

Master Micro and Nano Systems

Descriptions of the modules in English

Please note:

This paper is a service of the Faculty of Electrical Engineering and Information Technology for additional information of interested English speaking students only. It is not binding.

Binding are the German original documents (Amtliche Bekanntmachungen) only.

**Attachment 2:
Description of the modules to the course “Micro and Nano Systems”
with the certificate “Master of Science”**

Compulsory Module

Module number	MNS 1.1						
Module	Microsystems design						
Responsible of module	Chair of Microsystems and Precision Engineering						
Contents and objectives	<p><u>Inhalte/Contents:</u></p> <ul style="list-style-type: none"> • Methods and tools for design of MEMS • Modelling of heterogeneous systems with lumped parameters • Behavioural analysis of physical domains based on FEM • Macro modelling of complex systems (order reduction) • Link of component and system models <p>Focus is put on a consistent behavioural description of coupled physical domains at different levels of abstraction. Practical training will be based on ANSYS/Multiphysics, Matlab/Simulink and languages as VHDL-A and Verilog-A.</p> <p><u>Qualifikationsziele/Objectives:</u> Goal of the course is providing of knowledge and capabilities in analytical and numerical modelling and simulation as well designing of complex heterogeneous Microsystems.</p>						
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">-L: Microsystems design</td> <td style="width: 20%; text-align: right;">2 LVS</td> </tr> <tr> <td>-T: Microsystems design</td> <td style="text-align: right;">1 LVS</td> </tr> <tr> <td>-PC: Microsystems design</td> <td style="text-align: right;">2 LVS</td> </tr> </table> <p>Classes are taught in English</p>	-L: Microsystems design	2 LVS	-T: Microsystems design	1 LVS	-PC: Microsystems design	2 LVS
-L: Microsystems design	2 LVS						
-T: Microsystems design	1 LVS						
-PC: Microsystems design	2 LVS						
Prerequisites for participation	---						
Usability of the module	---						
Prerequisites for awarding credit points	<p>Successfully passed the exam. Acceptance restrictions for the exam: - Successfully passed PC</p>						
Module examination	Final written exam, 120 minutes, language English						
Credit points and marks	<p>6 credits The evaluation of the exam follows the examination regulations (§10).</p>						
Frequency	The module is offered once a year.						
Work load	180 hours						
Duration of the module	One semester.						

**Attachment 2:
Description of the modules to the course “Micro and Nano Systems”
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Compulsory Module

Module number	MNS 1.2
Module	Systems Design
Responsible of Module	Professur Schaltkreis- und Systementwurf
Contents and Objectives	<p><u>Contents:</u> Introduction</p> <ul style="list-style-type: none"> • Technology development <p>Design process</p> <ul style="list-style-type: none"> • Design flow • Design levels • Y Diagram • Design strategies <p>VHDL</p> <ul style="list-style-type: none"> • Origin and development • Example: Half-adder – different approaches • Model • Simulation <p>VHDL language constructs</p> <ul style="list-style-type: none"> • Signals, constants, data types, statements, process, structural and functional description <p>Hardware description languages</p> <ul style="list-style-type: none"> • Simulation of VHDL models • VHDL vs. Verilog <p>Modern design approaches</p> <ul style="list-style-type: none"> • VHDL+ • Interface based design <p><u>Objectives:</u> To understand necessity and principles of modern hierarchical design methods using hardware description languages.</p>
Forms of teaching	<p>Lectures, tutorials and practical courses</p> <ul style="list-style-type: none"> - L: Systems design (3 LVS) - T: Systems design (0 LVS) - PC: Systems design (2 LVS) <p>Classes are taught in English.</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credits	Successfully passed the exam.
Exams	Final written exam, (90 min.), language English.
Credits	6 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	180 hours
Duration of module	1 semester

**Attachment 2:
Description of the modules to the course “Micro and Nano Systems”
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Compulsory Module

