TECHNISCHE UNIVERSITÄT DRESDEN

Faculty Electrical and Computer Engineering

Current Study Guide for the consecutive Master's program Nanoelectronic Systems Summer Term 2021

Please note: This is an English translation of the German original. **Only the German version is legally binding.**

Content

Appendix 1
Module Descriptions

Required modules

Module number	Module name	Lecturer in charge
NES-12 ASW-14.1	Academic and Scientific Work	Dean of studies
Contents and objectives	After completion of the module students have the key competencies for the academic and scientific work. They can deal critically with scientific texts or pass on their knowledge to others and monitor their learning process. This includes understanding the essential content of scientific texts, their integration into the current scientific context, the critical reflection of social, economic and cultural impact as well as their representation and presentation. To stimulate and to enable the development of knowledge among learners the students have acquired knowledge of the general academic teaching and can apply this.	
Modes of teaching and learning	The module consists of 3 hours per week lectures, tutorials, labs, or seminars and self study. The courses are choosen in the specified amount from the catalog "Wissenschaftliches Arbeiten (Scientific Work)". The catalog is given inclusive of the required examinations at the beginning of the semester faculty usually known.	
Prerequisites		
Usability	The module is a required module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module test is passed. The assessment consists of the prescribed examinations according to the catalog "Wissenschaftliches Arbeiten (Scientific Work)".	
Credit points and grades	4 credit points can be obtained by the module. The grade is derived from the unweighted mean of the grades of the individual examinations.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 01-14.1	Fundamentals of Estimation and Detection	Dr. Rave
Contents and objectives	After completion of the module the students know the key approaches for parameter estimation and detection as well as the basics of linear estimation techniques and of memory-afflicted systems. They understand the different mathematical models and approaches that the current methods are based, and thus they are able to select and apply the appropriate procedures for various practical scenarios. Students can evaluate different estimators / detectors on the basis of quality criteria.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Knowledge in system theory and basic knowledge in stochastic on bachelor level	
Usability	The module is a required module of the branch of study Nanoelectronic in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 03-14.1	Hardware/Software Codesign	Prof. Fettweis

Contents and objectives	The module content includes: - Methods and different aspects of hardware and software implementation of embedded systems (including telecommunications). - Mutual influence of both designs (co-design) in order to optimize the circuit design, - New arallel processing concepts through massive structure reduction towards the "Nano Scale". Objectives: After completing this module, students have an overview of current hardware systems, specifically the various hardware platforms for software implementation of digital signal processing algorithms, and can evaluate these with respect to various criteria (eg, flexibility, power consumption). Students can derive from algorithms the hardware requirements in compliance with the requirements of flexibility for the hardware and software components. They know strategies to enhance performance and minimize power consumption and can apply them safely
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.
Prerequisites	
Usability	The module is a required module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems. The module creates the prerequisites for the module Hardware / Software Codesign Lab.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes, if the number of registered students exceeds 16. With up to 16 registered students the written exam is replaceed by an oral exam as individual exam worth 20 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.
Frequency	The module is offered every summer semester.
Workload	The total effort is 120 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-11 06 01-19.1	Lab Sessions	Prof. Dr. Christof Fetzer
Contents and objectives	This module provides the practical skills and abilities in the field of embedded system design and semiconductor manufacturing. Participants gain experience in teamwork and project work and deepen their skills in lecture and presentation techniques. After completing the module the students have a first state of knowledge on issues of embedded system design and have some experience with the most important process steps in semiconductor manufacturing.	
Modes of teaching and learning	The module consists of 3 hours per week practical training and self-study.	
Prerequisites		
Usability	The module is a required module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of two lab protocols. A collection of exercises has to be solved as exam prerequisites.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the unweighted mean of the grades of the lab protocols.	
Frequency	The module is offered every academic year beginning in the winter semester.	
Workload	The total effort is 150 hours.	
Duration	The module takes two semesters.	

Module number	Module name	Lecturer in charge
NES-11 06 02-14.1	Principles of Dependable Systems	Prof. Dr. Christof Fetzer
Contents and objectives	After the completion of this module, students are able to design and to implement highly reliable and secure systems. Special skills they acquired for the design of distributed protocols for critical systems, due the variety of possible error and failure types in this area. Based on their theoretical knowledge, students can design effective solutions to practical scenarios.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Participants should be familar with the basics of design, development and operation of computer-based systems (bachelor level).	
Usability	The module is a required module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 60 minutes, if the number of registered students exceeds 10. With up to 10 registered students the written exam is replaceed by an oral exam as individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty. A collection of exercises has to be solved as exam prerequisites.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 PW-14.1	Project Work	Dean of studies
Contents and objectives	Contents: - Research, development, modeling, analysis, planning, design, system design, programming, - Implementation and coding, operation, maintenance, verification and testing, commissioning, Outcomes: The students have expertise in handling complex problems in modern engineering professional practice and to document and present their results. They have social skills of professional communication, project and product management.	
Modes of teaching and learning	The module consists of a project including self-study.	
Prerequisites		
Usability	The module is a required module of the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of the project report in the amount of 36 days and a presentation of 15 minutes duration..	
Credit points and grades	10 credit points can be obtained by the module. The module grade is the weighted mean of the grades of the two examinations, in which the grade of project report is weighted with 4/5 and the grade of the presentation is weighted with 1/5.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 300 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 08 02-14.1	Radio Frequency Integrated Circuits	Prof. Ellinger

Contents and objectives	The module content includes: - High frequency integrated circuits for high speed wireless communications such as low noise amplifiers, power amplifiers, mixers, oscillators on basis of active and passive devices, as well as complete radio frontends and architectures, are lectured. - Advantages and challenges of aggressively scaled CMOS and BiCMOS, Moore than Moore (e.g. FinFET, SOI, strained silicon) and Beyond more Moore (silicon nano wire, CNT and organic) technologies are discussed from circuit design perspective. Qualification goals: After completion of the module the students obtain competences regarding - Methods for the design of analog high frequency integrated circuits. They know the basic circuits and architectures of the systems. - analysis and optimisation of these circuits, - complete design cycle for high frequency integrated circuits using the Cadance CAD system and are therefore prepared in this field for the requirements in industry and academia, - technical English
Modes of teaching and learning	The module consists of 3 hours per week lectures, 1 hour per week tutorials, 2 hours per week practical training and self-study.
Prerequisites	Basic knowledge in circuit design on bachelor level is required.
Usability	The module is a required module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment is a written exam in the amount of 120 minutes. The exam can be taken in German or English.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the examination.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 12 02-19.1	Semiconductor Technology	Prof. Bartha

