Solid state physics (*winter term 2015/2016*)

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Exercise sheet 8

Semiconductors

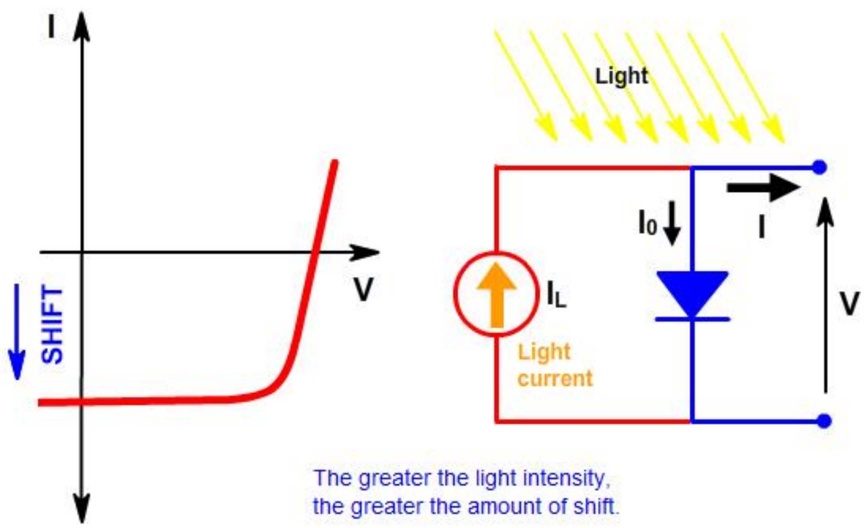
Exercise 1: pn-Junction

a) Find the built-in voltage for a silicon p-n junction at room temperature with doping concentrations $N_A = 10^{16} cm^{-3}\ (acceptor)\ and\ N_D = 10^{12} cm^{-3} (donor)$.

b) Derive the width of the natural space-charge region and the maximum electric field ε_{max} for an abrupt p-n junction as a function of the doping concentration N_A and N_D. Calculate the width for a very highly doped ($N_A=10^{16}$ cm^{-3}) p-type junction on n-type detector-grade material with $N_D=10^{12}$ cm^{-3}.

Exercise 2: Solar Cell

A biased pn-junction is a basic element of silicon solar cells. It function can be understood by means of the I-V characteristics curve of a pn-junction shifted by



I_L along the current axis (towards negative current), where I_L is the radiation induced current.

Determine the effective working point (I_W, V_W) providing maximum power harvest of the solar cell (neglect any other losses).

Exercise 3: Structure of Bands

(a) Draw a pn diode junction in thermal equilibrium with its parts separated. Indicate on the sketch the levels of the valance band energy, conduction band and Fermi energy for both the p and n type semiconductors.

(b) Repeat part (a) when the two semiconductors are braught togather.

(c) For different doping concentration of the p and n type materials, plot the change of the electric field E, the potential V and the charge density p along the depleted area. Use figure below.

