**TECHNISCHE
UNIVERSITÄT
DRESDEN**

Faculty Electrical and Computer Engineering

Current Study Guide for the consecutive Master's program Nanoelectronic Systems Winter Term 2017

Content

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

Appendix 1
Module Descriptions

Required modules

Module number	Module name	Lecturer in charge
NES-12 ASW-14.1	Academic and Scientific Work	Studiendekan

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	Prof. Fettweis
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 01-14.1	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 1 hours per week lectures, 5 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 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 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	Studiendekan

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	The credit points are awarded when the module assessment is passed. The module assessment is a written exam in the

points	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 02-14.1	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 minia-turization 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, 1 hour 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 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	10 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.

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Duration	The module takes two semester.

Required elective modules

Modulnummer	Modulname	Verantwortlicher Dozent
NES-12 10 20	Communication Networks 3	Prof. Dr.-Ing. F. Fitzek

Inhalte und Qualifi-kationsziele	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.
Lehr- und Lernformen	4 hours per week lectures, 2 hours per week tutorials and self-study.
Voraussetzungen für die Teilnahme	
Verwendbarkeit	The module is a required elective module in the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.
Voraussetzungen für die Vergabe von Leistungspunkten	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.
Leistungspunkte und Noten	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.
Häufigkeit des Moduls	The module is offered every winter semester.
Arbeitsaufwand	The total effort is 210 hours.
Dauer des Moduls	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 10 02-14.1	Communications	Prof. 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 credit points are awarded when the module assessment is

the award of credit points	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-12 10 07-14.1	Computational Photonics	Jun.-Prof. Jamshidi

Contents and objectives	After the completion of the module the students know how to simulate various photonic structures including complex waveguides, resonators, photnic crystals. They know the basic principles of various techniques, focusing on Beam Propagatin Method (BPM), Finite Difference Time Domain (FDTD), Finite Element Method (FEM), and Eigen mode calculation methods. They know the practical scope and constraints of these algorithms. 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 and Semiconductors
Usability	The module is an required elective module for 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 average of the grade of the assigned paper and 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
Accompanied Literature	S. Obayya, Computational Photonics (Wiley, 2010). A. Bondeson, T. Rylander, and P. Ingelström, Computational

	Electromagnetics (Springer, 2005).
	J. D. Joannopoulos, S. G. Johnson, J. N. Winn, R. D. Meade, Photonic Crystals: Molding the Flow of Light (Princeton University Press,2008).

Module number	Module name	Lecturer in charge
NES-11 02 03-14.1	Computer Arithmetic	Prof. Spallek

Contents and objectives	Contents / Topics - design of binary adder circuits (rippling, block parallel, hierarchical) - carry-save and signed-digit number representations - multi-operand addition, generalized counters - multiplication - division by digit recurrence and by numerical approximation - square rooting - CORDIC algorithms - general function evaluation Qualifications / Competences - ability to describe the implementation of arithmetic operations and their associated complexities in space and time - ability to construct custom arithmetic circuits according to set design goals
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 consists of an oral exam worth 45 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.

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 Acquiring 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.
Work Load	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-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-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 Nanoelec-tronic 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 Acquiring 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.
Work Load	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

Please note: NES-10 01 01-14.1 is not offered in summer term 2017

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 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 Packag-

	ing 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.
Duration	The module takes two semesters.

Module number	Module name	Lecturer in charge
NES-12 12 03-14.2	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 25 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 characteri-za-tion of advanced electronic devices, including small-signal, noise and distortion measurements. • Present research trends and special device modeling related topics relevant for the semiconductor industry (incl. test structures, model parameter determination, statistical model-ing, thermal effects). • Fundamentals of one-dimensional (1D) carrier transport in emerging devices (e.g. nano-tube/-wire field-effect transis-tors). • Multi-scale modeling of 1D nanoelectronic devices from car-rier transport to compact models (i.e. circuit level) and appli-cation to experimental 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 solu-tion 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 modules *Technologies and Electronic Devices* and *Physics of selected devices* for example.

Usability	The module is a required elective module in the field of study Microelectronics 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 academic year beginning in the summer semester.
Workload	210 hours
Duration	2 semesters

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	12 credit points can be obtained by the module. The module

grades	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
ET-12 08 06	Neuromorphic VLSI Systems	Prof. Dr.-Ing. habil. C. Mayr
Content 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.	
Methods 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 Acquiring 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 assign-	

	ment paper weighted by 2/3 and the grade of the presentation weighted by 1/3.
Frequency	The module is offered every summer semester.
Work Load	The total effort is 210 hours.
Duration	1 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 two oral exams as individual exams worth 20 minutes for each.
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 06 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._x000D_ 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 Acqiuring 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 will be offered every winter semester.	

