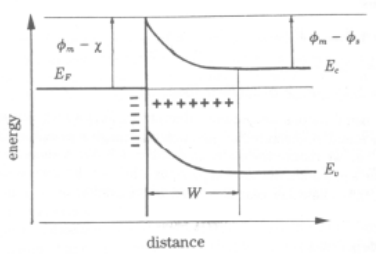
Name:

Student Number:

Quiz 4 ELEC 4705
Tuesday Nov. 24 2009

1. (5 marks) Schottky diode
   Describe the carrier flow in a Schottky diode with an equilibrium band structure as shown under forward bias.



   Clearly address the following questions:

   (a) What two currents do we use to describe the device operation?
   The two currents we used to analyse the device were J_{ms} the current that goes from the metal to the semiconductor over the barrier $\phi_m - \chi$ and J_{sm} the current that goes from the semiconductor to the metal over the barrier $\phi_m - \phi_s$.

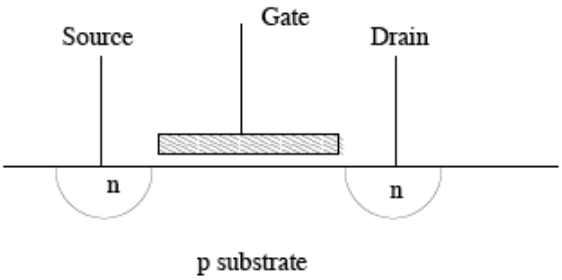
   (b) What is the relationship between these two currents and the applied voltage?
   J_{ms} is independent of V_a as $\phi_m - \chi$ does not change. J_{sm} is exponentially related to V_a as the barrier height is $\phi_m - \phi_s - V_a$.

   (c) Is the device a majority or minority carrier device and why? **Majority**

   (d) How does W vary with applied bias?
   Forward bias reduces it. Reverse bias increases it

2. (5 Marks) MOSFET

   (a) Sketch the basic structure of the MOSFET



   (b) Describe how a channel is formed in the mosfet (p-type substrate) and the difference between Depletion and Inversion.

   For n-channel mosfet a positive potential is applied to the gate attracting electrons to the surface and repelling holes. For $V_g < Vth$ this produces a depleted region under the gate due the loss of holes. For $V_g \geq V_{th}$ we have enough electrons to form a channel by "inverting" the surface.

   (c) What is the mechanism that is used to create a current in the device?

   We establish a voltage across the device by applying a bias to the drain this creates an electric field which cause a current flow due to drift.

3. (5 marks) Optical System

   (a) Contrast the various advantages and disadvantages of using photons rather then electrons to transmit information.

   Some of:

Electrical Transmission	**Optical Transmission**
$t > 10ns = 10^{-8}s$ **bandwidth limited**	$t > 100ps = 10^{-11}s$ **dispersion and electronics limited**
Bandwidth $\sim 100MHz = 10^{8}Hz$	**Bandwidth** $\sim 100THz = 10^{14}Hz$
Electromagnetic interference	**No EMI**
Copper or Aluminum (expensive, large and heavy)	**Glass (cheaper, small, light, but more fragile)**
Energy loss, signal attenuation $> 20\,dB/km$	**Attenuation** $\sim 0.2\,dB/km$
Signal remains electrical	**Signal must be converted electrical** $\Longrightarrow$ **optical** $\Longrightarrow$ **electrical**

   (b) What do we use as a "light wire"? **Optical Fiber**

   (c) Describe the basic physical operation of such a device in terms of "rays" of light.
   Light rays "bounce" down the fiber reflected by total internal reflection. Must make sure that the incident angle satisfies the critical angle.

   (d) How do we construct such a device in practice?
   Create a glass fiber with a core and a cladding – each having different optical indexes. The core index must be greater then the cladding for total internal reflection to occur