Module Guide

Master Study Programme

Photonics

PO 2023

Version 2023.1

Inhaltsverzeichnis

1 Study schedule

Study schedule: **Masters Study Programme Photonics**

Abbreviations

WS = Winter semester
SoSe = Summer semester
SWS = Semester load
CP = Credit Points

V = Lecture
SU = Seminar-based teaching
Ü = Exercise class
P = Practical

PE = Examination performance
MP = Module examination

12.10.2023	Language*	1.Semester WS						2.Semester SoSe						3.Semester WS						4.Semester SoSe				
	E=English	SWS						SWS						SWS						SWS				
Type of course	G=German	V	SU	Ü	P	CP	PE	V	SU	Ü	P	CP	PE	V	SU	Ü	P	CP	PE	V	Ü	P	CP	PE
Subject, discipline		**Compulsory module**																						
Image Processing	E		2		2	6	ME																	
Integrated Devices	E	3		1	1	6	ME																	
Laser Physics	E	2		1	2	6	ME																	
Theoretical Optics	E	3		2		6	ME																	
Development of Optical Systems	E							2			2	6	ME							**Master thesis 25 CP**				
Laser Metrology	E							2			2	6	ME							**Colloquium 5 CP**				
Quantum Sensors	E							1	2	1	1	6	ME											
Wave and Quantum Optics	E							2		1	2	6		2		1		6	ME					
Development of Solid State Lasers	E													2		1	2	6	ME					
Laser Material Processing	E													2		1	2	6	ME					
Optical Measurement Technology	E													2		1	2	6	ME					
Total of column		8	2	4	5	24		7	2	2	7	24		8		4	6	24					30	
Total of examination performance		4						3						4										
Total SWS		19						18						18										
		Optional modules																						
Optional modules						6	ME					6	ME					6	ME				30	
Total from compulsory and optional modules						30	5					30	4					30	5					

Total CP: 120

Catalogue of optional modules	Language	WS						SoSe					
	E=English	SWS						SWS					
	G=German	V	SU	Ü	P	CP	PE	V	SU	Ü	P	CP	PE
Chemical Technology of Materials	E	3		1	1	6	ME						
Functional Materials	G	3		2		6	ME						
German as Foreign Language	G	2		1		3	ME						
Incoherent Light Sources	E							3	1	1		6	ME
Intercultural Communication and Competence	E							1		1		3	ME
Microscopy and Surface Science	E								3		2	6	ME
Modelling and Simulation	E							2		2		6	ME
Optical Coherence Tomography	E	3		1	1	6	ME						
Optical Communications	E	2		1	1	6	ME						
Photonic Crystals and Materials	E							3		1	1	6	ME
Photonic Integrated Circuits	E								3	1	1	6	ME
Photovoltaic Systems	G							2		1	1	6	ME
Quantum Statistical Physics	E							3		2		6	ME
Solid State Physics and Semiconductors	E	4	2	1		6	ME						
Free optional module*	G						ME						

* Free optional module from the Master study programme of the FH Münster upon application and in coordination with the study programme lecturer.

** Choice of optional modules depending on availability

2 Modules

The master study programme Photonics is modularised. A module mostly consists of one subject, occasionally two subjects are jointed. In the compulsory area, one examination must be taken in each module. In the optional area, students have to achieve at least 24 credit points.

Compulsory Modules

Modul	Language D = German E = Englisch	Term WS = Winter SoSe = Summer	Credit Points
Development of Optical Systems	E	SoSe	6
Development of Solid State Lasers	E	WS	6
Image Processing	E	WS	6
Integrated Devices	E	WS	6
Laser Material Processing	E	WS	6
Laser Metrology	E	SoSe	6
Laser Physics	E	WS	6
Optical Measurement Technology	E	WS	6
Quantum Sensors	E	SoSe	6
Theoretical Optics	E	WS	6
Wave and Quantum Optics	E	SoSe + WS	12

Optinal Modules

The courses for the optional modules are subject to continuous updating and expansion. The courses offered are updated at the beginning of each semester and announced on a notice board.