Contents and objectives	The module contains the technological basics for the fabrication of micro- and nano devices as well as the manufacturing concepts for integrated circuits. Students have the ability - to describe the operation of individual technologies for the production of micro- and nano-devices, - to work with basic principles for the production and miniaturization of components and circuits, - to add the individual technologies to complex process flows together and explain their interaction.
Modes of teaching and learning	The module consists of 6 hours per week lectures and self-study.
Prerequisites	
Usability	The module is a required module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consist of a written exam in the amount of 120 minutes, if the number of registered students exceeds 20. With up to 20 registered students the witten exam will be replace by an oral exam as an individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.
Credit points and grades	9 credit points can be obtained by the module. The module grade is the grade of the examination.
Frequency	The module is offered every academic year beginning in the winter semester.
Workload	The total effort is 300 hours.
Duration	The module takes two semesters.

Required elective modules

Module number	Module name	Lecturer in charge
NES-12 10 05-20.1	Antennas and Radar Systems	Prof. Dr.-Ing. Dirk Plettemeier
Objectives	After completion of the module, the students are able to describe important antenna parameters and evaluate different antenna types in this context. They are able to synthesize the radiation characteristics of antenna arrays and present radiation mechanisms of certain antenna types. They know how to compare simulation and measurement data of a self-designed and measured antenna. Furthermore, they are able to classify antenna models from the current literature. The students are able to analyze the radar equation and to explain basic radar principles. They are in the position to classify an unknown radar system and to derive its functionality from a block diagram. They are capable of evaluating the performance and limitations of radar systems and are skilled in designing a radar system for a given problem.	
Contents	The content of the module focuses on the fundamentals of antenna theory (e.g. parameter, antenna arrays, linear, aperture, patch, slot, on-chip antennas) and of Radar Systems (e.g. radar equation, pulse/pulse Doppler, CW, SFCW, FMCW, PRN, SAR).	
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Knowledge as it can be obtained from the module Radio Frequency Technology is advantageous.	
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral exam as individual exam worth 45 minutes.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 20	Communication Networks 3	Prof. Dr.-Ing. F. Fitzek
Contents and objectives	The content of the module includes: 1. tools for investigating the performance of communication systems, in particular the analytical and simulative approach and the exemplary build-up by means of implementation 2. future communication systems, especially planning, analysis and architecture 3. approaches to project-based work, incl. work-structuring and presentation of work results (in writing and verbal) in front of a specialist audience. Qualification objectives: After completion of the module, the students have a thorough understanding of the modeling and performance analysis of communication networks and its protocols. They are able to select and apply appropriate methods of investigation for various problems. The students have learned to look at their tasks in a professional manner, to structure their project in terms of work and time, and to present their results in a public-oriented manner.	
Modes of teaching and learning	4 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites		
Usability	The module is a required elective module in the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes and a project report with a scope of 30 hours, if the number of registered students exceeds 15. With up to 15 registered students the written exam is replaced by an oral exam as individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the unweighted mean of the grade of the examination and of the project report.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 02-14.1	Communications	Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis

Contents and objectives	The module content includes: Signal theory (sine waves, Dirac function, convolution, Fourier transform), linear time-invariant systems (transfer function, impulse response) bandpass signals (real and complex up and downward mixing of signals, equivalent lowpass signal), analog modulation (modulation, demodulation, properties of AM , PM, FM), analog-digital conversion (sampling, signal reconstruction, quantization, sub- and over sampling), digital modulation schemes (modulation methods, matched-filter receiver, bit error probability). Outcomes: After completing this module, students master the basic principles and practical application of communications. The students will be able to understand the basic signal processing in communications systems and to describe them mathematically. They are familiar with the transmission in base band and band-pass area and know the basic analog and digital modulation methods. They understand for simple analog and digital transmission scenarios the impact of noise on the transmission quality.
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.
Prerequisites	It is assumed the knowledge of systems theory for analog and digital systems, algebra, calculus, complex analysis, partial differential equations and probability theory at the bachelor level.
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes.
Credit points and grades	3 credit points can be obtained by the module. The module grade is the grade of the examination.
Frequency	The module is offered every summer semester.
Workload	The total effort is 90 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-11 20 19	Design and Programming of Embedded Multicore Architectures	Prof. Göhringer

Objectives	After successful completion of this module, the participants have qualifying knowledge in the areas of design and programming of modern embedded systems and in the area of simulation of embedded multicore architectures. They will also have practical skills in the use of embedded operating systems, such as Embedded Linux or FreeRTOS, on a modern embedded system, such as a Xilinx Zynq System-on-Chip.
Contents	The module provides overview and special knowledge in the fields of design, simulation, and programming of modern embedded systems consisting of several processors and special accelerators. The lecture-accompanying exercises serve to consolidate the lecture material and include practical experience in the subject area.
Modes of teaching and learning	The module includes 2 SWS lectures and 2 SWS exercises as well as self-study.
Prerequisites	Basic knowledge and skills of computer architectures are required, in particular the participants should be familiar with the basics at Bachelor level.
Usability	The module is an elective module in the Nanoelectronic Systems Master's program.
Requirements for the award of credit points	The credit points are earned when the module examination has been passed. For up to 10 registered participants, the module examination consists of an oral examination performance as an individual examination lasting 20 minutes. If there are more than 10 participants, the examination consists of a written examination lasting 60 minutes. The type of concrete examination will be determined by the module supervisor at the end of the examination registration period and will be publicly announced in accordance with faculty practice.
Credit points and grades	6 credit points can be earned through the module. The module grade corresponds to the grade of the examination performance.
Frequency	The module is offered every summer semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Modulnummer	Modulname	Verantwortlicher Dozent
NES-12 12 04-14.1	Electromechanical Networks	Prof. Dr.-Ing. habil. Marschner