Module number	MNS 1.3
Module	Semiconductor physics/Nano structures
Responsible of module	Professur Halbleiterphysik
Contents and objectives	<p><u>Inhalte/Contents:</u> Semiconductor physics/Nano structures:</p> <ul style="list-style-type: none"> • A survey of semiconductors • Crystal structure, definitions and notations. • Electronic band structures, calculations by pseudopotential methods. • Vibrational properties of semiconductors, and electron-phonon interaction • Electronic properties of defects, classification of defects, effective mass approximation, doping. • Electrical transport phenomena, carrier mobilities, temperature dependence, carriers scattering, relaxation time. • Optical Properties, dielectric function, excitons, phonon-polaritons and lattice absorption, absorption by free carriers and carriers bound to shallow donors and acceptors. • Surface effects, surface states and reconstructions. • Effect of quantum confinement on electrons and phonons in semiconductors. • Quantum wells, wires and dots, superlattices, applications. • Magnetic nanostructures, spintronics. <p><u>Qualifikationsziele/Objectives:</u> Understanding of basic concepts and methods of semiconductor physics and effects of confinement in nanostructures.</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <p>-L: Semiconductor physics/Nano structures (3 LVS) -T: Semiconductor physics/Nano structures (1 LVS) -PC: Semiconductor physics/Nano structures (0 LVS)</p> <p>Classes are taught in English</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Final written exam, 90 minutes, language English
Credit points and marks	5 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	150 hours
Duration of the module	One semester

**Attachment 2:
Description of the modules to the course “Micro- and Nano Systems”
with the certificate “Master of Science”**

Compulsory Module

Module number	MNS 1.4						
Module	Micro- and Nanodevices						
Responsible of module	Professur Elektronische Bauelemente der Mikro- und Nanotechnik						
Contents and objectives	<p><u>Inhalte/Contents:</u></p> <ul style="list-style-type: none"> • MOS-transistors with dimensions in the sub-100 nm-region • New MOS-transistor concepts (multi-gate-transistors, FinFETs, etc.) • Single-electron-transistors • Quantum mechanical devices (resonant-tunneling diodes RTDs etc.) • Bipolar transistors with dimensions in the sub-1 μm-region • Carbon-nanotubes <p><u>Qualifikationsziele/Objectives:</u> Knowledge of the parasitic effects of MOS- and bipolar devices with very small dimensions. Knowledge about fundamentally new devices which depend on effects depending very small dimensions.</p>						
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">-L: Micro- and Nanodevices</td> <td style="text-align: right;">(2 LVS)</td> </tr> <tr> <td>-T: Micro- and Nanodevices</td> <td style="text-align: right;">(1 LVS)</td> </tr> <tr> <td>-PC: Micro- and Nanodevices</td> <td style="text-align: right;">(2 LVS)</td> </tr> </table> <p>Classes are taught in English.</p>	-L: Micro- and Nanodevices	(2 LVS)	-T: Micro- and Nanodevices	(1 LVS)	-PC: Micro- and Nanodevices	(2 LVS)
-L: Micro- and Nanodevices	(2 LVS)						
-T: Micro- and Nanodevices	(1 LVS)						
-PC: Micro- and Nanodevices	(2 LVS)						
Prerequisites for participation	---						
Usability of the module	---						
Prerequisites for awarding credit points	<p>Successfully passed the exam. Approval condition of the final written exam: Practical course completed successfully.</p>						
Module examination	Final written exam, 180 minutes, language English.						
Credit points and marks	<p>6 credits The evaluation of the exam follows the examination regulations (§10).</p>						
Frequency	The module is offered once a year.						
Work load	180 hours						
Duration of the module	One semester						

**Attachment 2:
Description of the modules to the course “Micro and Nano Systems”
with the certificate “Master of Science”**