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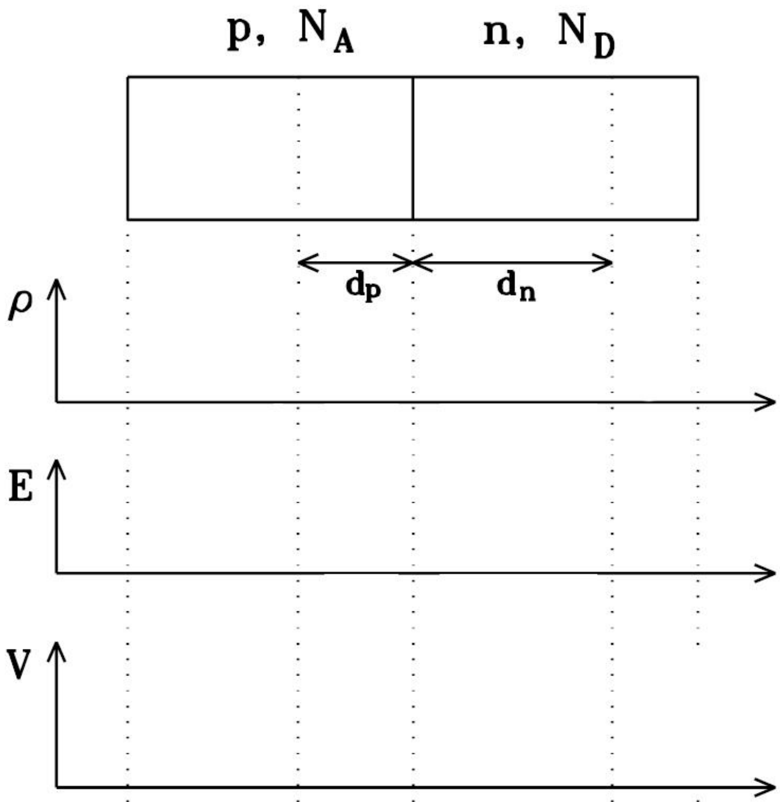
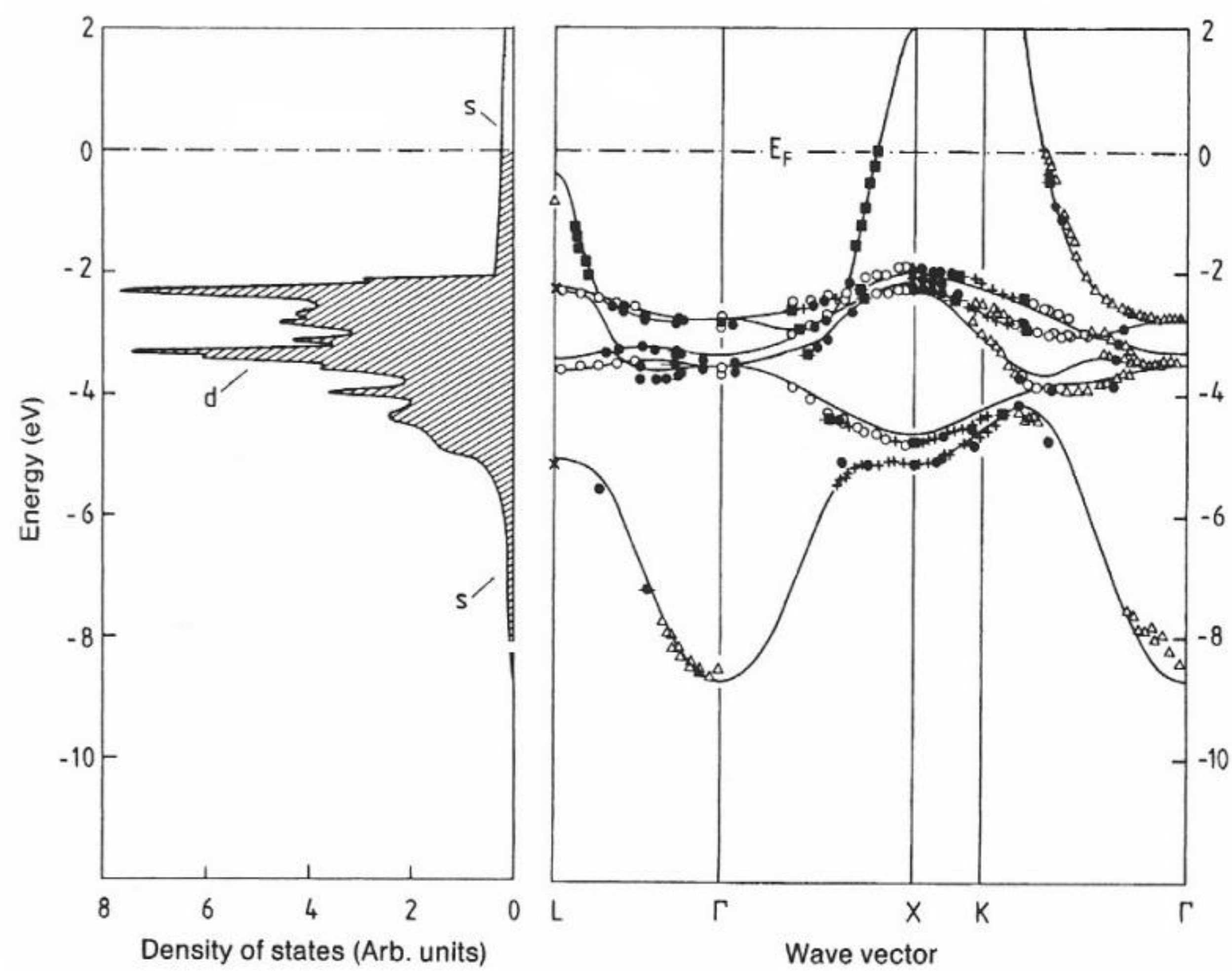


Exercise 4: Band Structure (Bonus)

Below is the density of states and the electron dispersion relation of some crystal.

a) What can you say about this material (metal, insulator or semiconductor?) And why?
b) What is the crystal structure?
c) What row of the periodic table is it in?



Please return on 06/01/2016