Objectives	The students — are skilled with the basic methodological and practical knowledge to analyse and to design effectively the dynamic behavior of coupled electromechanical, magnetic and fluidic systems using a circuit representation of the different subsystems including their interactions based on network theory, — master the function and modelling of electromechanical transducers, — can simulate the behavior of electromechanical systems with existing circuit simulation software such as Spice. The students are thus able to use the clear and illustrative analysis methods of electrical networks to develop a better physical understanding and to design physically different subsystems in a closed manner.
Contents	Module contents are the description of coupled multiphysical subsystems in the form of a common circuit diagram and their behavioral simulation. Simple mechanical, magnetic, fluidic (acoustic), electrical and coupled systems, including their interactions, are analyzed.
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.
Prerequisites	Basic knowledge on bachelor level of electrical circuits, sophomore level mathematics (calculus and elementary linear algebra).
Usability	The module is an elective module in the master's program "Nanoelectronic Systems".
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of written exam in the amount of 120 minutes.
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.
Frequency	The module will be offered every winter semester.
Workload	The total effort is 120 hours.
Duration	The module takes one semester.
Literature	Lenk, A., Ballas, R.G., Werthschützky, R., Pfeifer, G.: Electromechanical Systems in Microtechnology and Mechatronics - Electrical, Mechanical and Acoustic Networks, their Interactions and Applications, 1st Edition., 2011, ISBN: 978-3-642-10805-1

Module number	Module name	Lecturer in charge
NES-12 08 01-20.1	Future Computing Strategies in Nanoelectronic Systems	Prof. Dr. phil. nat. Ronald Tetzlaff
Objectives	After completion of the module, the students have advanced knowledge of future computer strategies which use the functionalities of state-of-the-art nanotechnologies.	
Contents	The content of the module focuses on state-of-the-art computing structures for data processing using innovative nanotechnologies which increase the efficiency of integrated circuits and therefore reach far beyond the age of Moore's law. The following computer architecutures, amongst others, are dealt with in the module: neuromorphic structures, Cross-Point Arrays, Crossbar Arrays, neural networks, and quantum computing.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.	
Prerequisites	Students should have knowledge of higher mathematics, system theory and circuit design on Bachelor level.	
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 90 minutes if the number of registered students exceeds 5. With up to 5 registered students the written exam can be replaced by an oral exam as individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-30 GLC-14.1	German Language and Culture	
Contents and objectives	Content of the module: German lessons with regional and cultural topics Objective: Knowledge about German everyday language (written and spoken) on A1-Level of the CEFR	
Modes of teaching and learning	The module consists of 4 hours per week language courses and self-study.	
Prerequisites		
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam with the amount of 90 minutes.	
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-11 20 20	Hardware Modelling and Simulation	Prof. Göhringer

Objectives	After successful completion of this module, the participants have qualifying knowledge in the areas of simulation, evaluation and verification of digital systems, such as field programmable gate arrays (FPGAs) and in the area of modeling digital systems using SystemC. Further, they have practical skills in programming digital systems using the hardware description language VHDL and experience from sample projects.
Contents	The module provides overview and special knowledge in the fields of simulation, evaluation and verification of digital systems. The practical course accompanying the lecture includes practical experience in programming digital systems using the hardware description language VHDL and the modelling language SystemC.
Modes of teaching and learning	The module includes 2 hours per week lectures and 2 hours per week exercises as well as self-study.
Prerequisites	Programming knowledge in C/C++ as well as basic knowledge and skills in technical computer science are required, in particular the participants should be familiar with the basics at Bachelor level.
Usability	The module is an elective module in the Nanoelectronic Systems Master's program.
Requirements for the award of credit points	The credit points are earned when the module examination has been passed. For up to 10 registered participants, the module examination consists of an oral examination performance as an individual examination lasting 20 minutes. If there are more than 10 participants, the examination consists of a written examination lasting 60 minutes. The type of concrete examination will be determined by the module supervisor at the end of the examination registration period and will be publicly announced in accordance with faculty practice.
Credit points and grades	6 credit points can be earned through the module. The module grade corresponds to the grade of the examination performance.
Frequency	The module is offered every winter semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 10 04-14.1	Hardware/Software Codesign Lab	Dr. Emil Matúš
Contents and objectives	Content of the module: Approaches to accelerate digital signal processing algorithms Outcomes: The students know the ASIP design methodology (Application Specific Instruction Processor). They can independently implement algorithms and are able to participate with their own contributions to discussions about the complexity, memory usage, layout of data in the memory architecture and possible improvements.	
Modes of teaching and learning	The module consists of 2 hours per week practical training and self-study.	
Prerequisites	Knowledge in Hardware/Software Codesign, as e.g. are taught in the module Hardware/Software Codesign, and basic knowledge in assembly language programming, Matlab and DSP architecture concepts on bachelor level.	
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a project report in the scope of 30 hours.	
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 12 07-14.1	Innovative Semiconductor Devices	Prof. Dr.-Ing. T. Mikolajick

Contents and objectives	Content of the module are: – Realisation of Semiconductor devcies – Semiconductor devices for special applications – Semiconductor devices in nm-dimensions The qualification goals are: After completing this module, students are able – to design innovative concepts for active nanoelectronic devices, – to understand physical effects and transport mechanisms, – to identify the specific types of components existing at the present technology and the research or development stage, as well as to realize the corresponding materials science and electrical boundary conditions. The students can communicate in English.
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hours per week tutorials and self-study. The language of instruction is at least partly English.
Prerequisites	Requirements are necessary , which can be obtained in the first part of module Semiconductor Technology and in the module Materials for Nanoelectronics and Vacuum Technology for example.
Usability	The module is an elective module for the master's program Nanoelectronic.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consist of a written exam in the amount of 90 minutes, if the number of registered students exceeds 20. With up to 20 registered students the witten exam will be replace by an oral exam as an individual exam worth 15 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.
Credit points and grades	4 credit points can be earned by the module. The module grade is the grade of the modul assesment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 120 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 08 04-14.1	Integrated Circuits for Broadband Optical Communications	Prof. Ellinger

