5 MS Diodes / Capacitance Name:_____ Complete ____

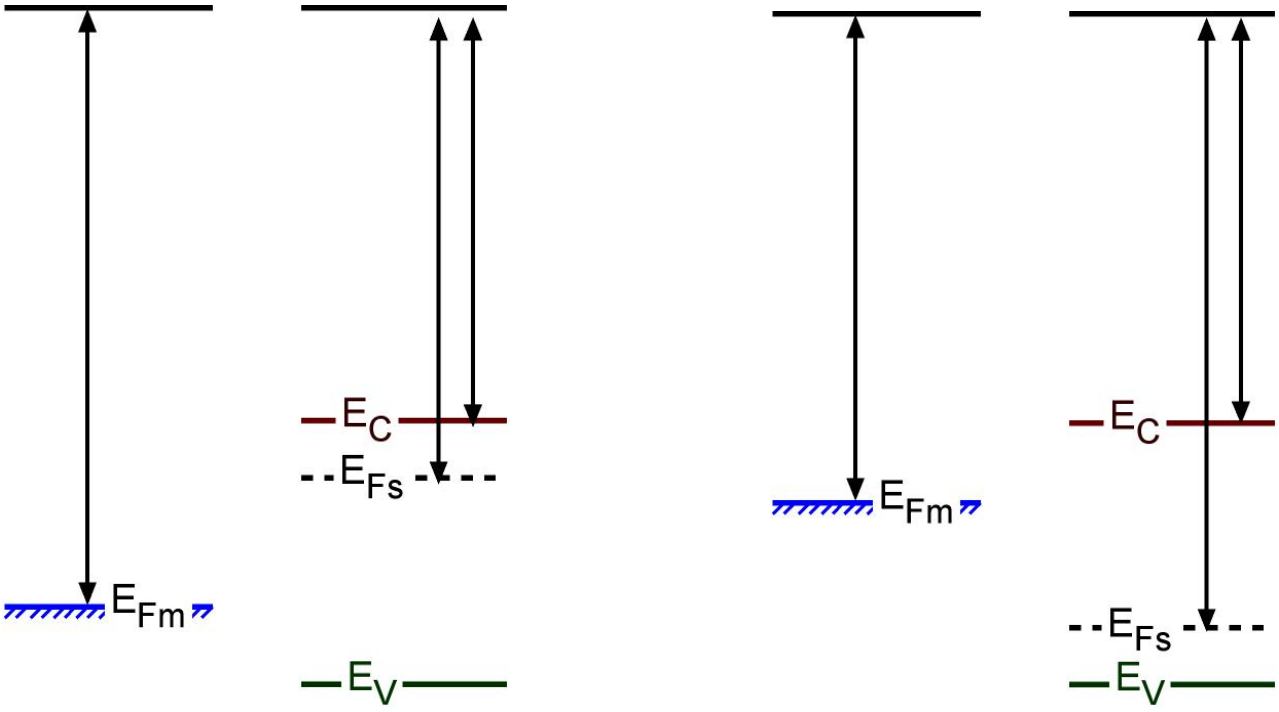
In-Class Problems

(1) For both of the metal-semiconductor junctions shown below

(a) draw the band diagram, and label with an arrow what causes current in forward or reverse bias (further label the arrow as drift vs. diffusion). Use the same step-by-step approach I used in the lecture. The black line at top is the vacuum level. Make sure you label the barrier height and the contact potential on your band diagrams, and how each is calculated (in terms of work-functions and electron affinities).

(b) draw an IV plot for each, and on the plot label the forward and reverse currents as due to electrons or holes.

(c) Draw the E-field vs. distance plot for each.



(2) Draw a diagram of TWO ways to make an ohmic contact on a n-type semiconductor, and then explain to the Prof. how each works.

(3) Diode capacitance calculations…

(a) A Si pn junction has an area of 100x100 μm^2 and Na=1x10^{17}/cc and Nd=1x10^{15}/cc. Calculate the junction (depletion) capacitance at an applied reverse bias of 4 V. You will need to calculate contact potential also.

$$C_J = A\left[\frac{\varepsilon q}{2(V_o - V_{app})}\frac{N_A N_D}{N_A + N_D}\right]^{1/2} = 10^{-4}\left[\frac{8.854\times10^{-14}\times11.8\times1.6\times10^{-19}}{2(0.695-(-4V))}\right]^{1/2} = 4.2\times10^{13}F = 42pF$$

(b) What is the depletion width for this capacitance? This is easy if you remember that junction (depletion) capacitance is just the same as the classical capacitor equation.

$$C_J = \frac{\varepsilon A}{W} = \frac{11.8\times8.854\times10^{-14}\times(5\times10^{-4})^2}{W} = 4.2\times10^{-13}F \qquad \therefore W = 2.5\times10^{-4}cm = 2.5\mu m$$

(c) The above questions were related to REVERSE bias where you can use a classical capacitor equation. In FORWARD bias diffusion capacitance dominates. List below the most basic capacitance equation that describes how capacitance is calculated in forward bias.

