Linnæus University

Course syllabus

Faculty of Technology

Department of Physics and Electrical Engineering

4FY535 Experimentell fysik och teknik av nanostrukturer, 7,5 högskolepoäng

Experimental physics and technology of nanostructures, 7.5 credits

Main field of study
Physics

Subject Group
Physics

Level of classification
Second Level

Progression
A1F

Date of Ratification
Approved by Faculty of Technology 2016-10-10
The course syllabus is valid from autumn semester 2017

Prerequisites
Mathematics 45 credits or the equivalent; Physics 90 credits, including a 7.5 credit course in quantum mechanics, a 7.5 credit course in thermodynamics and statistical physics, and a 7.5 credits introductory course in solid state physics or equivalent

Objectives

After completing the course the student will acquire knowledge about:

- different types of condensed matter nanostructures currently fabricated in research laboratories all over the world
- physical properties of 2D (quantum wells), 0D (quantum dots) and 1D (quantum, wires) nanostructures
- fabrication methods of nanostructures (i) top-down approach – optical and e-beam lithography and chemical etching (ii) bottom-up approach by self-assembled (self-organized) growth
- experimental tools used for realization of (i) and (ii) approaches, with the main focus on molecular beam epitaxy growth
- experimental tools used for characterization of nanostructures – SEM, TEM, micro PL, cathodoluminescence
- physical models describing formation of self-assembled 0D and 1D nanostructures

Content

Kinds of nanostructures which have been fabricated & investigated during the recent two decades in the field of semiconductor physics, particularly

(1) 2-dimensional structures – quantum wells and superlattices
(2) 0-dimensional structures – quantum dots
(3) 1-dimensional structures – nanowires

Basic physical properties of the nanostructures (1) – (3) via a simple model description in effective mass approximation.

The most popular nanostructure formation methods

(1) Top-down approach - optical, e-beam, AFM, nanoimprint lithography
(2) Bottom-up approach – MBE, CBE, MOVPE, ALD

The most important nanostructures in view of the research and potential applications

(1) Quantum dots

- Stranski-Krastanow QDs, Droplet epitaxy QDs, Quantum rings, Colloidal quantum dots.
- Theoretical description of the formation mechanisms

(2) Nanowires

- VLS and VSS growth mechanisms
- Self-catalysed NWs
- Colloidal nanowires
- Nanowire heterostructures
- Theoretical description of the formation mechanisms

Experimental tools used for investigations of nanostructures

- Scanning electron microscopy
- Transmission electron microscopy & electron diffraction basics
- Scanning tunnelling microscopy
- Micro photoluminescence and micro Raman scattering
- X-ray diffraction

Applications of Quantum Dots

- quantum dot lasers
- single photon emitters
- drug carrying vector

Applications of nanowires

- Single electron transistors
- Nanosensors
- Solar cells
- Single nanowire lasers
- Memory structures

Selected current new research results concerning nanowires and quantum dots

(1) Nanowires

- Polytypism
- Axial and radial nanowires heterostructures
- Branched nanowires
- Fractal nanowire structures
- Nanowire quantum dots

(2) Quantum dots

- Single electron quantum dots
- Quantum dots with single magnetic atom
- Quantum dots in microcavities

Type of Instruction
The teaching consists of lectures and lab sessions.

Examination
The course is assessed with the grades A, B, C, D, E, Fx or F.
The grade A constitutes the highest grade on the scale and the remaining grades follow in descending order where the grade E is the lowest grade on the scale that will result in a pass. The grade F means that the student's performance is assessed as fail (i.e. received the grade F).

Assessment of student performance is made through lab reports.

Course Evaluation
During the course or in close connection to the course, a course evaluation is to be carried out. The result and analysis of the course evaluation are to be communicated to the students who have taken the course and to the students who are to participate in the course the next time it is offered. The course evaluation is carried out anonymously. The compiled report will be filed at the Faculty.

Other
Grade criteria for the A–F scale are communicated to the student through a special document. The student is to be informed about the grade criteria for the course by the start of the course at the latest.

Required Reading and Additional Study Material
Reference literature
Chapters will be selected from the books below:

Alexander Tartakovskii Quantum Dots: Optics, Electron Transport and Future Applications Cambridge University Press 2012.

Helmut. Sitter, Marian A. Herman, Molecular beam Epitaxy Fundamentals and current status Springer, 1996.

Marian A. Herman, W. Richter, Helmut Sitter - Epitaxy: Physical Principles and Technical Implementation, Springer 2004.

M. Henini (Ed), Molecular Beam Epitaxy: From research to mass production, Elsevier 2013

Scientific Papers