University of Liverpool
Department of Physics

Semiconductor Applications, PHYS389

Tutorial 2

Work should be handed to your tutor by 5.00pm on Tuesday 6th December for a tutorial on Thursday 8th December

1. What is the reason for utilising lithographic methods? Describe the three primary processes used in lithography, with the aid of diagrams.

2. What are the principle differences between the operation of the Bipolar Junction Transistor and the Field Effect Transistor? What advantages do Schottky contacts offer over traditional p-n junctions?

3. Describe the three primary methods by which gamma-rays interact with matter. How does the cross-section for interaction of these three processes vary with energy?
   Draw an energy level diagram showing the variation of the energy bands across a reverse biased p-n junction. Indicate the semiconductor bands, Fermi level, and depletion region.
   Write down the expression for the overall energy resolution achievable in a germanium detector, describe the origin of each of the terms. If the value of the Fano factor is 0.06 calculate the contribution to the final energy resolution for a gamma-ray of energy 511keV.

4. Draw a schematic diagram of a bulletised n-type closed end coaxial germanium detector used for high resolution gamma-ray spectroscopy. Label the respective contacts.

   Describe the main principles of operation for this device.

   The voltage required to fully deplete a true coaxial germanium detector is:

$$V_d = \frac{\rho}{2\varepsilon}\left[r_1^2 \ln\left(\frac{r_2}{r_1}\right) - \frac{1}{2}(r_2^2 - r_1^2)\right]$$

   For a detector of 8cm outer diameter and 1.5cm inner diameter calculate the voltage required for full depletion.

   A photon interacts via the photoelectric effect at a radial position 5mm from the outside of the detector. Calculate the charge collection time for the electrons in a fully depleted n-type germanium detector, assuming that the electric field strength is 10^5V/m.