ELEC-3140 Semiconductor physics **Mid-term exam 1, Oct 25, 2017**

Write your name, student number, degree programme (*e.g.*, NanoRad), course code, and date of the exam on each of the answer papers.

1. Explain briefly and exactly (with a couple of sentences):
   a) covalent bond, b) Wigner-Seitz cell,
   c) pseudomorphic, d) biaxial strain,
   e) reactive ion etching, f) law of mass action.

2. a) Describe the division of crystal defects by their dimensionality. Give examples of crystal defects in each category. b) Describe how to determine the Miller indices for a crystal plane and for a crystal surface in a cubic crystal.

3. a) Describe shortly the main epitaxial growth methods and at least three techniques to fabricate semiconductor single crystals. b) Describe shortly what methods or phenomena can be used to engineer the value of the semiconductor band gap energy and other band properties.

4. a) Calculate the packing fraction of body-centered cubic (BCC) crystal structure by assuming that the atoms are hard spheres with a radius of R (all the same size). Then calculate what is the relative volume that the spheres take for themselves, if the nearest neighbour spheres are touching each other. b) Calculate the primitive vectors of the reciprocal lattice for the BCC lattice.

5. A semiconductor structure, in which the charge carriers can move in two dimensions, is called a quantum well. Therefore, the structure has energy barriers and a small dimension in one dimension to create the confinement. Calculate the density of states function for a quantum well with the width L_z (this dimension is very small compared to the other two).

Constants:

$m_e = 9,1091 \times 10^{-31}$ kg	$m_p = 1,6725 \times 10^{-27}$ kg	$m_n = 1,6748 \times 10^{-27}$ kg	amu $= 1,6605 \times 10^{-27}$ kg
$e = 1,6021 \times 10^{-19}$ C	$c = 2,9979 \times 10^{8}$ m/s	$\hbar = 1,0545 \times 10^{-34}$ Js	$\mu_B = 9,2732 \times 10^{-24}$ JT^{-1}
$\varepsilon_0 = 8,8544 \times 10^{-12}$ C^{2}N^{-1}m^{-2}	$K_e = 1 / 4\pi\varepsilon_0$	$\mu_0 = 1,2566 \times 10^{-6}$ mkgC^{-2}	$K_m = \mu_0 / 4\pi$
$\gamma = 6,670 \times 10^{-11}$ Nm^{2}kg^{-2}	$N_A = 6,0225 \times 10^{23}$ mol^{-1}	$R = 8,3143$ JK^{-1}mol^{-1}	$k = 1,3805 \times 10^{-23}$ JK^{-1}