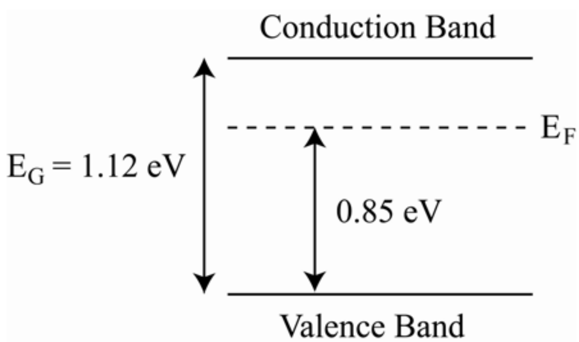
University of Delaware
Department of Electrical and Computer Engineering
ELEG620: Solar Electric Systems

Homework #2
Semiconductors and *pn* Junctions

1. Consider a slab of intrinsic silicon under thermal equilibrium. Given that the electron and hole concentrations will be equal find an expression for the Fermi energy for the intrinsic silicon. Given that $n_i = 1 \times 10\ cm^{-3}$, find the Fermi energy for intrinsic silicon. Why is it not in the centre of the band gap?

2. Give a brief explanation of why the Fermi energy for a semiconductor can lie within the band gap.

3. The simplified band diagram of a doped piece of silicon is given below.



(a) What is the doping in the silicon, both type (n or p) and the concentration?

(b) What are the equilibrium majority and minority carrier concentrations?

(c) If the silicon is cooled to a temperature ~ 0K what will happen to the majority and minority carrier concentrations and why?

4. Consider a semi-infinitely long slab of semiconductor where there is a constant injection of minority carriers, N_{inj}, at one edge

(a) Taking τ as the minority carrier lifetime and D as the diffusivity find an expression for the minority carrier diffusion current at some point x in the slab.

(b) Sketch the minority carrier concentration and diffusion current in the slab for the two cases of the lifetime being very large and very small.

(c) If the slab is made much thinner and a region of high recombination is present at the rear edge sketch the minority carrier concentration and diffusion currents.

5. Briefly describe how the depletion (space charge) region forms close to the physical junction of p and n type semiconductors. Sketch the idealized charge densities assuming the magnitudes of the dopings for n and p are roughly equal. What is responsible for the charge present? If the magnitude of doping of one side of the junction was decreased what would happen to the depletion region width? What happens to the depletion region width when a forward bias is applied?

6. Draw the band diagram of a pn junction under equilibrium and forward bias. Include the Fermi levels and quasi-Fermi levels as appropriate.