UNIVERSITY OF GOTHENBURG

DEPARTMENT OF PHYSICS

FCC040 Semiconductor materials physics, 7.5 credits

Halvledarfysik - material och heterostrukturer, 7,5 högskolepoäng

Second Cycle

Confirmation

This course syllabus was confirmed by Department of Physics on 2021-03-01 to be valid from 2021-03-16, spring semester of 2021.

Field of education: Science 100%
Department: Department of Physics

Position in the educational system

The course can be part of the following programmes: 1) Complex Adaptive Systems, Master's Programme (N2CAS) and 2) Physics, Master's Programme (N2PHY)

Main field of studies	*Specialization*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Entry requirements

Bachelors degree in physics or equivalent, including basic course in solid state physics or equivalent

Learning outcomes

On successful completion of the course the student will be able to:

- Know about semiconductor materials, important discoveries, and their impact on our society.

- Acquire basic information about electronic structures and classification of different materials such as metals, semimetals, graphene, semiconductors, insulators, topological Insulators.

- Describe how the electron energy dispersion affects the electron mass, mobility and electronic transport.

- Understand how the defects and dopants affect the electronic properties of semiconductors.

- Understand and interpret band diagrams of semiconductor heterostructures.

- Understand the principles of quantum mechanical effects in semiconductor nanostructures.

- Describe methods for single crystal growth and epitaxy of semiconductor materials.

- Information about the discovery and physics of 2D materials such as graphene, h-BN, MoS2, topological insulators and their heterostructures.

- Understand and describe the charge and spin polarized electronic transport in semiconductors and novel 2D materials.

Course content

Introduction: general course information, historical background, semiconductors today, future materials and novel phenomena.

Electron structure : Semiconductor crystal structure, electronic energy band structure, materials classification such as metals, semi-metals, graphene, semiconductors, insulators, topological insulators.

Electron transport : Charge transport in semiconductors, electronic effect of impurities, charge carrier scattering, diffusive and ballistic transport.

Semiconductor surfaces, interfaces and heterostructures : metal-semiconductor Schottky contacts, semiconductor-semiconductor junctions, semiconductor-insulator interfaces.

Semiconductor growth and nanofabrication technology and applications: Crystal growth, epitaxial growth, nanofabrication, electronic and optoelectronic devices.

Semiconductor quantum structures: Quantum-wells, -wires and -dots; Electronic and optical properties in quantum structures.

Quantum device physics in semiconductors : Coulomb blockade, quantum point contacts, weak localization, Aharonov-Bohm effect, Shubnikov de Haas oscillations and Quantum Hall effects.

Novel two-dimensional (2D)
materials : Electronic and quantum properties of
2D materials such as - graphene, hexagonal boron nitride (h-BN), MoS2 and their heterostructures.

Spin polarized electron transport in semiconductors : Introduction to spintronics, spin scattering and
relaxation processes in semiconductors, spin transport and
dynamics in semiconductors.

Spin polarized electron transport in 2D materials
heterostructures : Spin transport in graphene, spin polarized tunneling
through h-BN, spin and valley polarization in MoS2.

Topological insulators: Electronic
band structure of topological insulators, spin polarized current in
topological insulators.

Form of teaching
Organisation

Lectures.
Three compulsory home assignments.
Two compulsory lab exercises.
One compulsory project assignment.

Language of instruction: English

Assessment
Three compulsory home assignments.
Two compulsory lab exercises.
One compulsory project assignment.

Written exam.

A student who has taken two exams in a course or part of a course without obtaining a pass grade is entitled to the nomination of another examiner. The student needs to contact the department for a new examiner, preferably in writing, and this should be approved by the department unless there are special reasons to the contrary (Chapter 6 Section 22 of the Higher Education Ordinance).

If a student has received a recommendation from the University of Gothenburg for

special educational support, where it is compatible with the learning outcomes of the course and provided that no unreasonable resources are required, the examiner may decide to allow the student to sit an adjusted exam or alternative form of assessment.

In the event that a course has ceased or undergone major changes, students are to be guaranteed at least three examination sessions (including the ordinary examination session) over a period of at least one year, but no more than two years, after the course has ceased/been changed. The same applies to placements and professional placements (VFU), although this is restricted to just one additional examination session.

Grades

The grading scale comprises: Pass with Distinction (VG), Pass (G) and Fail (U).

Course evaluation

The results of and possible changes to the course will be shared with students who participated in the evaluation and students who are starting the course.