

Nanophysics

Programme course

6 credits

Nanofysik

TFYM03

Valid from: 2021 Spring semester

Determined by

Board of Studies for Electrical
Engineering, Physics and Mathematics

Date determined

2020-09-29

Main field of study

Applied Physics, Physics

Course level

Second cycle

Advancement level

A1X

Course offered for

- Applied Physics and Electrical Engineering, M Sc in Engineering
- Applied Physics and Electrical Engineering - International, M Sc in Engineering
- Master's Programme in Physics and Nanoscience
- Master's Programme in Materials Science and Nanotechnology

Specific information

The course can not be included in degree together with TFYA91, TFYY54.

Prerequisites

Solid state physics.

Intended learning outcomes

The aim of this course is to give an introduction to the semiconductor physics at the nanometer scale. The participants in the course obtain basic understanding of the principles, fabrication and characterization methods, and application aspects of low-dimensional semiconductor structures. After the course the students should be able to:

- define the fundamental physical principles, which govern properties of the semiconductor materials and predict the effects of reduced dimensionality on optical, electronic and transport-related properties in quantum structures
- describe and evaluate the different fabrication methods of semiconductor nanostructures - quantum wells, quantum wires and quantum dots
- apply imaging and optical characterization techniques, perform analysis of the obtained information and write a lab report in English
- explain the operation principles of nanoelectronic and nanophotonic devices and identify their area of applications.

Course content

A. Introduction to the semiconductor physics and nanostructures – scaling laws at nanoscale; quantum nature of nanoworld; semiconductor band structure and effective masses; phonons, free charge carriers and scattering processes; quantized electronic levels in quantum wells, quantum wires and quantum dots.

B. Fabrication and characterization of semiconductor nanostructures - epitaxial techniques for growth of quantum wells, quantum wires and quantum dots; imaging techniques for structural analysis of semiconductor nanostructures; spectroscopic methods for characterization of quantized electronic levels; local probe spectroscopy.

C. Properties and application of semiconductor nanostructures - optical properties of quantum wells, quantum wires and quantum dots - absorption, emission, excitons, carrier relaxation and recombination; quantum electron transport in semiconductor heterostructures (two-dimensional electron gas) and in quantum wires (ballistic transport); nanophotonic devices - light-emission diodes, laser diodes, photodetectors and solar cells; nanoelectronic devices - high-mobility field-effect transistors, resonant tunneling diodes, single-electron transistors.

Teaching and working methods

Lectures and laboratory exercises. Project work based on a literature survey of a special topic in nanophysics.

Examination

UPG1	Assignments	3 credits	U, G
LAB1	Laboratory Work	1 credits	U, G
UPG2	Project Work	2 credits	U, 3, 4, 5

Grades

Four-grade scale, LiU, U, 3, 4, 5

Other information

About teaching and examination language

The teaching language is presented in the Overview tab for each course. The examination language relates to the teaching language as follows:

- If teaching language is Swedish, the course as a whole or in large parts, is taught in Swedish. Please note that although teaching language is Swedish, parts of the course could be given in English. Examination language is Swedish.
- If teaching language is Swedish/English, the course as a whole will be taught in English if students without prior knowledge of the Swedish language participate. Examination language is Swedish or English (depending on teaching language).
- If teaching language is English, the course as a whole is taught in English. Examination language is English.

Other

The course is conducted in a manner where both men's and women's experience and knowledge are made visible and developed.

The planning and implementation of a course should correspond to the course syllabus. The course evaluation should therefore be conducted with the course syllabus as a starting point.

Department

Institutionen för fysik, kemi och biologi

Director of Studies or equivalent

Magnus Boman

Examiner

Plamen Paskov

Education components

Preliminary scheduled hours: 48 h

Recommended self-study hours: 112 h

Course literature

Regular literature

Books

M. Grundmann, (2010) *The Physics of Semiconductors - An Introduction Including Nanophysics and Applications* Springer

Additional literature

Books

D. Bimberg, M. Grundmann, N. N. Ledentsov, (1999) *Quantum dot heterostructures* John Wiley & Sons

E. L. Wolf, (2004) *Nanophysics and nanotechnology: An introduction to modern concepts in nanoscience* Wiley-VCH