Contents and objectives	The module content includes: - Design of integrated circuits in aggressively scaled nanotechnologies, focusing on the broadband optical communications - Transimpedance amplifier, detector circuits, laser drivers, multiplexers, frequency dividers, oscillators, phase locked loops, synthesizers and data recovery circuits - Challenges (eg, high bandwidth, gain, noise and good large signal performances despite of lower voltages) and appropriate solutions for circuits in nanotechnology Qualication goals: Students obtain competences regarding - methods for the design of very fast integrated circuits and systems for optical communications, - the analysis and optimisation of these circuits, and - complete design cycle of circuits for optical communications using the Cadance CAD system.
Modes of teaching and learning	The module consists of 3 hours per week lectures, 1 hour per week tutorials, 2 hours per week practical training and self-study.
Prerequisites	Basic knowledge in analog circuit design on bachelor level is required.
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes. The exam can be written either in German or Englisch.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the written exam.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 10 06-14.1	Integrated Photonic Devices for Communications and Signal Processing	Jun.-Prof. Jamshidi

Contents and objectives	After the completion of the module the students know theoretical background and technologies of various integrated photonic devices on silicon, with the emphasis on communications and signal processing. They can model, design, and simulate basic components including passive devices (waveguides, couplers, Gratings, Interferometers, resonators, filters) as well as high speed electro-optical modulators (Mach Zehnder and micro ring), electro-absorption modulators, high speed photo diodes, and lasers. They are able to analyze and synthesize these devices using different analytical and numerical methods. Students can communicate in English.
Modes of teaching and learning	The module consists of 4 hours per week lectures and 2 hours per week practical training and self-study. The language of instruction is English at least partly.
Prerequisites	Knowledge on bachelor Niveau of Electromagnetism and Semiconductors
Usability	The module is a required elective module of the branch of study Nanoelectronics in the Master's program of Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an assigned paper in scope of 30 hours and an oral exam as individual exam worth 30 minutes.
Credit points and grades	7 credit points can be earned by the module. The module grade is the unweighted mean of the grades for the assigned paper and the oral exam.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.
Accompanied Literature	G. T. Reed, Silicon Photonics: The State of the Art (Wiley, 2008). A. Yariv and P. Yeh, Photonics, 6th ed (Oxford, 2007).

Modulnummer	Modulname	Verantwortlicher Dozent
NES-12 10 08	Introduction to Optical Non-classical Computing: Concepts and Devices	Jun.-Prof. Jamshidi
Contents and objectives	After the completion of the module the students know various optical computing methods. They know the basic principles of artificial neural networks, quantum computation, and Ising machines. Also, students know both linear and nonlinear photonic devices which are needed for the realization of these methods. Students can communicate in English	
Modes of teaching and learning	The module consists of 4 hours per week lectures and 2 hours per week practical training and self-study. The language of instruction is English	
Prerequisites	Knowledge on Bachelor Niveau of Electromagnetism, System theory, and Semiconductors.	
Usability	The module is an elective module for the Master's program of Nanoelectronic Systems	
Requirement for the award of credit points	The credit points are awarded if the module examination is passed. The credit points are awarded when the module assessment is passed. The module assessment consists of an assigned paper in the scope of 30 hours and an oral exam as individual exam worth 30 minutes.	
Credit points and grades	7 credit points can be earned by the module. The module grade is the unweighted average of the grade of the assigned paper and the grade of the oral exam $M = (PL1 + PL2) / 2$.	
Frequency	The module will be offered every winter semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester	
Accompanied Literature	1. Quantum Computations and Quantum Information by M. Nielsen and I. L. Chuang 2. Adiabatic Quantum Computation and Quantum Annealing: Theory and Practice by C. C. McGeoch 3. Principles of Artificial Neural Networks by D. Graupe Other materials presented in the class	

Module number	Module name	Lecturer in charge
NES-10 01 01-14.1	Investing in a Sustainable Future	Prof. E. Günther

Contents and objectives	Contents of the module: - Basics and history of innovation and the implementation of innovation in organisations - Definition, assessment and concrete application within organizations of sustainable issues of organizational decisions - Different perspectives on entrepreneurial decisions Qualification objectives: Students taking this course achieve to include ecological and economical aspects of Corporate Social Responsibility in their decisions making and understand the basics of innovation management. Furthermore, they can work in interdisciplinary and intercultural teams, develop themselves solutions and present them in writing and which they present in written and oral form.
Modes of teaching and learning	The module consists of 1 hours per week lectures, 2 hours per week seminars and self-study.
Prerequisites	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 90 minutes.
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the written exam.
Frequency	The module is offered every summer semester.
Workload	The total effort is 120 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 12 01-14.1	Materials for Nanoelectronics and Vacuum Technology	Prof. Richter

Contents and objectives	The module contains: The materials fundamentals for nanoelectronics and the fundamentals for vacuum technology. Objectives: The students have the ability from the knowledge of - the structure, the properties, the manufacture and the structure forming materials, and - the effects and the basic types of small structures the opportunities and challenges of nanoelectronic materials systems to derive. Students can - derive relationships of vacuum technology from the knowledge of the kinetic gas theory - justify suitable pump and pressure measuring methods for various pressure ranges.
Modes of teaching and learning	The module consists of 4 hours per week lectures, 1 hour per week practical training and self-study.
Prerequisites	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of two written exams in the amount of 90 minutes for each and a collection of practical protocols, if the number of registered students exceeds 20. With up to 20 registered students, the written exams will be replaced by an oral exam as an individual exam worth 30 minutes. The nature of the specific exams are announced at the end of the registration period as usually known from the faculty.
Credit points and grades	6 credit points can be obtained by the module. The module grade is weighted mean of the grades from the written exams weighted by 40 % each and the grade of the collection of lab protocols weighted by 20 %.
Frequency	The module is offered every winter semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 06 01-14.1	Materials for the 3D System Integration	Prof. Dr.-Ing. Dr. h.c. K. Bock