Compulsory Module

Module number	MNS 1.5						
Module	Smart Sensor Systems						
Responsible of module	Professur Mess- und Sensortechnik						
Contents and objectives	<p><u>Inhalte/Contents:</u></p> <ul style="list-style-type: none"> • Introduction into Smart Sensor systems • Sensor Technologies • Sensor Properties • Selected Principles • Design of Sensor Systems • Data Acquisition and Analog Interfaces • Advanced Methods of Analog Digital Converters • Sensor Signal Processing • Selected Sensor Applications <p><u>Qualifikationsziele/Objectives:</u> The obtained knowledge should enable the students to be able to develop sensor systems for a given measurement task and to develop necessary components for sensor systems including sensor interfaces.</p>						
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">-L: Smart Sensor Systems</td> <td style="text-align: right;">(2 LVS)</td> </tr> <tr> <td>-T: Smart Sensor Systems</td> <td style="text-align: right;">(1 LVS)</td> </tr> <tr> <td>-PC: Smart Sensor Systems</td> <td style="text-align: right;">(2 LVS)</td> </tr> </table> <p>Classes are taught in English.</p>	-L: Smart Sensor Systems	(2 LVS)	-T: Smart Sensor Systems	(1 LVS)	-PC: Smart Sensor Systems	(2 LVS)
-L: Smart Sensor Systems	(2 LVS)						
-T: Smart Sensor Systems	(1 LVS)						
-PC: Smart Sensor Systems	(2 LVS)						
Prerequisites for participation	none						
Usability of the module	---						
Prerequisites for awarding credit points	Successfully passed the exam.						
Module examination	Final written exam, 120 minutes, language English						
Credit points and marks	6 credits The evaluation of the exam follows the examination regulations (§10).						
Frequency	The module is offered once a year.						
Work load	180 hours						
Duration of the module	One semester						

**Attachment 2:
Description of the modules to the course “Micro and Nano Systems”
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Compulsory Module

Module number	MNS 1.6
Module	Reliability of Micro- and Nanosystems
Responsible of module	Professur Werkstoffe und Zuverlässigkeit
Contents and objectives	<p><u>Inhalte/Contents:</u></p> <ul style="list-style-type: none"> • Basics of Reliability Estimation • Reliability Concepts for Micro- and Nanosystems... • Fracture Mechanics and Crack Concepts • Calculation and Reliability Evaluation of MEMS... • Experimental Reliability Investigations • Applications <p><u>Qualifikationsziele/Objectives:</u> Active Knowledge in Basics of Reliability Estimation Active Knowledge of state of the art of Calculations and Experimental Techniques in Reliability of Micro- and Nanosystems</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <p>-L: Reliability of Micro- and Nanosystems (3 LVS) -T: Reliability of Micro- and Nanosystems (1 LVS)</p> <p>Classes are taught in English</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Final written exam, 60 minutes, language English
Credit points and marks	5 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	15 hours
Duration of the module	One Semester

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Compulsory Module

Module number	MNS 1.7
Module	Technologies for Micro and Nano Systems
Responsible of module	Professur Mikrotechnologie
Contents and objectives	<p><u>Contents:</u></p> <ul style="list-style-type: none"> • Process steps for Si MEMS/NEMS (doping, layer deposition, lithography, 3D patterning, thinning, wafer bonding) • Process steps for non-Si NEMS/MEMS (layer deposition, molding, embossing, mounting) • Si-based technologies (bulk, surface, high aspect ratio, thin film encapsulation) • Technologies based on alternative materials (LIGA, polymer based process flows) • Packaging and 3D integration technologies • Measurement techniques for MEMS/NEMS • Examples of Si MEMS (spectrometers, inertial sensors, RF MEMS, actuators) • Examples of non-Si MEMS (large area tactile arrays, fluidic systems, lab on chip) • Examples of nanocomponents and NEMS (nanoresonators, surface Plasmon resonance, sub-wavelength gratings) • Examples of smart systems • Trends and roadmaps.... <p><u>Objectives:</u> Understanding of technology steps and technology process flows for MEMS and NEMS components and systems, technologies for advanced MEMS and NEMS, technologies for system integration</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <p>-L: Technologies for Micro and Nano Systems (2 LVS) -T: Technologies for Micro and Nano Systems (2 LVS)</p> <p>Classes are taught in English</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Final written exam, 120 minutes, language English
Credit points and marks	5 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	150 hours
Duration of the module	One semester