Modul	Language G = German E = Englisch	Term WS = Winter SoSe = Summer	Credit Points
Chemical Technology of Materials	E	WS	6
Functional Materials	G	WS	6
German as Foreign Language	G	WS	3
Incoherent Light Sources	E	SoSe	6
Intercultural Communication and Competence	E	SoSe	3
Microscopy and Surface Science	E	SoSe	6
Modelling and Simulation	E	SoSe	6
Optical Coherence Tomography	E	WS	6
Optical Communications	E	WS	6
Photonic Crystals and Materials	E	SoSe	6
Photonic Integrated Circuits	E	SoSe	6
Photovoltaic Systems	G	SoSe	6
Quantum Statistical Physics	E	SoSe	6
Solid State Physics and Semiconductors	E	WS	6
Free Optional Module	G / E	WS / SoSe	≥ 6

3 Compulsory Modules

3.1 Development of Optical Systems

1	**1.1 Title of module (GER / ENG)** Development of Optical Systems	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):** Master Photonics	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)** Pf	**3.3 Recommended semester:** 2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	2	30	**180**	**6**
	Lab class	2	30		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 4	Sum contact hours in hrs. 60		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Lecture		60		
	Lab class		60		
	Sum		Sum self-study in hrs 120		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students should be familiar with the theoretical foundations of optical system calculations and can use these to directly calculate a simple system. The origins and countermeasures of optical aberrations can be explained. The students can recognize and sketch common optical system designs. They can state their benefits, weaknesses, and applications.

The students are able to use their acquired practical skills in computer-assisted optical design to design an optical system. In detail, they should be able to understand the specifications of the optical system, design this system according to specifications, and make corrections and optimizations. They can present the achieved design, including the limitations, to a technical audience.

5.2 Course content

The course contents are as follows:

- Fundamentals of optical calculations (based on technical optics)
  - Optical imaging
  - Pupils and stops
  - Compound imaging
  - Aperture and field angle

  - Diffraction limit
- Paraxial layout of optical systems
  - Paraxial ray tracing (ynu method)
  - Marginal and principal rays
  - Paraxial invariant
  - Calculation of paraxial figures for optical systems
- Analysis and optimization of optical systems
  - Geometric-optical methods (transverse and longitudinal aberrations, spot diagrams)
  - Physical-optical methods (point spread function, modulation transfer function)
  - Optimization methods
- Theory of image aberrations
  - Monochromatic aberrations (3rd order)
  - Chromatic aberrations (1st order)
  - Design principles
- Examples of optical systems
  - Photographic lenses
  - Telescopes (refractors, reflectors, catadioptric telescopes)
  - Eyepieces
  - Non-rotationally symmetric systems
- Aspheric lenses

In the accompanying computer-aided laboratory, the covered insights and methods will be further explored, and practical skills in the development of optical systems will be imparted. Dedicated software for optical design will be used for the construction and numerical optimization of lens systems.

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

You can design and optimize lens systems for specific applications. With this knowledge, you can select optimal lens systems for your problem at hand in industry, research, or consumer applications.

6 **6.1 Prerequisites** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Good knowledge of physics and technical optics should have been acquired.

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing the examination.

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

The module exam will be one or a combination of the following formats: written exam (120 min), oral exam (30 min), presentation (30 min), or written paper.

6.4 Requirements for admission to examination

Attendance and successful completion of the lab class work, enrollment in the degree programme, and register for the examination.

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐German ☒ English ☐ others, namely:

7.2 Contact person for module:

Prof. Dr. techn. Florian Vogelbacher

7.3 Professors (optional)

Prof. Dr. techn. Florian Vogelbacher

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.2 Development of Solid State Lasers

1	**1.1 Title of module (GER / ENG)** Development of Solid State Lasers	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☐ **each summer semester,** ☒ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):** Master Photonics	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)** Pf	**3.3 Recommended semester:**

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	2	30	210	6
	Exercise	1	15		
	Project Work	2	30		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Lecture		55		
	Exercise		40		
	Project Work		40		
	Sum		Sum self-study in hrs 135		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

Students who have successfully passed this course will have a good understanding of the working principles of solid state lasers. This enables them to design and build solid state lasers for different applications. They have proven these skills in their project work, where they develop, characterize, or optimize a solid state laser. This project work also provides experience in project management and collaborative writing.

5.2 Course content

Students get to know the properties of various solid state laser media. The rate equations for laser gain media are derived and solved for steady state, small perturbations, and q-switching. Saturation of the laser gain is treated in detail. Different concepts for mitigating thermo-optical effects in solid state lasers will be discussed in depth. Fiber lasers are touched upon briefly. Students will learn to calculate output power, efficiency, and thermal effects of solid state lasers and laser amplifiers.

→ details can be found in course syllabus, recommended study plan etc.