Contents and objectives	The module consists of content 1. 3D system integration and 3D technologies - Introduction: 3D/2.5D concepts and Si interposer - Fabrication of the Through Silicon Vias (TSVs) - Cu-Plating for TSV, Redistribution Layer (RDL) and Bumping - Si Wafer Thinning - Si Wafer Bonding und Stacking 2. Micro-/Nanomaterials and reliability aspects - Scaling of the interconnects and new challenges - Materials for interconnects (phase diagrams, microstructure, mechanical/thermo-mechanical behavior, reliability) - Nanomaterials for the 3D system integration (nanocomposites, functional layers, nanoporous materials, etc.) - Reliability prognosis for new interconnect systems Qualification goals: The students know the technologies for the fabrication of miniaturized 3D and 2.5D components as well as Si interposer with TSVs. They can select the materials for the 3D packages with a respect of their impact on reliability. Students are familiar with new concepts in nanomaterials application for 3D packages. The students can communicate in English.
Modes of teaching and learning	The module consists of 4 hours per week lectures, 1 hour per week labs, one excursion and self-study. The language of instruction is English at least partly.
Prerequisites	There are competences required, that can be purchased for example at the modules *Semiconductor Technology (first semester) and Materials for Nanoelectronics and Vacuum Technology.* The basic knowledge in the area of Electronics Packaging Technology is welcome.
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of two written exams in the amount of 90 minutes for each and an ungraded lab course. The lab course must be passed.
Credit points and grades	7 credit points can be earned by the module. The module grade is the unweighted mean of the grades of the two written exams.
Frequency	The module is offered every academic year beginning in the summer semester.

Workload	The total effort is 210 hours.	29
Duration	The module takes two semesters.	

Module number	Module name	Lecturer in charge
NES-12 12 03-14.1	Memory Technology	Prof. Dr.-Ing. T. Mikolajick

Contents and objectives	This module covers memory concepts in the market and in research respectively development stage: - Magnatic memories - Optival memories - Semiconductor memories (SRAM, DRAM, nonvolatile Memories (EPROM, EEPROM, Flash)) - Innovative semiconductor memories (e.g. ferroelectric, magnetoresistive, resisitive, organic, and single molecule memories) Qualification goals: After completion of the module the students have the comeptences to optimize and develop new generetions of existing memory concepts. Based on the physical effects they will also be able to devolpe new memory concepts. Furthermore the students are able to evaluate areas of application for the memory concept and are aware of their limitation.
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hours per week seminars and self-study.
Prerequisites	Requirements are necessary , which can be obtained in the first part of module Semiconductor Technology and in the module Materials for Nanoelectronics and Vacuum Technology for example.
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems and a required elective module in the main study of the degree program Elektrotechnik.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consist of a written exam in the amount of 90 minutes, if the number of registered students exceeds 20. With up to 20 registered students the witten exam will be replace by an oral exam as an individual exam worth 15 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the module assessment.
Frequency	The module is offered every academic year beginning in the summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes two semester.

Module number	Module name	Lecturer in charge
NES-12 08 26	Modeling and Characterization of Nanoelectronic Devices	Prof. Dr.-Ing. habil. M. Schröter

Contents and objectives	The module comprises two courses: one focusing on practical modeling and measurement aspects typically encountered in an industrial environment, and the other one covers emerging nanoelectronic devices that have a high potential for revolutionizing future analog and high-frequency electronic applications. Both lectures are accompanied by exercises including a student lab. Major topics of this module are: • Overview on typical methods for the experimental characteriza-tion of advanced electronic devices, including small-signal, noise and dis-tortion measurements. • Present research trends and special device modeling related topics relevant for the semiconductor industry (incl. test structures, model parameter determination, statistical modeling, thermal effects). • Fundamentals of one-dimensional (1D) carrier transport in emerging devices (e.g. nano-tube/-wire field-effect transistors). • Multi-scale modeling of 1D nanoelectronic devices from carrier transport to compact models (i.e. circuit level) and application to ex-perimental characteristics. After completing this module, students are capable of • understanding the basic operation of selected advanced tran-sistors incl. their most important characteristics and models; • analyzing measurement results and applying advanced solution methodologies to practical problems.
Modes of teaching and learning	4 hours per week lectures, 1 hour per week tutorials, 1 hour per week practical training and self-study
Prerequisites	There are competencies required, which can be obtained in the mod-ules *Technologies and Electronic Devices* and *Physics of selected devices* for example.
Usability	The module is a required elective module in the field of study Microe-lectronics of the *Diplom* and master's program Electrical Engineering and a required elective module in the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 90 minutes and an assigned paper.
Credit points and grades	7 credit points can be earned by the module. The module grade is the weighted mean of the grade for the written exam (50 %) and the grade for the assigned paper (50 %).
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.

Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-13 14 02-14.1	Molecular Electronics	Prof. Cuniberti
Contents and objectives	The students know the basics of molecular electronics with emphasis on: experimental methods, physical effects and theoretical tools, such as single molecule electronics, raster probe and break-junction techniques, transport mechanisms at the nanoscale, molecular components (diodes, transistors, sensors) and molecular architectures. The students know the most important experimental and theoretical methods of investigation of charge transport at the molecular scale.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites		
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consits of a written exam in the amount of 90 minutes, if the number of registered students exceeds 10. With up to 10 registered students the written exam will be replaced by an oral exam as individual exam worth 20 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-13 14 03-14.1	Nanotechnology and Material Science	Prof. Cuniberti

Contents and objectives	After completing the module the students know the basic physics of nanotechnology and the production and properties of nanostructured materials, including - quantum effects, mesoscopic systems, scaling laws - fabrication of clusters and nanotubes - band structure, density of states, electron transport in low-dimensional solids - theoretical foundations of scanning tunneling microscopy, atomic force microscopy, and optical near-field microscopy - nanostructuring via electron beam lithography, optical lithography, and scanning probe methods - Giant magnetoresistance, single electronic devices
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hours per week tutorials, 2 hours per week practical training and self-study.
Prerequisites	The basics of physics, chemistry, and quantum mechanics
Usability	The module is a required elective module of the branch of study nanoelectronics in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 90 minutes, an oral exam as an individual exam worth 20 minutes and a graded lab course record, if the number of registered students exceeds 10. With up to 10 registered students the written exam is replaced by an oral exam as individual exam worth 20 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.
Credit points and grades	12 credit points can be obtained by the module. The module grade is the unweighted mean of the grades of the exams.
Frequency	The module is offered every summer semester.
Workload	The total effort is 360 hours.
Duration	The module takes one semester.

