

Write your name, student number, degree programme, course code, and date of the exam in one of the answer papers. Write "Full exam" into the comment box. Write your name and student number in each of the answer papers.

If you answer to both the mid-term and full exams, mention that in the comment boxes of both exams. Problems 1 d-f, 4 and 5 are common to both exams and you do not need to repeat them if you do both exams.

1. Explain briefly and exactly (with a couple of sentences):
  - a) diamond lattice structure,
  - b) Wigner-Seitz cell,
  - c) superlattice,
  - d) quasi-Fermi level,
  - e) continuity equation, and
  - f) Kramers-Kronig relation.
2. a) Describe the division of crystal defects by their dimensionality. Give examples of crystal defects in each category. (2p) b) Draw and describe the four band model of the direct semiconductor energy bands. What are the four bands, what are their functional shapes and how the curvature of the band has an effect on the semiconductor parameters? (4p)
3. a) Describe shortly the four main epitaxial growth methods. In addition, mention at least two techniques to fabricate semiconductor single crystals and ingots. b) Describe shortly what methods or phenomena can be used to engineer (i.e. band-gap engineering) the value of the semiconductor band gap energy and other band properties.
4. Describe the different recombination processes in semiconductors and evaluate in which circumstances (high/low temperature, high/low injection level, etc.) each process is significant.
5. Let us consider an abrupt pn-junction in silicon ( $n_i = 1 \cdot 10^{10} \text{ cm}^{-3}$ ) with doping concentrations of  $N_A = 1 \cdot 10^{16} \text{ cm}^{-3}$  and  $N_D = 2 \cdot 10^{17} \text{ cm}^{-3}$ . a) Calculate the built-in voltage of the junction. b) Calculate the width of the depletion region, the maximal value of the electric field and the potential difference over the n-side when the external bias is  $V_a = -3 \text{ V}$ .

Constants and material parameters on the other side!