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Compulsory Module

Module number	MNS 1.8
Module	Advanced Integrated Circuit Technologies
Responsible of module	Professur Mikrotechnologie
Contents and objectives	<p><u>Contents:</u></p> <ul style="list-style-type: none"> • Semiconductor Technology Roadmap Requirements and Trends • Processes for Micro- and Nanoelectronics (Thin Film Deposition, Ion Implantation, Advanced Lithography, Etching/Patterning, Chemical Mechanical Polishing, Advanced Cleaning) incl. emerging processes • CMOS / Bipolar / BiCMOS Technology • CMOS Process Modules for modern IC technologies (STI, Gate, Source/Drain, Interconnect Modules, Packaging etc.) • Specific aspects of sub 100 nm CMOS • New transistor and memory concepts; beyond CMOS approaches • 3D technology for increased integration density • Numerical methods for semiconductor process and equipment simulation • Models and programming for advanced deposition techniques (Monte Carlo and Molecular dynamics calculations) • Parameter optimization methods / Applied programming in Java <p><u>Objectives:</u> Understanding of basics and trends in modern integrated circuit technology, knowledge of process steps and modules; Knowledge of physical models for semiconductor processes, methodology and tools for process and equipment simulation, programming practice</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <p>-L: Advanced Integrated Circuit Technologies (3 LVS) -T: Advanced Integrated Circuit Technologies (1 LVS)</p> <p>Classes are taught in English</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Final written exam, 120 minutes, language English
Credit points and marks	5 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	150 hours
Duration of the module	One semester

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Compulsory Module

Module number	MNS 1.9
Module	Materials in micro- and nanotechnologies
Responsible of module	Professur Materialsysteme der Nanoelektronik
Contents and objectives	<p><u>Contents:</u></p> <p>Generic methodologies for nanotechnology: classification and fabrication Generic methodologies for nanotechnology: characterisation Inorganic semiconductor nanostructures Nanomagnetic materials Processing and properties of inorganic materials Electronic and electro-optic molecular materials Self-assembling nanostructured molecular materials Macromolecules at interfaces and structured organic films Bionanotechnology</p> <p><u>Objectives:</u> Introduce basic concepts and methods to create and understand Micro- and Nanomaterials</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <p>-L: Advanced Integrated Circuit Technologies (2 LVS) -PC: Advanced Integrated Circuit Technologies (2 LVS)</p> <p>Classes are taught in English</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Final oral exam, 45 minutes, language English
Credit points and marks	5 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	150 hours
Duration of the module	One semester

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Elective Module

Module number	MNS 2.1
Module	Automotive Sensor Systems
Responsible of module	Professur Mess- und Sensortechnik
Contents and objectives	<p><u>Inhalte/Contents:</u></p> <ul style="list-style-type: none"> • General Aspects for Use of Sensors in Automotives • Sensors for Motor Control • Sensors for Chasis • Sensors for Active and Passive Security (ABS, ESP, ..) • Driver Assistance Systems • Sensors for Air Quality Control • Sensors for Exhaust Emissions • Sensors for Acceleration, Forces, Pressure, Rotation • Self-Test and Self-Calibration for Reliability Improvements <p><u>Qualifikationsziele/Objectives:</u> The lessons enable students to have an overview of different principles and realizations of sensor systems for automotive applications.</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <p>-L: Automotive Sensor Systems (2 LVS) -T: Automotive Sensor Systems (2 LVS)</p> <p>Classes are taught in English.</p>
Prerequisites for participation	none
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Final oral exam, 30 minutes, language English and elaboration of a technical report (10 .. 15 pages) for a special topic.
Credit points and marks	5 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	150 hours
Duration of the module	One semester

