HAND IN TASKS ON SEMICONDUCTOR DETECTORS

Research training course in Detector Technology in High Energy Physics 2015

1. From exercise session

More details can be found in the instructions for the exercises session at NBI which is available on the course Indico page. You did start the work in Copenhagen so some tasks are probably already done. I summarize here what I expect you to hand in.

a) Simulate a pn-junction. Study the effect of changing the temperature, donor/acceptor concentration and Si/Ge semiconductor material for a pn-junction in equilibrium.

- Simulate the junction potential, electric filed and built in junction width for three combinations of temperature, donor/acceptor concentration and semiconductor material.
- Compare result with theory. Use the basic models from lectures or from textbook/web for the calculation.
- Simulate a IV-curve for a 100 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, study both forward and reverse bias.
- At what voltage do the devices deplete? How do the simulated result compare with theory?

b) Simulate a Schottky contact. Study the effect of changing the temperature, donor/acceptor concentration and work function of the metal contact for the Schotky diode in equilibrium.

- Simulate the junction potential, electric filed and built in junction width for three combinations of temperature, donor/acceptor concentration and semiconductor material.
- How do the Schottky diode compare with pn-junction.
- How does it compare with theory. Use the basic models from lectures for the calculation.
- Do a reverse IV-curve for a Schottky device built with one of the substrate you simulated for the pn-junction and similar geometrical dimensions. Use as maximum reverse voltage the voltage that made the pn-jnction to fully deplete.
- How does the Schottky device compare with the pn-junction. (Current, depletion width, electric field?).

2. Laboratory exercise

For further details have a look in the instructions of the lab. You are welcome to put screen dumps in the report!

a) For the pre-amplifier noise measurement with oscilloscope I expect the following:

- A calculation of injected charge trough the test capacitor
- A table with amplitude, rise time and noise from the pre-amplifier output
- A graph of the above
- Calculation of the Equivalent Noise Charge, ENC.
- A graph of the ENC as a function of load capacitor and a fit showing the noise for the unloaded pre-amplifier (pedestal noise) and noise slope.

b) Noise measurement with spectroscopy amplifier.

- Calibration spectrum for two shaping times
- Measurement of the ENC noise for two shaping times and a comparison with the measurement with the oscilloscope.

c) The source measurement with 137Cs (and 241Am) source did not work that well for all groups. The fault that we did not manage so well with all groups was partly the pressed schedule that did not allow us to trace the noise sources so we could get a clean measurement. The best results was achieved with the last group. This was thanks to the accumulated experience from the groups before. The spectra from the last group is available on the Indico page just to show that things can work very nicely. I ask you to report the results (plots, screen dumps) you got with the source. The better results the more you can report.

3. Final simulation and comparison with clean room measurement.
Using GSS simulate a IV-curve for a non-irradiated pn-device and compare the result with your measurement in the clean room. The processing parameters are:

- Diode thickness: 300 μm
- Active area: 5 mm X 5 mm
- Bulk concentration n-type: 1E12 cm-3
- Implant concentration p-type: 5E18 cm-3
- Implant depth: 2 μm
- Thickness of Al metallisation: 0.5 μm