Modulnumber	Module Name	Lecturer in Charge
NES-12 08 06	Neuromorphic VLSI Systems	Prof. Dr.-Ing. habil. C. Mayr
Contents and objectives	Content of the module: - Methods for design and sizing of integrated analogue CMOS circuits - Neuromorphic VLSI systems: neurobiological fundamentals, common abstraction models, and application in science and technology, e.g. in brain machine interfaces and for signal processing - Fundamentals, concepts and methods of design and analysis of analouge and neuromorphic CMOS circuits using the design framework Cadence DF2 The module consists of lectures on fundamentals of neuromorphic systems and on CMOS circuit design, as well as accompanying computer exercises using the corresponding VLSI design tools. Objectives: After completing the module, students are literate in the field of neural networks from neurobiological principles up to applications. They are able to use industrial design tools (Cadence DF2, Spectre), to design and size CMOS circuits, to verify parameters and constraints by simulation and to design circuit layouts.	
Modes of teaching and learning	4 hours per week lectures, 2 hours per week exercises, and self-study	
Prerequisites		
Usability	The module is an elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	Credit points are awarded on passed module assessments. The module assessment consists of an assignment paper and a presentation.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the weighted mean of the grades from the assignment paper weighted by 2/3 and the grade of the presentation weighted by 1/3.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 12 05-14.1	Optoelectronics	Prof. Lakner

Contents and objectives	Contents: Nano-Optics: - Optical phenomena on the length scale much lower than the diffraction limit of the wavelength λ, e.g. interaction between fluorescent atoms and molecules, optical interaction between molecules and surfaces, but also surface-reinforcing effects. - Usage of nano-optics for novel devices and applications (analysis and characterization). Opto-Electronic Devices and Systems: The principles and technical realization of optoelectronic devices and systems (such as light emitting diodes, laser diodes, compound semiconductors, organic semiconductors, micro-opto-electro-mechanical systems for modulation and deflection of light) and applications of these devices in projection systems, displays, modulators and optical storage. Outcomes: The students know the most important optical phenomena on length scales far below the diffraction limit (etc. bright and non-brihht recombination processes, electric field enhancement at interfaces and surfaces) and understand their application in optical devices and their use in applications. They know how optoelectronic components and systems are implemented and how they are used in applications (e.g. projection systems, displays).
Modes of teaching and learning	The module consists of 4 hours per week lectures, 1 hour per week tutorials and self-study.
Prerequisites	Basic knowledge about technical optic on bachelor level
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral exam as individual exam worth 20 minutes and a written exam in the amount of 60 minutes, if the number of registered students exceeds 20. With up to 20 registered students the written exam is replaced by an oral exam as individual exam worth 20 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.
Credit points and grades	7 credit points can be obtained by the module. The module grade is unweighted mean of the grades of the examinations.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.

Duration	The module takes one semester.
Accompanied Literature	1. Bergmann, Schäfer, Niedrig (Hg): Lehrbuch der Experimentalphysik. Band III Optik. Walter de Gruyter Verlag Berlin, New York 2004 2. L. Novotny, B. Hecht: Principles of NanoOptics, Cambridge University Press (2006)

Module Number	Module Name	Lecturer in Charge
NES-02 04 01	Quantum Mechanics for Nanoelectronics	Prof. Dr. M. Helm

Contents and objectives	The module deals with basic quantum mechanics with applications to solid state physics and nanoelectronics. The foundations will be laid for a microscopic understanding of electronic materials and devices. The students know basic quantum mechanics and its application to periodic solids. They know the treatment of the hydrogen atom and time-dependent perturbation theory. In particular, they can apply the Schrödinger equation to one-dimensional problems independently. They know about semiconductor nanostructures (two, one, and zero-dimensional structures, i.e., quantum wells, wires, and dots), their fabrication and their energy levels, electron transport and optical absorption, their application to devices, as well as the effect of a magnetic field.
Modes of teaching and learning	The module consists of 5 hours per week lectures and 1 hour per week exercises.
Prerequisites	Knowledge of basic physics at bachelor level.
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded, when the module assessment has been passed. The module assessment consists of an individual, oral exam of 30 minutes duration.
Credit points and grades	7 credit points can be earned by the module. The module grade is the grade of the oral exam.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Please note: NES-11 06 05-14.1 is not currently offered.

Module number	Module name	Lecturer in charge
NES-11 06 05-14.1	Real-Time Systems	Prof. Härtig
Contents and objectives	Upon completion of the module, students are able to classify, model, and evaluate real-time systems and they can concern oneself in depth with real-time systems. The module covers the basics of load and resource description, time, clocks and clock synchronization, timed vs. event-driven design and scheduling techniques. The students have advanced knowledge to topics such as real-time programming languages (synchronous and event-driven), real-time operating systems, real-time hardware, microcontrollers, caches, real-time communication in field bus systems and wide area networks, and general applications of real-time systems. With this broad knowledge the students have the holistic fundamentals on this subject.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.	
Prerequisites	Basic knowledge on bachelor level in the areas of operating systems, computer architecture and software engineering	
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment is an oral exam as individual exam worth 30 minutes.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-11 06 03-14.1	Software Fault-Tolerance	Prof. Dr. Christof Fetzer
Contents and objectives	After the completion of this module, graduates of this module are able to develop and to use mechanisms and systems designs, that address on often than the average as software errors occurring system failures in distributed systems at run time. They have the necessary expertise on the subject of forgiveness and use their expertise to discuss and evaluate current scientific work in this area. The students to have the necessary practical skills with which they can analyze and correct errors in specific application scenarios. They are in a position to use the acquired skills of this module in new, unknown scenarios and apply them to develop effective practical solutions.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Participants should be familar with the basics of design, development and operation of computer-based systems. (bachelor level)	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consist of a written exam in the amont of 60 minutes, if the number of registered students exceeds 5. With up to 5 registered students the written exam is replace by an oral exam as individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty. A collection of exercises has to be solved as exam prerequisites.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 09 01-14.1	Stochastic Signals and Systems	Prof. Jorswieck
Contents and objectives	After completion of the module the students master the description methods of stochastic signals as realizations of stochastic processes. They are in a position to calculate the behavior of deterministic and stochastic systems under the condition that the systems handle stochastic processes.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours of tutorials per week, and self-study.	
Prerequisites	Basics of the theory of deterministic systems and basic knowledge of probability calculus on bachelor level	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment is a written exam in the amount of 90 minutes.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-11 06 06-14.1	Distributed Systems Engineering	Prof. Fetzer
Contents and objectives	After completing this module, students are familar with the basics of design, development and operation of computer-based systems. They have an overview of structures of such systems, which usually consist of several hardware components and several layers of software. The students have the necessary knowledge, especially to non-functional aspects of systems, such as reliability and availability, and control mechanisms for providing these non-functional aspects. The students should be able to understand fundamental relationships of the subject and they can use this knowledge during their further studies.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Basic knowledge in the areas of system architecture, modularization and structuring of complex systems (on bachelor level).	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consist of a written exam in the amont of 60 minutes, if the number of registered students exceeds 5. With up to 5 registered students the written exam is replace by an oral exam as individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty. A collection of exercises has to be solved as exam prerequisites.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 150 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-11 06 07-14.1	Ubiquitous Systems	Prof. Dr. rer. nat. habil. Alexander Schill

