Name:

Student Number:

Quiz 4 ELEC 4705
Monday Nov. 29 2010

1. (4 Marks) (Generation/Recombination)

   (a) What is a direct band-gap semi-conductor? Describe the optical properties of a direct band-gap material? How do we model these properties?

   (b) What is the recombination of electrons and holes? Describe the energy relationships that occur during recombination.

   - Direct Bandgap Is the case where the maximum of the valence band occurs at the same k value as the minimum of the conduction band such as the band structure in GaAs and we have $\Delta k = 0$, the change of electron momentum is zero for a transition.
     A photon with energy $E = \hbar w$ can be absorbed by promoting a valence band electron to the conduction band, creating an electron-hole pair. This is a simple two body collision (electron, photon) as only energy needs to be supplied not momentum. Photons have a lot of energy but little momentum.
     Direct bandgap materials have strong light absorption and are easily modeled by an absorption parameter.
   - Recombination is the movement of an electron from the conduction band to the valence band. This results in the destruction of and electron-hole pair. Once the holes and electrons are recombined, the energy can be released as light (radiative recombination) or heat (non-radiative recombination).

2. (6 Marks) (Diode/BJT)

   (a) Draw the band structure of a PN junction under a forward bias? Label the different regions?

   (b) Show the band structure of metal-semiconductor junction?

   (c) What are the junction biases in forward active for the BJT. What are the current components of a BJT in forward active mode?

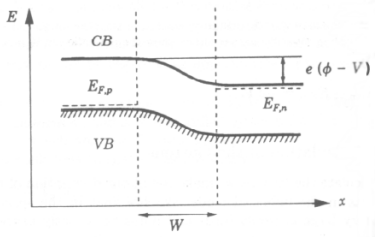

Figure 1: Forward Bias

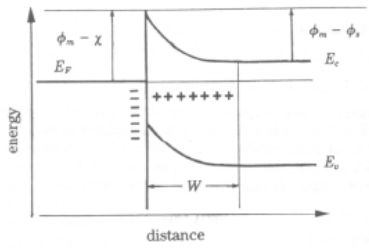

Figure 2: Metal-Semiconductor Band Structure After Touching

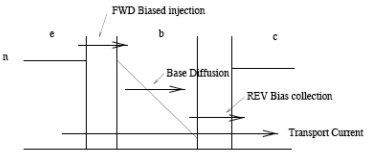

Figure 3: Electron Transport Current in a npn Transistor

3. (5 Marks) (MOSFET)

   (a) What is velocity saturation?

   (b) What is inversion in a MOS structure?

   (c) What are the regions of operation in a MOSFET?

   - **at high electric field the velocity becomes limited and** $v \neq \mu E$.
   - **page 8/L15**
   - **cutoff, triode, saturation**