University of Liverpool
Department of Physics

Semiconductor Applications, PHYS389

Tutorial 1

Work should be handed to your tutor by 5.00pm on Tuesday 15th November

1. Briefly outline the difference between a direct and an indirect band gap semiconductor. Sketch the expected E-k relationship for the valence band and the conduction band. Give an example of each.

2. Calculate the effective momentum and wavevector of an electron in the conduction band of GaAs when the electron energy measured from the bandedge is 1.5eV. Also calculate the momentum of a free electron in space with the same energy. Comment on any difference in magnitude between the two momenta.

3. A 20μm diameter p-n diode is fabricated from silicon. The donor density is $10^{16}cm^{-3}$ and the acceptor density is $10^{18}cm^{-3}$. The intrinsic carrier concentration for Si(300K) is $1.5\times10^{10}cm^{-3}$.
    a. Describe the main applications of a Diode.
    b. Calculate the Fermi level positions in the *p* and *n* regions.
    c. State what is meant by "The Law of mass action".
    d. Using the law of mass action, calculate the built in potential for the diode at 300K.
    e. Calculate the depletion width for the *n* and *p* regions of the diode under a reverse bias of 0 and 8V and a forward bias of 1V. Comment on your results.

4. The optical absorption coefficient for GaAs is:

$$\alpha = 5.7\times10^{4}\frac{(\hbar\omega - E_g)^{1/2}}{\hbar\omega}cm^{-1}$$

   Calculate:
    1. The absorption coefficient for photons with energy 1.8eV. Assume that the band gap for GaAs is 1.43eV.
    2. The fraction of this light absorbed in a GaAs sample of thickness 0.5μm.