Contents and objectives	After completion of the module, the students will be able to analyse the requirements needed by distributed applications and also in the context of mobile networks. They can evaluate existing solutions and put them into practice based on a reasonable conceptional foundation. The module provides knowledge of the problems, concepts and possible solutions regarding the development of distributed systems. The focus will be on essential fundamental principles and basic techniques as well as latest standards. Furthermore, the students will learn the basics of mobile communication and its application in the field of mobile computing. Besides transmission basics of wireless networks, typical standards and network concepts, the module also deals with software architectures for mobile computing and distributed systems in the field of application support. In addition, the module gives an outlook on future high performance mobile networks and its applications.
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hours per week tutorials and self-study.
Prerequisites	Students should have basic knowledge of the areas of computer networks and operating systems on Bachelor level.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amont of 120 minutes.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the examination.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.
Accompanied Literature	Tanenbaum, A.S.: Computer Networks.

Modul Number	Modul Name	Lecturer in Charge
NES-12 08 07	VLSI Processor Design	Prof. Mayr

Contents and objectives	Content of the module: • Basics, concepts and methods for designing complex digital VLSI-systems • Architectures for highly integrated digital processing systems, with emphasis on user-specific signal processing systems • Methods for the efficient transfer of architectural concepts in the highly integrated implementation of a digital system. • Specification and abstract modelling of the system, conversion into a Register-Transfer-Level (RTL) description, automated circuit synthesis and physical implementation (place & route, layout synthesis), which results in the data needed for manufacture of the chip. • Verification of the design on all levels of abstraction (behaviour, implementation) via simulation (functional verification) • Proof of the equivalence of transformation steps via formal verification, i.e. by checking compliance with design rules (signoff-verification) • Training in working together as a design team (division of tasks, definition of interfaces, schedule planning and time management) Objectives: After completion of this module, the students will be able to carry out a complete implementation and verification of a VLSI-System (e. g. a processor with a complexity comparable to an 8051) using industrial design software (Synopsys, Cadence).
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours tutorial, 2 hours lab work and self-study.
Prerequisites	
Usability	The module is an elective module in the master's program, Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a project report with a scope of 30 hours and a presentation of 20 minutes duration.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the weighted mean of the grades of the project weighted by 2/3 and the grade of the presentation weighted by 1/3.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-11 06 04-14.1	Wireless Sensor Networks	Dr.-Ing. habil. Dargie

Contents and objectives	After completion of the module, the students have a qualified understanding of wireless sensors, the networks designed with them, their architecture, the protocols and the common applications. They are able to evaluate existing networks and to design new ones. The content of the module focuses on self-management algorithms, media access methods, routing algorithms, localization technologies and data management tools for wireless sensor networks.
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week seminars and self-study.
Prerequisites	Students should have basic knowledge of computer architecture, distributed systems, mobile communication, and software engineering on Bachelor level.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 60 minutes.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.
Frequency	The module is offered every summer semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Appendix 2 Curriculum Plans

A-2.1. Curriculum plan for full-time students in the branch of study Nanoelectronics

with type and number of SWS (= class hours per week per semester) and the necessary assessments, the type, hours and organisation of which are described in the module descriptions

A-2.1.1 Overview of required modules

module no.	module name	1st semester V/Ü/Se/Sp/P	2nd semester V/Ü/Se/Sp/P	3rd semester V/Ü/Se/Sp/P	4th semester V/Ü/Se/Sp/P	CP
NES-11 06 01-19.1	Lab Sessions	0/0/0/0/2 PVL PL	0/0/0/0/1 PL			5
NES-11 06 02-14.1	Principles of Dependable Systems	2/2/0/0/0 PVL PL				6
NES-12 10 01-14.1	Fundamentals of Estimation and Detection	2/2/0/0/0 PL				6
NES-12 12 02-19.1	Semiconductor Technology	4/0/0/0/0	2/0/0/0/0 PL			9
NES-12 08 02-14.1	Radio Frequency Integrated Circuits		3/1/0/0/2 PL			7
NES-12 10 03-14.1	Hardware/Software Codesign		2/1/0/0/0 PL			4
NES-12 ASW-14.1	Academic and Scientific Work			*/*/*/*/* *		4
NES-12 PW-14.1	Project Work			project PL		10
	required elective modules, see following pages	6 CP	17 CP	16 CP		39
					master thesis	29
					defence	1
		30	**30**	**30**	**30**	**120**

V   lecture
Ü   tutorial
Se   seminar
Sp   language course
P   lab course

PL   assessment(s)
PVL   pre-exam achievement(s)
CP   credit points
*   in acc. with student's choice

