S-104.3310 Optoelectronics **Exam** **January 8, 2010**

1. Explain briefly the following terms: a) zinc blende lattice structure, b) population inversion, and c) differential gain.

2. a) Explain the principles of LPE, MOVPE ja MBE methods in the fabrication of epitaxial semiconductor layers. b) Compare the suitability of these methods to manufacture different III-V semiconductors and various optoelectronic component structures.

3. Let us consider the coupling efficiency of a light-emitting diode into an optical fiber. Assume that the refractive indexes of the cladding and the core of the fiber are 1,48 and 1,52, respectively. a) Calculate the acceptance angle θ_a, which is the largest angle, in which the incoming light can be coupled into a progating mode of the fiber. b) Derive an approximation for the acceptance angle θ_a, when the difference between the refractive indexes of the core and the cladding is small. c) Calculate the coupling efficiency of a surface-emitting LED (intensity distribution $I = I_0 \cos\theta$) into an optical fiber.

4. Name three semiconductor laser structures that enable monomode operation (lasing in one longitudinal mode). Describe briefly the principles of each structure.

5. a) Write the RATE equations describing the dynamics of a semiconductor laser. Explain the meaning of each term. b) Using RATE equations derive an equation for the lasing delay of a semiconductor laser.

Physical constants and parameters:
$c = 3 \times 10^8$ m/s $h = 6.626 \times 10^{-34}$ Js $q = 1.602 \times 10^{-19}$ C N_C (GaAs) = 4.4×10^{17} cm^{-3}
$k_B = 1.38 \times 10^{-23}$ J/K = 8.617×10^{-5} eV/K N_V (GaAs) = 8.2×10^{18} cm^{-3}

Write your name, student number, degree programme, course code, and date of the exam in each paper.