**Attachment 2:
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Elective Module

Module number	MNS 2.2						
Module	Integrated circuit design - transistor level						
Responsible of module	Professur Elektronische Bauelemente der Mikro- und Nanotechnik						
Contents and objectives	<p><u>Contents:</u></p> <ul style="list-style-type: none"> • Design specifics in integrated circuits • Elementary digital circuits – MOS-logic gates • Elementary digital circuits – Bipolar-logic gates • BiCMOS digital logic gates • Advanced circuit design – dynamic logic • Fundamentals in analog integrated circuit design – elementary circuitry • Special circuits <p><u>Objectives:</u> Knowledge of function, analysis and design of transistor level integrated circuits. Operational experience in integrated elementary digital and analog circuits design.</p>						
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 80%;">- L: Integrated circuit design - transistor level</td> <td style="width: 20%; text-align: right;">(2 LVS)</td> </tr> <tr> <td>- T: Integrated circuit design - transistor level</td> <td style="text-align: right;">(1 LVS)</td> </tr> <tr> <td>- PC: Integrated circuit design - transistor level</td> <td style="text-align: right;">(1 LVS)</td> </tr> </table> <p>Classes are taught in English</p>	- L: Integrated circuit design - transistor level	(2 LVS)	- T: Integrated circuit design - transistor level	(1 LVS)	- PC: Integrated circuit design - transistor level	(1 LVS)
- L: Integrated circuit design - transistor level	(2 LVS)						
- T: Integrated circuit design - transistor level	(1 LVS)						
- PC: Integrated circuit design - transistor level	(1 LVS)						
Prerequisites for participation	Fundamentals of circuit design						
Usability of the module	---						
Prerequisites for awarding credit points	<p>Successfully passed the exam. Approval condition of the final written exam: Practical course completed successfully</p>						
Module examination	Final written exam, 180 minutes, language English						
Credit points and marks	<p>5 credits The evaluation of the exam follows the examination regulations (§10).</p>						
Frequency	The module is offered once a year.						
Work load	150 hours						
Duration of the module	One semester						

Attachment 2:
Description of the modules to the course “Micro and Nano Systems”
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Elective Module

Module number	MNS 2.3
Module	Fields and Waves
Responsible of module	Professur Hochfrequenztechnik und Photonik
Contents and objectives	<p><u>Contents:</u> Concepts and applications of Basic Wave Theory:</p> <ul style="list-style-type: none"> • Review of the basic scalar wave equation and its solutions: Description of a wave. • Wave packet propagation: Dispersion and group velocity. • Quantum (Photon) description of electromagnetic waves. • Photon Statistics: Laser applications. • Generalised Maxwell's equations: A physical approach. • Consequences of Maxwell's equations: Modes of EM wave propagation. • Wave propagation along transmission lines. • Concept of wave impedance and its applications. • Wave propagation along rectangular waveguides, circular waveguides and optical fibre cables: A physical approach. <p>Wave Polarisation and basic EM-interaction:</p> <ul style="list-style-type: none"> • Representation of elliptically polarised waves. • Reflection and transmission of polarised waves (Brewster's Angle). • Wave propagation in free space: Radar and Friis equations. • Basics of radiation and scattering. <p><u>Objectives:</u> Introduce basic concepts and methods of Microwave Engineering and Photonics.</p>
Forms of teaching Lecture, tutorial, practical course	Lectures, tutorials, practical course (§ 4): -L: Fields and Waves (2 LVS) -T: Fields and Waves (1 LVS) Classes are taught in English.
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Final written exam, 120 minutes, language English.
Credit points and marks	3 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	90 hours
Duration of the module	One semester

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Elective Module

Module number	MNS 2.5
Module	Power Semiconductor Devices
Responsible of module	Professur Power Electronics and Electromagnetic Compatibility
Contents and objectives	<p><u>Contents:</u></p> <ol style="list-style-type: none"> 1. Introduction 2. Basic semiconductor physics <ol style="list-style-type: none"> 2.1 Characteristics of semiconductors 2.2 pn-junctions 2.3 Short introduction to power device technology 3. Semiconductor devices <ol style="list-style-type: none"> 3.1 Fast power diodes 3.2 Schottky-diodes 3.3 Bipolar transistors 3.4 Thyristors 3.5 MOS-transistors 3.5 IGBTs 4. Basics of packaging and interconnection technologies <p><u>Objectives:</u></p> <p>Understanding of the effects of semiconductor physics in power devices, knowledge of the specifics of the particular device.</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <ul style="list-style-type: none"> -L: Power Semiconductor Devices (3 LVS) -T: Power Semiconductor Devices (1 LVS) <p>Classes are taught in English</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successful passed the test
Module examination	Oral exam, 60 minutes, language English
Credit points and marks	5 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once or twice a year.
Work load	150 hours
Duration of the module	One semester