A-2.1.2 Required elective modules

module no.	module name	1st semester V/Ü/Se/Sp/P	2nd semester V/Ü/Se/Sp/P	3rd semester V/Ü/Se/Sp/P	CP
NES-30 GLC-14.1	German Language and Culture	0/0/0/4/0 PL			4
NES-12 12 01-14.1	Materials for Nanoelectronics and Vacuum Technology	4/0/0/0/1 3xPL			6
NES-11 06 06-14.1	Distributed Systems Engineering	2/2/0/0/0 PVL PL			5
NES-12 09 01-14.1	Stochastic Signals and Systems	2/2/0/0/0 PL			6
NES-12 10 05-20.1	Antennas and Radar Systems		4/2/0/0/0 PL		7
NES-12 10 02-14.1	Communications		2/1/0/0/0 PL		3
NES-11 20 19	Design and Programming of Embedded Multicore Architectures		2/2/0/0/0 PL		6
NES-12 10 06-14.1	Integrated Photonic Devices for Communications and Signal Processing		4/0/0/0/2 2xPL		7
NES-10 01 01-14.1	Investing in a Sustainable Future		1/0/2/0/0 PL		4
NES-13 14 03-14.1	Nanotechnology and Materials Science		4/2/0/0/2 3xPL		12
NES-12 08 06	Neuromorphic VLSI Systems		4/2/0/0/0 2xPL		7
NES-11 06 03-14.1	Software-Fault Tolerance		2/2/0/0/0 PVL PL		6
NES-12 08 07	VLSI Processor Design		2/2/0/0/2 2xPL		7
NES-11 06 04-14.1	Wireless Sensor Networks		2/0/2/0/0 2xPL		6
NES-12 06 01-14.1	Materials for the 3D System Integration		2/0/0/0/0 PL	2/0/0/0/1 2x PL	7
NES-12 12 03-14.1	Memory Technology		2/0/1/0/0	2/0/1/0/0 PL	7
NES-12 08 26	Modeling and Characterization of Nanoelectronic Devices		4/1/0/0/1 2xPL		7

module no.	module name	1st semester	2nd semester	3rd semester	CP
		V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	
NES-12 10 20	Communication Networks 3			4/2/0/0/0 PL	7
NES-12 12 04-14.1	Electromechanical Networks			2/1/0/0/0 PL	4
NES-12 08 01-20.1	Future Computing Strategies in Nanoelectronic Systems			2/1/0/0/0 PL	4
NES-11 20 20	Hardware Modelling and Simulation			2/2/0/0/0 PL	6
NES-12 10 04-14.1	Hardware/Software Codesign Lab			0/0/0/0/2 PL	4
NES-12 12 07-14.1	Innovative Semiconductor Devices			2/1/0/0/0 PL	4
NES-12 08 04-14.1	Integrated Circuits for Broadband Optical Commu-nications			3/1/0/0/2 PL	7
NES-12 10 08	Introduction to Optical Non-classical Computing: Concepts and Devices			4/2/0/0/0 2xPL	7
NES-13 14 02-14.1	Molecular Electronics			2/2/0/0/0 PL	6
NES-12 12 05-14.1	Optoelectronics			4/1/0/0/0 2xPL	7
NES-02 04 01	Quantum Mechanics for Nanoelectronics			5/1/0/0/0 PL	7
NES-11 06 05-14.1	Real-Time Systems			2/1/0/0/0 PL	6
NES-11 06 07-14.1	Ubiquitous Systems			4/2/0//00 PL	7

A-2.2 Curriculum plan for full-time students in the branch of study Nanoscience and Nanotechnology

with type and number of SWS (= class hours per week per semester) and the necessary assessments, the type, hours and organisation of which are described in the module descriptions

A-2.2.1 Overview of required modules

module no.	module name	1st semester	2nd semester	3rd semester	4th semester	CP
		V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	
		°	°	°	°	60
NES-12 ASW-14.1	Academic and Scientific Work			*/*/*/*/* *		4
NES-12 PW-14.1	Project Work			project PL		10
	required elective modules, see following pages			16 CP		16
					master thesis	29
					defence	1
		30	**30**	**30**	**30**	**120**

V   lecture
Ü   tutorial
Se   seminar
Sp   language course
P   lab course
PL   assessment(s)
PVL   pre-exam achievement(s)
CP   credit points
°   Academic achievements and assessments of the degree program Nanoscience and Nanotechnology
        at KU Leuven (Belgium) according to a cooperation agreement
*   according to choice of student

A-2.2.2 Required elective modules

Modul-Nr.	Modulname	1. Semester V/Ü/Se/Sp/P	2. Semester V/Ü/Se/Sp/P	3. Semester V/Ü/Se/Sp/P	LP
NES-11 06 06-14.1	Distributed Systems Engineering	2/2/0/0/0 PVL PL			5
NES-12 12 04-14.1	Electromechanical Networks			2/1/0/0/0 PL	4
NES-12 08 01-20.1	Future Computing Strategies in Nanoelectronic Systems			2/1/0/0/0 PL	4
NES-30 GLC-14.1	German Language and Culture			0/0/0/4/0 PL	4
NES-12 10 04-14.1	Hardware/Software Codesign Lab			0/0/0/0/2 PL	4
NES-12 12 07-14.1	Innovative Semiconductor Devices			2/1/0/0/0 PL	4
NES-12 08 04-14.1	Integrated Circuits for Broadband Optical Communications			3/1/0/0/2 PL	7
NES-12 10 08	Introduction to Optical Non-classical Computing: Concepts and Devices			4/2/0/0/0 2xPL	7
NES-12 12 01-14.1	Materials for Nanoelectronics and Vacuum Technology	4/0/0/0/1 3xPL			6
NES-13 14 02-14.1	Molecular Electronics			2/2/0/0/0 PL	6
NES-12 12 05-14.1	Optoelectronics			4/1/0/0/0 2xPL	7
NES-02 04 01	Quantum Mechanics for Nanoelectronics			5/1/0/0/0 PL	7
NES-11 06 05-14.1	Real-Time Systems			2/1/0/0/0 PL	6
NES-11 06 07-14.1	Ubiquitous Systems			4/2/0/0/0 PL	7