GHENT UNIVERSITY

Course Specifications

Valid in the academic year 2022-2023

Multiscale and Multiphysics Modelling Techniques for Nanoelectronic Devices (E006600)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h** **Contact hrs** 60.0h

Course offerings and teaching methods in academic year 2022-2023

A (semester 2)	English	Gent	seminar	60.0h
B (semester 2)	Dutch	Gent	self-reliant study activities	60.0h

Lecturers in academic year 2022-2023

Vande Ginste, Dries	TW05	lecturer-in-charge

Offered in the following programmes in 2022-2023	**crdts**	**offering**
Master of Science in Engineering Physics	6	B
Master of Science in Engineering Physics	6	A

Teaching languages

English, Dutch

Keywords

Multiscale modelling, multiphysics modelling, nanoelectronic devices, numerical computation and simulation, electromagnetics, quantum mechanics, thermodynamics.

Position of the course

The course starts from the application domain, which is the design and manufacturing of nanoelectronic devices. Within these devices, physical phenomena occur on different scales (multiscale aspect, both in space and in time) and pertaining to different branches of physics (multiphysics aspect). Based on their knowledge of electromagnetics, quantum mechanics, thermodynamics, etc., the student will gain insight in the holistic formulation of the behaviour of nanoelectronic devices and learn to couple and solve the pertinent sets of partial differential equations that govern this behaviour. Whereas the focus of this course is on the relevant modelling techniques, many application examples will illustrate the techniques' necessity and appositeness for state-of-the-art design of novel devices and applications.

Contents

Part 1: Multiscale modelling

- Description of multiscale and multiresolution problems in space and time in nanoelectronic components
- Non-uniform gridding
- Collocated methods
- Hybrid methods
- Domain decomposition techniques

Part 2: Multiphysics modelling

- Formulation of multiphysics problems in nanoelectronic components
- Modelling of Maxwell-Fourier systems + applications
- Modelling of Maxwell-Schrödinger systems + applications
- Modelling of Maxwell-Dirac problems + applications

Initial competences

Electromagnetism I, Electromagnetism II, Quantum Mechanics I, Quantum Mechanics II, Atomic and Molecular Physics, Transport Phenomena, Computational Solutions of Wave Problems, Solid-state Physics and Semiconductors I, Solid-state

Physics and Semiconductors II

Final competences

1 Understand multiscale and multiphysics problems which arise in nanoelectronic devices
2 Describe multiscale problems; recognize the important parameters for selecting a particular computational solution method to deal with it (gridding, domain decomposition, hybrid); recognize potential and limitations of these methods
3 Describe multiphyscis problems; recognize the important parameters for selecting a particular computational solution method; couple and solve the relevant partial differential equations pertaining to the devices that need to be modeled and designed; recognize potential and limitations of these methods.
4 Cooperate and communicate within small groups on an open ended multiscale/multiphysics problem and plan a joint undertaking that takes several months during a modeling project related to nanoelectronic design

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture: plenary exercises, Demonstration, Group work, Guided self-study, Seminar, Lecture, Self-reliant study activities, Project, Seminar: coached exercises, Seminar: practical pc room classes

Extra information on the teaching methods

The course consists of lectures about theory and exercises, without making a strict, traditional distinction between them. All lectures are seminars which require interaction with and input from the students. During the semester numerical problems must be tackled and programmed in Python. The results of this project are written down in a report.

Learning materials and price

Electronic syllabus and slides available for free via Ufora (hardcopy via VTK).

References

See syllabus

Course content-related study coaching

The lecturer and his assistants are available for further explanations.

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Report, Open book examination

Examination methods in case of periodic assessment during the second examination period

Report, Open book examination

Examination methods in case of permanent assessment

Skills test

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible in modified form

Extra information on the examination methods

- During examination period: oral open-book exam; graded project reports
- During semester:
  - graded computer exercises spread over semester.
  - Second chance: Possible in adapted form

Calculation of the examination mark

Computer exercises throughout semester 30%, during examination period: discussion of project reports and theoretical questions 70%.