**Attachment 2:
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Elective Module

Module number	MNS 2.6				
Module	Microscopy and Analysis on the Nano Scale				
Responsible of module	Professur Analytik an Festkörperoberflächen				
Contents and objectives	<p><u>Contents:</u></p> <ul style="list-style-type: none"> • Introduction • Microscopy in real space • Diffraction techniques • Spectroscopy of electronic and vibronic states • Sample preparation • Data acquisition and image processing • Simulation methods • Outlook <p><u>Objectives:</u> Understanding the principles of operation and the physical background of contemporary microscopy and analysis as well as the corresponding preparation and postprocessing methods. As a consequence, the ability of suitable selection and combination of these techniques should be developed.</p>				
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 70%;">-L: Microscopy and Analysis on the Nano Scale</td> <td style="text-align: right;">2 (LVS)</td> </tr> <tr> <td>-T: Microscopy and Analysis on the Nano Scale</td> <td style="text-align: right;">1 (LVS)</td> </tr> </table> <p>Classes are taught in English.</p>	-L: Microscopy and Analysis on the Nano Scale	2 (LVS)	-T: Microscopy and Analysis on the Nano Scale	1 (LVS)
-L: Microscopy and Analysis on the Nano Scale	2 (LVS)				
-T: Microscopy and Analysis on the Nano Scale	1 (LVS)				
Prerequisites for participation	---				
Usability of the module	---				
Prerequisites for awarding credit points	Successfully passed the exam.				
Module examination	Final written exam, 120 minutes, language English.				
Credit points and marks	3 credits The evaluation of the exam follows the examination regulations (§10).				
Frequency	The module is offered once a year.				
Work load	90 hours				
Duration of the module	One semester				

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Elective Module

Module number	MNS 2.7
Module	Nanophysics – Physics of Mesoscopic Systems
Responsible of module	Professur Analytik an Festkörperoberflächen
Contents and objectives	<p><u>Contents:</u></p> <ul style="list-style-type: none"> • Introduction • Preparation of nanostructures • Some basics of surface and interface physics • Electronic states and charge transport in nanostructures • Optical effects on the nm-scale • Magnetic effects on the nm-scale • Outlook <p><u>Objectives:</u> Understanding the basic physical principles and fundamental effects on the nano-scale, i.e. in the transition region between classical and quantum physics. Acquiring the ability of interdisciplinary communication in the field.</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <p>-L: Nanophysics – Physics of Mesoscopic Systems 2 (LVS)</p> <p>-T: Nanophysics – Physics of Mesoscopic Systems 1 (LVS)</p> <p>Classes are taught in English.</p>
Prerequisites for participation	This course is recommended in combination with the course “Microscopy and Analysis on the Nano Scale“
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Final written exam, 120 minutes, language English.
Credit points and marks	3 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	90 hours
Duration of the module	One semester

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Elective Module

Module number	MNS 2.8
Module	Vacuum, plasma and thin films
Responsible of module	Professur Physik fester Körper
Contents and objectives	<p><u>Contents:</u></p> <ul style="list-style-type: none"> • Physics of vacuum, • Atomic processes on surfaces (adsorption, desorption, etc.), • Vacuum technique, • basic facts of plasma physics, • Interaction of ion beams and solids, • Methods of thin film deposition: thermal evaporation, cathodic arc, molecular beam epitaxy, magnetron sputtering, • Physics of thin film growth: growth modes, structure zone models, influence of ion bombardment, • in-situ characterization of thin film growth, • measurement of thin film properties <p><u>Objectives:</u> Knowledge of the basic physical concepts as well as of important technical solutions for plasma and vacuum based technologies</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lecture -L: Vacuum, plasma and thin films (4 LVS)</p> <p>Classes are taught in English</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successful passed the test
Module examination	Oral examination in English, duration 30 min.
Credit points and marks	5 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered every second year
Work load	150 hours
Duration of the module	One semester