5 5.3 Short information about module (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

This course will enable you to design and build solid state lasers for different applications. This is a key skill for working as a laser engineer in industry or for pursuing a career as a laser scientist.

6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise; module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Students should have attended the module "Laser Physics" from the M.Sc. Photonics programme. Furthermore, knowledge of geometrical optics, wave optics, and elementary quantum physics is necessary. Hands-on experimental skills in an optics laboratory are required.
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing examination.
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Written or oral examination.
	6.4 Requirements for admission to examination Regular participation in project class and accepted report on the assigned project.
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐ German ☒ English ☐ others, namely:
	7.2 Contact person for module: Prof. Dr. Ulrich Wittrock
	7.3 Professors (optional) Prof. Dr. Ulrich Wittrock
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.3 Image Processing

1	**1.1 Title of module (GER / ENG)** Image processing	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☐ **each summer semester,** ☒ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	Pf	1
	Master Materials Science and Engineering	WPf	1/3

4 Workload

	Teaching methods	Weekly teaching hours (“Semesterwochenstunde”) per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Seminar-based teaching	2	30	**180**	**6**
	Lab class	2	30		
	Sums	Sum contact hours in weekly teaching hours (“Semesterwochenstunden”)	Sum contact hours in hrs. 60		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Project work		120		
	Sum		Sum self-study in hrs 120		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students acquire a theoretical understanding of image processing methods and can apply them in the areas of image acquisition, image filtering, image enhancement, morphological image processing and detection of edges and contours in images. They can select, develop, or implement suitable methods to solve tasks for image processing systems. This enables students to find optimal solutions for given image processing problems in practice, such as quality and surface inspection or object detection.

In a project work, the students combine the fundamentals of image processing and apply them to a complex problem. The results are presented in a presentation, giving them insights into further areas such as remote sensing, feature extraction or computer vision.

5.2 Course content

- Basics and application examples
- Image acquisition and image representation
  - Image sensors
  - 3D image acquisition
  - Active illumination
- Image processing in spatial and frequency domain
  - Filtering
  - Color images
  - Image sequences
- Feature extraction and classification
- Image compression
- → details can be found in course syllabus, recommended study plan etc.

5	**5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms. Image processing covers image acquisition, representation in spatial and frequency domain, processing with filters as well as compression and classification. These basics are applied in a project work to solve a complex image processing problem.
6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* The module is based on the courses Mathematics I and II, Physics I and II, Technical Optics, Electrical Engineering, Measurement and Sensor Technology.
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing the lab course and the examination.
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Written or oral examination or presentation.
	6.4 Requirements for admission to examination Regular participation in lab course and approval of lab report.
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐ **German** ☒ **English** ☐ **others, namely:**
	7.2 Contact person for module: Prof. Dr. Jens Wermers
	7.3 Professors (optional) Prof. Dr. Jens Wermers
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.4 Colloquium

1	**1.1 Title of module (GER / ENG)** Colloquium	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☒ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	Pf	4

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)				150	5
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden")	Sum contact hours in hrs.		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Presentation and defense of master thesis		150		
	Sum		Sum self-study in hrs		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The graduates will be able to orally present the results of their thesis, the technical foundations and its interdisciplinary relationships.
The graduates can justify the importance of their results for science and / or practice and they are able to defend the results in a scientific discussion.

5.2 Course content

The application for admission should be sent one week before the examination date in writing on the appropriate form to the Audit Committee.
The colloquium will be conducted as a presentation followed by oral examination and takes about 30 to 60 minutes.

→ details can be found in course syllabus, recommended study plan etc.

5 5.3 Short information about module (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

You present a complex research project in a given time and lead a scientific discussion. The content of the colloquium is determined by the topic of the master's thesis.

6 6.1 Prerequisites (*formal*: examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

To the final colloquium can be admitted who´s Master thesis is marked at least "satisfactory" (4.0) and who has passed all module examinations.

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Pass examination

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

Presentation / oral examination (30 to 60 minutes).
The colloquium will be conducted as an oral examination.
The colloquium is evaluated by the examiners of the thesis.

6.4 Requirements for admission to examination

Enrollment in the programme, register for the examination at Exam office.

