

Computational nanotechnology and bio nanotechnology Beräkningar inom nano- och bionanoteknik

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Course code: BB2550

ECTS points: 10 points

Level of course/year of study: First year at master's level. Prerequisites

- Basic knowledge of Fortran is required since subroutines that calculate physical processes are written in Fortran. C and C++ will also work. Matlab and mathematica will be the basic graphic software tools during the course lectures as well as laborations. Self development of numerical computation and visualization tool/software is surely an extra bonus.
- Background in quantum mechanics, advanced solid state theory, and electromagnetic field theory

Course contents: This course has been developed in parallel with the fast-advancing multidisciplinary research and technological developments, and addresses two main areas: Nanoelectronic and nanophotonics.

- Part 1 fundamental quantum mechanics of carrier transport in nanostructures
- Part 2 nanoelectronic devices
- Part 3 fundamental quantum mechanics of light-matter interaction
- Part 4 nanophotonic devices
- Part 5 high throughput biosensors and biomarkers

The main purpose of the course is to study electrons and photons in and through nanostructures by the first-principles quantum mechanical theories and fundamental concepts (a unified coverage of nanostructured electronic and optical components) behind nano-electronics and optoelectronics, the material basis, physical phenomena, device physics, and designs and applications as high throughput biosensors and biomarkers. The combination of viewpoints presented within the course can help to foster further research and cross-disciplinary interaction needed to surmount the barriers facing future generations of technology design.

Many specific nanotechnologies are presented, including quantum electronic devices, resonant tunnelling devices, single electron devices, heterostructure bipolar transistors, high electron mobility transistors, photodetector, light emitting device. It contains essential and detailed information about the state-of-the-art theories, methodologies, the way of working and real case studies, helping students and researchers to appreciate the current status and future potential of nanotechnology as applied to the electronics and optoelectronics industry.

In part 5 of High throughput biosensors and biomarkers we will concentrate on local electromagnetic interactions between nanometric objects and optical fields (non-linear optics in nano- and microstructures photonic crystals) at the level of systems of nanostructures, into larger density on interfaces, which in turn leads to intriguing collective effects, such as

plasmonics or multiple reflection and refraction phenomena for biosensing and bioimaging applications.

Language of instruction and examination: English

Teaching methods: (a) lectures: 26 h; (b) 6 home assignments: 30 h; (c) 2 computational projects: 20 h

Teaching semester: Spring

Examination semester: Spring, Autumn

Assessment methods: lecture attendance, home assignments, projects, and written examination

Grading: Letter grades (A-F)

Home assignments (including computational exercises) will be required and the results will affect the final grade.

6 home assignments, 2,5 credits, grade scale: P, F

Attendants are required to complete written examination directly related to the courses (mostly concerning fundamental knowledge).

Examination, 4.5 credits, grade scale: A, B, C, D, E, FX, F

Two computational laborations will be coordinated based on practical problems and performed in the research lab of the department, which will affect the final grade. The two lab projects will be positioned approximately at 1/4 and 3/4 time of the course, aiming at assessing functioning knowledge.

LAB1 - 1,0 credits, grade scale: P, F

LAB2 - 2,0 credits, grade scale: A, B, C, D, E, FX, F

Course literatures

- Detailed lecture notes will be distributed by including the latest worldwide research and technological development activities
- Course books
 1. Y. Fu and M. Willander, Physical models of semiconductor quantum devices. Kluwer Academic Publishers Boston 1999.
 2. Y. Fu and M. Qiu, Optical properties of nanostructures. Pan Stanford Publishing. 2011.