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Elective Module

Module number	MNS 2.9
Module	Micro Optical Systems
Responsible of module	Professur Mikrotechnologie
Contents and objectives	<p><u>Contents:</u></p> <ul style="list-style-type: none"> • Fundamentals (geometric optics, diffractive optics, quantum optics, photometry, optical materials, ...) • Passive optical and microoptical components (lenses, mirrors, gratings) • Fabrication and packaging of optical components (classical methods and microtechnologies) • Lightsources and detectors • MOEMS (micro scanner, micro mirror arrays, ...) • Integrated optic (waveguides, ...) • Photovoltaic • Measurement and characterization methods • Conventional optical systems • MEMS-based optical systems (spectrometer, T-scanner, ...) • Optical measurement technique (distance, deformation, oscillation, tension, temperature, color) • Optical technologies in medicine and life science • Application of optical systems in environmental monitoring and analytics • Trends and roadmaps.... <p><u>Objectives:</u> Understanding of theoretical basis, functionality and technology of micro optical components and systems</p>
Forms of teaching Lecture, tutorial, practical course	<p>Lectures, tutorials, practical course (§ 4):</p> <p>-L: Micro Optical Systems (2 LVS)</p> <p>-T: Micro Optical Systems (1 LVS)</p> <p>Classes are taught in English</p>
Prerequisites for participation	---
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	oral exam, 30 minutes, language English
Credit points and marks	3 credits The evaluation of the exam follows the examination regulations (§10).
Frequency	The module is offered once a year.
Work load	90 hours
Duration of the module	One semester

**Attachment 2:
Description of the modules to the course “Micro and Nano Systems”
with the certificate “Master of Science”**

Research project

Module number	MNS 3.1
Module	Research project
Responsible of module	The dean of studies of the faculty.
Contents and objectives	<p><u>Contents:</u></p> <p>The module ‘Research project’ is focused on solving a comprehensive practical oriented research task in the fields of Microsystems, Microelectronics or Nanotechnologies.</p> <p><u>Objectives:</u></p> <p>Goal of the module is providing of knowledge and practical experience in solving engineering research tasks as well as competences in documentation, analyses and presentation of results.</p>
Forms of teaching Lecture, tutorial, practical course	Tasks of the ‚Research project’ are individually processed. A scientific supervisor will periodically evaluate temporary results.
Prerequisites for participation	Prerequisites for participation are certified credit points of all compulsory modules. The ‘Research project’ must be confirmed in writing professor of the faculty.
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Thesis about 20 - 30 pages and oral exam, 20 minutes, language English
Credit points and marks	20 credits The written thesis contributes 70 % and the oral exam 30 %.
Frequency	The module is offered once a year.
Work load	600 hours
Duration of the module	One semester

**Attachment 2:
Description of the modules to the course “Micro and Nano Systems”
with the certificate “Master of Science”**

Master thesis

Module number	MNS 4.1
Module	Master thesis
Responsible of module	The dean of studies of the faculty.
Contents and objectives	<p><u>Contents:</u></p> <p>The module ‘Master thesis’ is focused on solving a comprehensive scientific research project in the fields of Microsystems, Microelectronics or Nanotechnologies supervised by a Professor of the faculty.</p> <p><u>Objectives:</u></p> <p>Goal of the module is providing of knowledge and practical experience in solving scientific research projects as well as competences in documentation, analyses and presentation of results.</p>
Forms of teaching Lecture, tutorial, practical course	Tasks of the ‚Master thesis’ are individually processed. A scientific supervisor will periodically evaluate temporary results.
Prerequisites for participation	Prerequisites for participation are certified credit points of all modules including ‘Research project’. The ‘Master thesis’ must be confirmed in writing professor of the faculty.
Usability of the module	---
Prerequisites for awarding credit points	Successfully passed the exam.
Module examination	Thesis about 60 pages within 23 weeks and oral exam, 30 minutes, language English
Credit points and marks	30 credits The written thesis contributes 70 % and the oral exam 30 %.
Frequency	The module is offered once a year.
Work load	900 hours
Duration of the module	One semester