1. Explain briefly the following terms: a) pseudomorphic structure, b) population inversion, and c) surface recombination.

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 the manufacture of different III-V semiconductors and various optoelectronic component structures.

3. Threshold current density of a semiconductor laser is $J_{th} = 1.35$ kA cm^{-2}. A similar structure is used in a superluminescent LED by artificially raising the threshold current. What is the new threshold current density, if the current flows only through half of the area of the diode? Assume the relation of $J = 1\,\mathrm{kA/cm^2} + g \cdot 5\,\mathrm{A/cm}$ between current density and gain. Refractive index of the active material is 3.5, length of the laser component is 300 μm and the absorption coefficient of the active material at operation wavelength is $\alpha = 3000$ cm^{-1}.

4. The operation of a semiconductor diode laser can be described with the rate equations

$$\frac{dn}{dt} = AI - \frac{n}{\tau} - \frac{Bn\varphi}{\tau}$$
$$\frac{d\varphi}{dt} = \frac{Bn\varphi}{\tau} - C\varphi \quad ,$$

where φ is photon density, n injection density, τ recombination time constant, I current and A, B, C are parameters. a) Explain which processes are described by each of the terms in the equations. b) Calculate the threshold current of a diode laser based on these equations. c) Calculate the photon and injection densities at the steady-state situation.

5. Explain briefly the operation principles of a photoconductive, PIN-diode and an APD photodetectors. Compare the gain, noise and modulation properties of these detectors.

Physical constants and parameters:

$c = 3 \times 10^8$ m/s $\quad h = 6.626 \times 10^{-34}$ Js $\quad q = 1.602 \times 10^{-19}$ C $\quad N_C$ (GaAs) $= 4.4 \times 10^{17}$ cm^{-3}

$k_B = 1.38 \times 10^{-23}$ J/K $= 8.617 \times 10^{-5}$ eV/K $\quad N_V$ (GaAs) $= 8.2 \times 10^{18}$ cm^{-3}

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