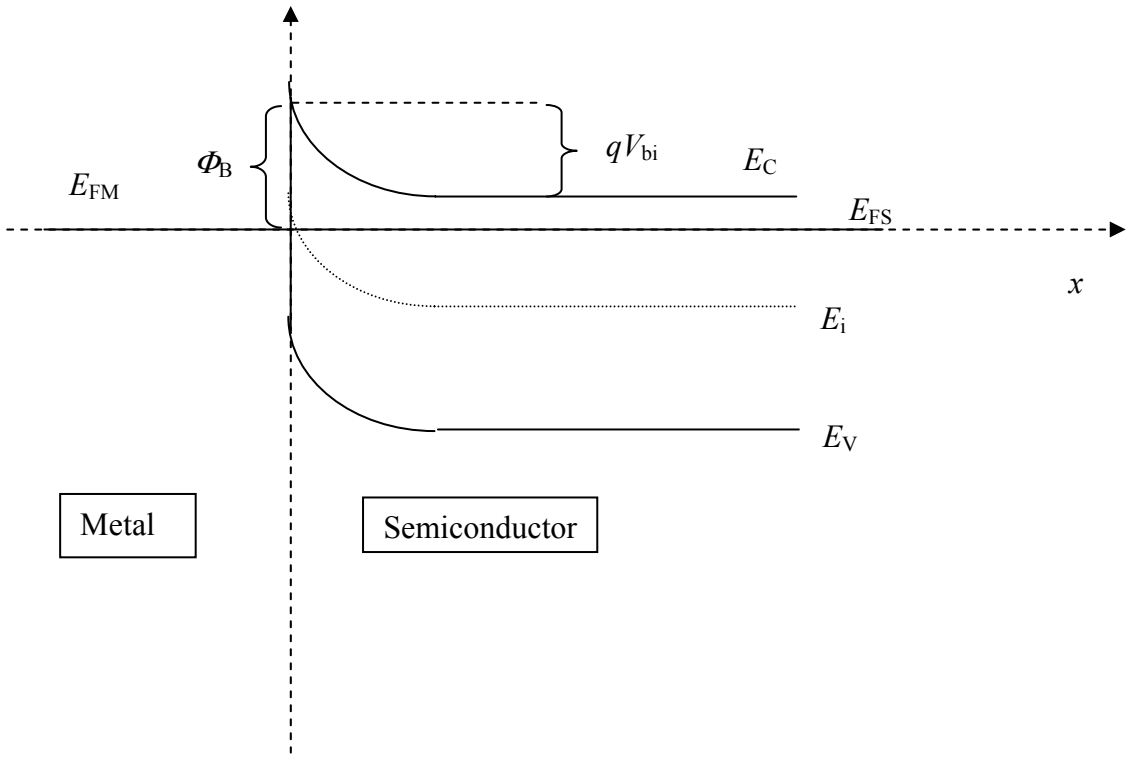
ECSE-2210 Microelectronics Technology
Class Activity 23 – Solution

1. The following figures show the band diagrams for an n-type Si and for a metal. An ideal Schottky barrier is formed by depositing this metal on to the n-type Si. The Si doping concentration is 2×10^{16} cm^{-3}.



(a) Draw an equilibrium band diagram for this metal-semiconductor junction. What is the barrier height for electron flow from the semiconductor to the metal (S → M)? What is the barrier height for electron flow from the metal to semiconductor (M → S)? Mark both barriers in the figure you draw.



Barrier heights for electron flow: M → S: Φ_B

$$S \rightarrow M: \quad q\,V_{bi}$$

$$\Phi_B = \Phi_M - \chi = 4.8\text{ eV} - 4\text{ eV} = 0.8\text{ eV}$$

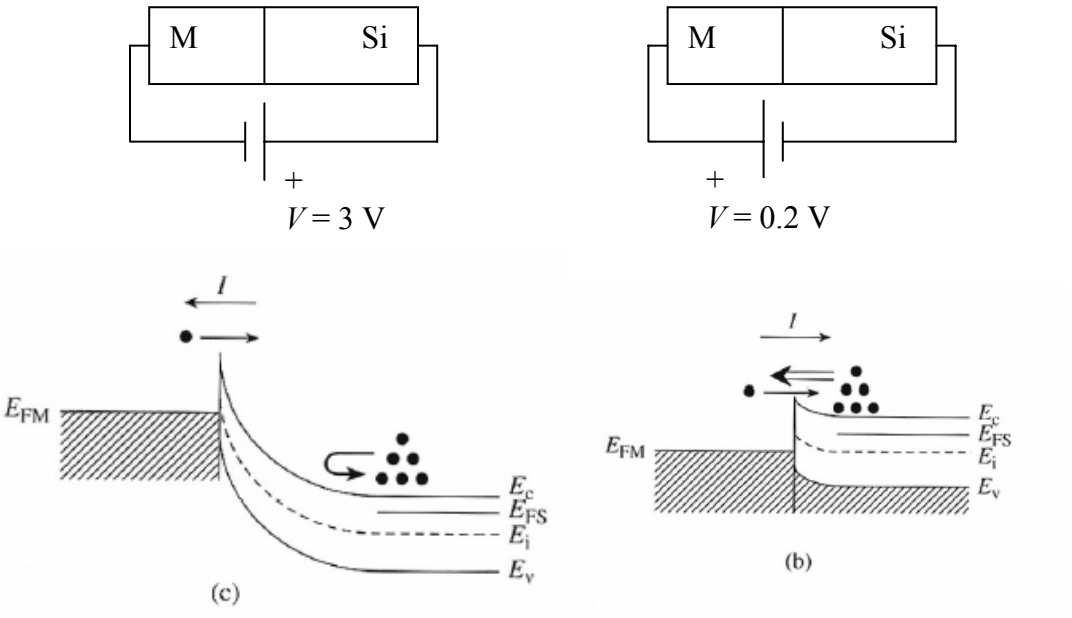
$$(E_C - E_{FS})_{FB} = (E_C - E_i)_{FB} - (E_F - E_i)_{FB} = \frac{E_G}{2} - kT\ln(\frac{N_D}{n_i}) =$$

$$= 0.55\text{ eV} - 0.0258\text{ eV}\ln\left(\frac{2\times10^{16}}{10^{10}}\right) = 0.175\text{ eV}$$

From the above band diagram

$$Q\,V_{bi} = \Phi_B - (E_C - E_{FS})_{FB} = 0.8\text{ eV} - 0.175\text{ eV} = 0.625\text{ eV}$$

(b) The above Schottky junction is biased as shown below. Now draw the band diagram for the junctions (see figure 14.3 in text). Mark the barrier height for electron flow from the semiconductor to metal (S → M) in the figure you draw. Also, mark the barrier height for electron flow from the metal to semiconductor (M → S) in the figure. Identify the forward biased and reverse biased junctions.



Reverse Biased

Forward Biased

(c) Calculate the depletion layer width W for the reverse biased case in part (b).

$$W = \sqrt{\frac{2\varepsilon}{qN_D}(V_{bi} - V_A)} = \sqrt{\frac{2x10^{-12}\,\frac{\text{C}}{\text{Vcm}}}{1.6x10^{-19}\text{C}\times 2\times10^{16}\text{cm}^{-3}}(0.625\text{V} - 3\text{V})} = 4.76\times10^{-5}\text{cm}$$