Phys 586 Laboratory

Lab 12

Goal: In this lab you will make measurements basic V-I measurements with a MOSFET and (optionally) measure x-ray spectra with a silicon PIN photodiode.

Reading: Knoll p752-753 and p398 and two posted papers on RADFETs.

Lab:

1. Look over the data sheets for the p-channel MOSFETs we are using. What is the gate-source threshold voltage? Under what conditions is this specified?

2. Also note the characteristic I_D versus V_{DS} curves and the I_D versus V_{GS} curve on the second page. You can see the meaning of the gate-source threshold voltage from the second curve.

3. Figure 1 shows a simplified circuit that is typically used to measure the change in threshold voltage as function of dose. This circuit is used in many dosimeter applications. Note the drain and gate are connected together so $V_{GS} = V_{DS}$ here.

4. Figure 2 shows the actual implementation of the the circuit in Figure 1. A resistor pot controls the magnitude of the constant current source.

5. Using the test setup, measure the threshold voltage as a function of the drain-source current for currents of 0 to 1000 μA as defined in the worksheet. You will have a set of VI curves for the pre-irradiated MOSFETs and a set for the irradiated MOSFETS. For a given MOSFET, plot the pre-irradiated and irradiated VI curves on the same plot.

6. There are several (arbitrary) ways to define the threshold voltage. One is to choose the voltage value at 800 μA. Another is to draw a tangent to the higher values of I_{DS} and call the point where the line crosses $I_{DS} = 0$ the threshold voltage.

7. Whichever method you choose, make a plot of ΔV_{th} (after-before) as a function of irradiation dose. The irradiation dose in grays is the last two numbers of the MOSFET serial number. Note these MOSFETS are not designed as RADFET's so this is just an experiment. Hopefully you will see an effect. RADFET's designed for this purpose usually have a thicker SiO_2 region and different fabrication processes compared to standard MOSFETs.

8. This section is optional.

9. Look over the data sheet for the XR-100CR x-ray detector. What is the specific silicon detector used? What is the bias voltage? Why is the detector cooled?

10. Collect data with the Maestro MCA for Cu, Rb, and Mo. Identify and comment on any peaks found in the spectra for each.

11. Make a plot of the lnR versus lnE where R is the energy resolution defined by FWHM/peak. Comment on your plot.

In your lab writeup, please include:

1. Briefly explain how a MOSFET works. Note this information is included in the silicon 2 lecture posted on D2L.

2. Briefly explain why the threshold voltage changes in a MOSFET when it is subjected to radiation. A short paper is posted under the readings for last week. There are also a few slides contained in the silicon 2 lecture posted on D2L.

3. The VI curves for each MOSFET. Plot the VI curve for the pre-irradiated and irradiated MOSFET on the same plot. You will have a total of five plots with two curves per plot.

4. The ΔV_{th} versus irradiation dose curve. Note these MOSFETS are not designed as RADFET's so this is just an experiment. Hopefully you will see an effect.

5. The following two items are optional.

6. As with proportional counters, one typically quotes energy resolutions at 5.9 keV, the energy of an ^{55}Fe source. What is the energy resolution of the XR-100CR at 5.9 keV? How does this compare to the data sheet spec?

7. How does the energy resolution at 5.9 keV compare to a typical proportional counter (see p176 Knoll).