ECE-606 Homework No. 9 Assigned: Nov. 8 Due: Nov. 15

1) For a given n-p-n silicon BJT, determine the avalanche break-down and punch-through voltage. Assume that the transistor operates in common-base mode. The following additional information is also provided.

   $N_{aB} = 10^{16}$ cm^{-3}, $W_B = 1.0$ μm. The critical field in silicon is **3 x10^5 V/cm**. The collector doping is large relative to the base.

   Hint: Determine the maximum electric field strength in a p-n junction.

2) Solve SDF 11.17

3) Consider a SiGe alloy type n-p-n-BJT, i.e. hetero bipolar transistor. The base is made of SiGe to increase the intrinsic carrier concentration in the base, while the collector and emitter are still silicon. You are given the following parameters.

   $N_E = 1\times10^{19} cm^{-3}$ $N_B = 1\times10^{18} cm^{-3}$ $N_C = 1\times10^{17} cm^{-3}$

   $W_E = 1\mu m$ $W_B = 0.5\mu m$ $W_C = 1\mu m$

   The intrinsic carrier concentration is $n_{SiGe} = 6\times10^{10} cm^{-3}$

   Using the above information, answer the following questions

   a) What is the DC common emitter current gain β_{DC} of this device?

   b) What is the DC common base current gain α_{DC} of this device?

   c) Repeat (a) and (b) but for a Si base, comment on the difference.

   d) Assuming that the dielectric constant for Si and SiGe are 12 and 15 respectively, compute their electrical base width $W_B^{'}$ at zero biasing conditions. Based on this result alone, which will have a poorer Early voltage characteristic?

4) Explain the following:

   Why does it take a long time for V_{BE} to change by a small voltage when the EB junction is forward biased? In contrast, V_{BE} changes almost instantaneously by a large voltage when the EB junction is reverse biased.

   You can assume that the transistor is an **n-p-n silicon BJT**. V_{BE} = 0.6V and the doping concentration of the base is 10^{17} cm^{-3}.

5) Determine the improvement in gain between a graded and abrupt AlGaAs-GaAs HBT if the alloy composition in the emitter is 25%. The energy gap discontinuity between AlGaAs and GaAs is given as $\Delta E_g = 1.247\beta$ where β is the Al composition in the AlGaAs alloy.

It is further known that the conduction band-edge discontinuity is 62% of the energy band-gap discontinuity. You may assume that the heterostructure is type-I.

6) Heterostructures are classified in to three types namely, type-I, II, and III. Draw schematics for heterostructures that belongs to each of the above types. Please indicate an example for each of the heterostructures that you draw.