In forward bias, diffusion capacitance dominates, which is basically capacitance calculated as change in charge vs. change in voltage (C=dQ/dV).

(d) Draw a diode I-V plot and diagram on the I-V plot why storage capacitance is zero for a reverse biased diode and why for a forward biased diode it increases exponentially.

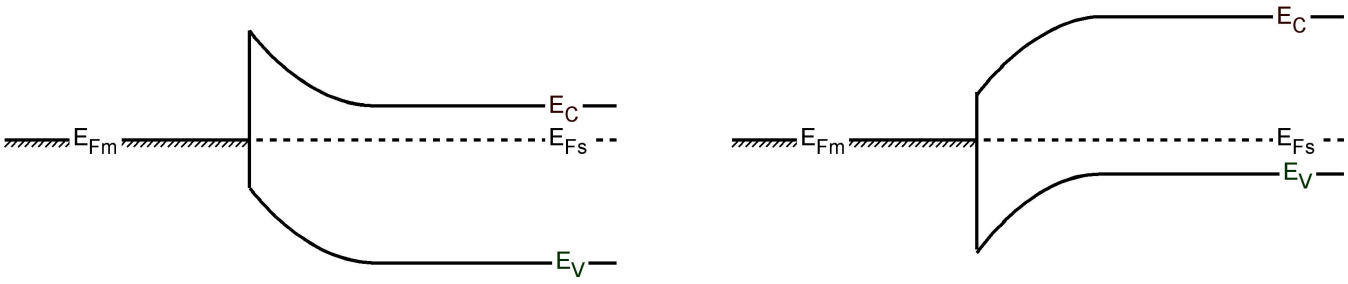
See online lecture for the example I gave.

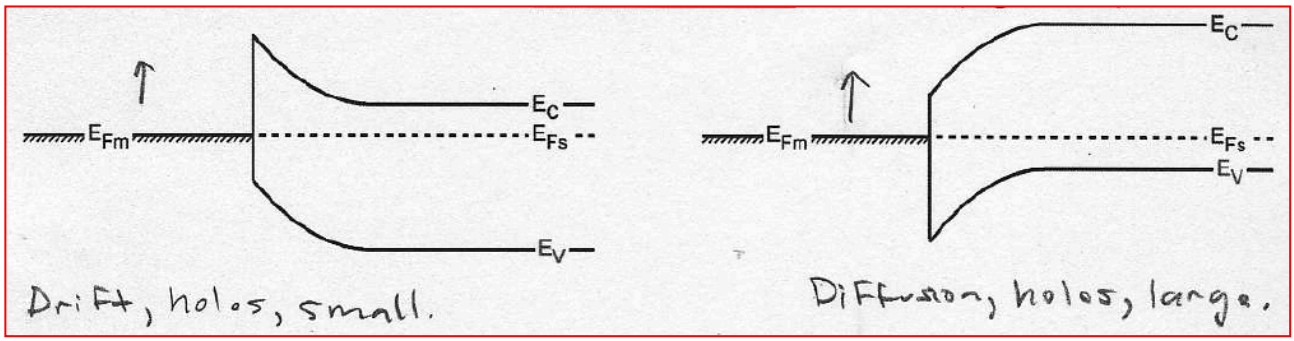
Extra Problems (if you have time, finish during class when I can help, or on your own time)

(4) Two metal/semiconductor junctions are given below. For both we ground the semiconductor and apply *negative* voltage to the metal. For both junctions, describe the **type of the current** and **carrier type** that determines the current flow for each case, and **the general magnitude** of the current (large or small). Remember, to solve this:

(1) always think of carrier flow from the semiconductor into the metal (the semiconductor determines the flow)

(2) do the conduction band or valence band, each separately, considering if the carriers are majority (lots of current) or minority (small current), if the current flow is due to drift (no change with voltage) or diffusion (large change with voltage)




E_{Fm}
E_C
E_{Fs}
E_V
Drift, holes, small.
E_C
E_{Fm}
E_{Fs}
E_V
Diffusion, holes, large.