Work Load	210 hours
Duration	1 Semester

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-12 12 06-14.1	Semiconductor Industry Challenges: Market Dynamics - Technology Innovations - Yield and Reliability Engineering	Prof. Dr. Ehrenfried Zschech
Contents and objectives	After completion of this module, students understand key aspects of the semiconductor industry, both in terms of the market under the changing conditions for development and production as well as the context of the technological development. Besides the ability to operate manufacturing cost efficient, in the module is focused mainly due to the applied physical and engineering process in micro- and nanoelectronics and their theoretical foundations for increasing the yield in mass production and to ensure the required reliability of the products. The students understand the importance of business concepts in introducing of new products. They can show the relationships between components design, technology, materials and analysis for products and can assess the importance of the reliability of components for the quality management of products and line stability of micro-and nanoelectronics. Students are able to communicate in technical English.
Modes of teaching and learning	The module consists of 3 hours per week lectures, one excursion within the scope of one week (blocked in the lecture-free period) and self-study. The language of instruction is English at least partially.
Prerequisites	Knowledge in electrical engineering, materials science and physics for engineers and scientists at the bachelor level. The competences are assumed, which can be acquired in the module Semiconductor Technology.
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 examinations. Examination 1 is an assigned paper. Examination 2 is by more than 20 registered students a written exam in the amount of 90 minutes. With up to 20 registered students the written exam is replaceed by an oral exam as group exam worth 45 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	4 credit points can be earned by the module. The module grade is wighted mean of the grades of the examinations, where examination 1 is weighted with 1/3 and examination 2 is weighted with 2/3.
Frequency	The module is offered every academic year beginning in the summer semester.
Workload	The total effort is 120 hours.
Duration	The module takes two semester.

Module number	Module name	Lecturer in charge
NES-11 06 03-14.1	Software Fault-Tolerance	Prof. 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 10. With up to 10 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	6 credit points can be obtained by the module. The module

grades	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	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 10. With up to 10 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-12 08 05-14.1	Theory of Nonlinear Networks	Prof. Tetzlaff
Contents and objectives	After completing this module, students know and apply the basic properties of nonlinear networks and can use important mathematical tools for analysis of networks. Furthermore, the students have knowledge of the structure, properties and applications of Cellular Nonlinear Networks, as well as of memristive networks. They are able to transfer this knowledge also to other nonlinear network structures.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.	
Prerequisites	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 consist 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 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 06 07-14.1	Ubiquitous Information Systems	Prof. Schill
Contents and objectives	After completing this module, students will be able to classify middleware architectures and platforms for the construction of distributed applications and information systems. This includes the area of mobile communication and mobile processing and the processing in distributed environments. Students can classify and develop concepts and architectures for distributed and ubiquitous application and information systems, select appropriate solutions and evaluate modern technological developments in the art.	
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hour per week tutorials and self-study.	
Prerequisites	Basic knowledge in the areas of computer networks and operating systems.	
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 consist of a written exam in the amont of 120 minutes, if the number of registered students exceeds 10. With up to 10 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.	
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 winter semester.	
Workload	The total effort is 270 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 Acquiring 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.
Credit Points and Grades	7 credit points can be obtained by the module. The module grade is the grade of the project.
Frequency	The module is offered every summer semester.
Work Load	The total effort is 210 hours.
Duration	1 Semester

Module number	Module name	Lecturer in charge
NES-11 06 04-14.1	Wireless Sensor Networks	Prof. Schill

Contents and objectives	After completion of this module, students are familiar with the fields of ubiquitous computing and wireless sensor and can discuss competent topics such as applications for wireless sensor networks and thier main components. They are aware of the typical aspects of such sensor networks such as energy comsumption, communication, network-level processing and self organisation. They are able to understand and design algorithms for link layer management and media access control in wireless sensor networks. Because a wireless sensor network is a distributed network, the students also master aspects like time synchronization, topology control, and data aggregation. They are familiar with the routing techniques and the request distribution. They can consider und discuss the issues and problems in the field of wireless sensor networks comprehensively.
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week seminars and self-study.
Prerequisites	Basic knowledge of computer architecture, distributed systems, mobile communication, and software engineering 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. This consists of an individual presentation and of a written axam in the amount of 90 minutes, if the number of registered students exceeds 20. With up to 10 registered students the witten exam will 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	6 credit points can be obtained by the module. The module grade is the unweighted mean of the grades of the examinations.
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 Nanoelectronic

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 Summary with 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 01-14.1	Lab Sessions	0/0/0/0/2 PVL PL	1/0/0/0/3 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 02-14.1	Semiconductor Technology	4/0/0/0/0	2/0/0/0/1 PL			10
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	16 CP	16 CP		38
					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	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 02-14.1	Communications		2/1/0/0/0 PL		3
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 Not offered in SS 2017		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 PL		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 03-14.2	Memory Technology		2/0/1/0/0	2/0/1/0/0 PL	7
ET-12 08 26	Modeling and Characterization of Nanoelec-		2/0/0/0/1 PL	2/1/0/0/0 PL	7

			1/0/0/0/0 PL	2/0/0/0/0 PL	
	tronic Devices				
NES-12 12 06-14.1	Semiconductor Industry Challenges: Market Dynamics - Technology Innovations - Yield and Reliability Engineering		1/0/0/0/0 PL	2/0/0/0/0 PL	4

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-11 02 03-14.1	Computer Arithmetic No longer offered			2/2/0/0/0 PL	6
NES-12 12 04-14.1	Electromechanical Networks			2/1/0/0/0 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-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-12 08 05-14.1	Theory of Nonlinear Networks			2/1/0/0/0 PL	4
NES-11 06 07-14.1	Ubiquitous Information Systems			4/2/0//00 PL	9

A-2.2 Curriculum plan for part-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 Summary with 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	Academic and Scientific Work			*/*/*/*/* *		4
NES-12 PW	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 02 03-14.1	Computer Arithmetic			2/2/0/0/0 PL	6
NES-12 12 04-14.1	Electromechanical Networks			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 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-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-11 06 05-14.1	Real-Time Systems			2/1/0/0/0 PL	6
NES-12 08 05-14.1	Theory of Nonlinear Networks			2/1/0/0/0 PL	4
NES-11 06 07-14.1	Ubiquitous Information Systems			4/2/0/0/0 PL	9