Exercise 1

1. a) Estimate the hole and electron concentrations in silicon that is doped with arsenic at a concentration of $2 \cdot 10^{25}$ atoms/m^3. The temperature is 300 K and the intrinsic carrier concentration n_i in this temperature is $1.5 \cdot 10^{16}$ carriers/m^3. The density of pure silicon is $5.0 \cdot 10^{28}$ atoms/m^3.

b) Estimate the electron and hole concentrations in the same material in 330 K temperature. How much did the temperature increase change the conductivity of the material?

2. The pn-junction of Figure 2.1 was fabricated using a 100 µm x 100 µm mask. The pn-junction is backward biased with a 5 V voltage source, as is shown in the figure. Due to the thermal generation, $3.2 \cdot 10^7$ new electron-hole pairs are generated each second in the depletion region of the diode.

a) How much reverse leakage current will flow in the diode? HINT: The charge of an electron is $q=1.6 \cdot 10^{-19}$ C.

b) Does this current depend on the reverse bias voltage? Why?

c) Does the current increase or decrease if the temperature increases? Why?

d) Next to this diode, another similar diode was fabricated using a 200 µm x 200 µm mask. How much is the reverse leakage current in this diode, if the temperature and the bias voltage are the same as with the 100 µm x 100 µm diode?

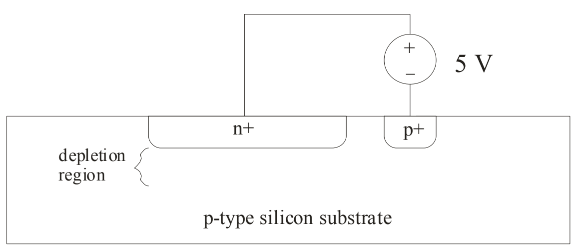

Figure 2.1

3. Find the current in the circuit of Figure 2.1 by simulating it with AIM-Spice. Use the diode model file 'DBSBdiode.mod', which models a 100 µm x 100 µm diode operating in the reverse biased region. NOTE: for simulating leakage currents in the pA –region, you must set the option GMIN to a very small value, e.g. GMIN=1e-39.