ELEC-3140 Semiconductor physics **Mid-term exam 2, Dec 13, 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 (with a couple of sentences):
   a) impurity scattering,
   b) quantum wire,
   c) Shockely-Read-Hall recombination,
   d) exciton absorption,
   e) MESFET,
   f) built-in potential.

2. Describe the different recombination processes in semiconductors and evaluate in which circumstances each process is significant.

3. a) Describe the two main scattering mechanisms of charge carriers moving in a semiconductor. Additionally, give at least one example of other scattering mechanisms. b) Describe the formation of depletion region in a pn-junction. List also the assumptions made in the abrupt depletion region approximation.

4. TSC method (TSC = thermally stimulated current) can be used to measure the energy level of an electron trap. The sample is cooled down and the trap states are filled by shining intense light onto the sample. Then, the sample is heated up in dark and the conductivity of the sample is measured at the same time. The conductivity reaches its maximum value σ_m at the temperature of T_m. At that temperature the Fermi level is at the same level as the trap state. What is the trap level in a GaAs sample when the maximum conductivity is achieved at $T_m = -33$°C? The sample is 0.5 mm long and the cross-sectional area is 1 mm^2. The current of 280 μA flows through the sample when the bias is 10 V. The electron mobility of the sample at the same temperature is 7 000 cm^2 V^{-1} s^{-1}.

5. A germanium wafer is doped with donors so that the carrier concentration is $n = 1 \cdot 10^{16}\,\mathrm{cm}^{-3}$. Then, the wafer is illuminated so that electron-hole pairs are generated. Let this "surplus" carrier concentration be $1 \cdot 10^{15}\,\mathrm{cm}^{-3}$. Calculate the quasi Fermi levels in relation to the quasi Fermi level of an undoped germanium wafer and compare the electron quasi Fermi level to a situation without illumination (for germanium $n_i = 2.33 \cdot 10^{13}\,cm^{-3}$).

Constants and material parameters on the other side! (The quality of the print is not the best, but mistakes made in interpreting it will not count.)