EXERCISE ON BASIC TRACKING DETECTORS
Study of semiconductor sensor

Caveat: This is the first time for this exercise hence beware the description may be incomplete.

Preparations:

We will simulate semiconductor sensors using GSS which is free software under GNU for MC field simulations (the software has similar structure but limited functionality compared with commercial TCAD software). A version of GSS that has been tested and demonstrated to work under Ubuntu 14.04LT and SLC6 linux distributions can be downloaded from the Indico page of the course.

1a. If you have made a local installation, then to run the software the *GSS_DIR* and *PETSC_DIR* environmental variables need to be defined

(in bash-shell → *export GSS_DIR= <gss_inst_dir>*
In Virtual box you just need to go to *"/home/penelope/GSS"* and do *"source soure_this_before_gss"* this will set the environment variables for you.

1b. If you run in VirtualBox then simply go in a terminal window to /home/penelope/GSS and type *source source_this_before_gss*

2. Create a directory with name GSS_work (or something descriptive). If running VirtualBox I suggest you create the directory on the USB-stick that you find in /media/XXXX

3. You will be given four input files (*pndiode.inp*, s*chottky.inp*, *mos.inp* and *IV-pn.inp*) for the exercise that you can use as they are but you may need to modify during the exercise. Study one of the files using the gss_cards.pdf file to understand the logic and structure of the file.

4. Run one of the file with command *gss file.inp* to see that the software runs.

In the following tasks please carefully document the parameters in your simulations.

Task 1: pn-junction (input file pndiode.inp)

In this exercise you will study the properties of a pn-junction.

1. Study the effect of changing the temperature, doping profile, donor/acceptor concentration and Si/Ge semiconductor material for a pn-junction in equilibrium. (you may have to change/extend the geometry in the input fiile).

- what effect has the change on junction potential, charge carrier concentration, width of space charge region. Do a few simulations with different parameters and list the parameters and results in a table.
- How does it compare with theory? Use the basic models from lectures or from re for the calculation. (home work)

2. Make a DCSWEEP (reverse bias) to obtain a IV-curve. Do it for a 300 micron wide and 300 micron thick sensors with highly doped 3 micron thick implants on a low doped bulk. Repeat the simulation for two temperatures and also at one temperature with Germanium (you will have to change/extend the geometry in the input file), study both forward and reverse bias.

- Plot the IV-curve. How do the current change with temperature (use root, gnuplot or your favourite plotting program)
- At what voltage is simulated device fully depleted?
- How does it compare with theory. Use the basic models from lectures for the calculation. (home work)

<u>Task 2: metal-semiconductor junction (input file schottky.inp)</u>

1. Study the effect of changing the temperature, donor/acceptor concentration and work function of the metal contact for the Schottky diode in equilibrium. The device has the same size as the pn device you just simulated (you may have to change/extend the geometry in the input file).

- How the changes affect the built in potential, electric field, space-charge region.
- How do the Schottky diode compare with pn-junction.
- How does it compare with theory. Use the basic models from lectures for the calculation. (home work)

2. Make a DCsweep to obtain a IV-curve at one temperature that has been studied for a pn-diode and with similar geometry.

- Plot the IV-curve. How do the current compare with the pn-junction
- How does the shape of the Efield in the region compare between Schottky and pn-diodes?

<u>Task 3: metal-oxide-semiconductor junction (input file mos.inp)</u>

- Study the MOS structure in equilibrium. Determine the flat band voltage
- Study the mos structure in accumulation, depletion, inversion.

Good luck!

Richard