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☒German ☒ English ☐ others, namely:

7.2 Contact person for module:

Chairman of the examination board

7.3 Professors (optional)

Lecturers / Professors of the Department of Engineering Physics at the University of Applied Sciences Münster

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.5 Integrated Devices

1	**1.1 Title of module (GER / ENG)** Integrated Devices	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☐ **each summer semester,** ☒ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	Pf	1
	Master Materials Science and Engineering	WPf	1 / 3

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	3	45	**180**	**6**
	Exercise class	1	15		
	Lab class	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures, exercises, and lab class.		105		
	Sum		Sum self-study in hrs 105		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students are familiar with common materials and industry processes for the fabrication of integrated devices. These processes can be orally described/presented and schematically sketched by the students. The limitations of these processes can be orally discussed, and potential workarounds can be described. The students know the working principle of integrated building blocks and can explain them to a technical audience/person.

Using software tools, the students can numerically calculate eigenmodes of optical waveguides of different cross-sections and distinguish between the guided/radiating modes based on the field distribution. Characteristic material choices for photonic integrated circuits are known, and the reasons why they are commonly employed can be stated. Major elements found in photonic integrated circuits, i.e., couplers, bends, power splitters, and modulators, can be orally described/presented. This knowledge can be used to sketch larger building blocks, e.g., interferometers for sensing or signal modulation.

The students are able to work with optical waveguides in the laboratory environment. Relevant hands-on skills are acquired during the lab classes and can be demonstrated in practical experiments.

Technological details about recent trends in the subject's field, for example, from peer-reviewed publications, can be orally presented by students (in groups) to exchange knowledge among other members of the course. The students can actively/critically discuss topics in the subject's field.

5.2 Course content

Integrated devices combine many electronic, mechanical, and/or photonic components in a small area, replacing discrete and bulky components with small-scale integrated components. This integration results in reduced costs, increased performance, and the possibility to include additional functionality. The fabrication of these devices is usually based on specialised clean-room processes.

This course introduces common materials and major fabrication processes found in industry to fabricate electronic, mechanical, and photonic integrated circuits. The most relevant integrated components are introduced and discussed. For photonic components, the waveguiding effect plays an important role. Hence, the theory of optical waveguides is used to calculate the guided modes. The physical properties of these guided modes are discussed. The applications of photonic integrated circuits (PICs) are given with examples from industry.

Lab classes are used to train practical skills for handling optical waveguide components and devices.

The course contains:

- Materials for integrated devices
- Fabrication methods, e.g., doping of semiconductors, lithography, etching, bonding, packaging
- Integration of components
    - Electronic: transistors, resistors, capacitors
    - Mechanical: gyroscope, inertial measurement systems, digital mirror devices
    - Photonic: optical waveguides, fibers, couplers, power splitter, modulators

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

This module introduces you to materials and fabrication methods used in the semiconductor industry to create devices from miniaturized components with applications in computation, optical communication, and sensing.

6 **6.1 Prerequisits** (*formal*: examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

The following knowledge and skills should have been acquired: basics in semiconductor physics and electromagnetic waves.

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing the examination.

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

The module exam will be one or a combination of the following formats: written exam (120 min), oral exam (30 min), presentation (30 min), or written paper.

6.4 Requirements for admission to examination

Attendance and successful completion of the lab class work, enrollment in the degree programme, and register for the examination.

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐German ☒ English ☐ others, namely:

7.2 Contact person for module:

Prof. Dr. techn. Vogelbacher, Prof. Dr. Gregor

7.3 Professors (optional)

Prof. Dr. techn. Vogelbacher, Prof. Dr. Gregor

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

Literature: reading recommendations are given at the beginning of the lecture.

3.6 Laser Material Processing

1	1.1 Title of module (GER / ENG) **Laser Material Processing**	1.2 Short description (optional)	1.3 Module code (from HIS-POS)
2	2.1 Cycle of module: ☐ each summer semester, ☒ each winter semester other cycle, namely:	2.2 Duration of module ☒ 1 semester ☐ 2 semesters	
3	3.1 Module offered in the following study programme(s):	3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)	3.3 Recommended semester:
	Master of Science Photonics	Pf	1
	Master Materials Science and Engineering	W	

4 Workload

	Teaching methods	Weekly teaching hours (“Semesterwochenstunde”) per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	2	30	**180**	**6**
	Exercise	1	15		
	Lab class	2	30		
	Sums	Sum contact hours in weekly teaching hours (“Semesterwochenstunden”) 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures, exercises, and lab class.		105		
	Sum		Sum self-study in hrs 105		

5 **5.1 Intended learning outcomes** (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

Students should understand basics of the laser interaction with metals and dielectrics. Should be able to build systems for delivering and scanning the laser beam over the sample surface. Make simple operations like laser welding, soldering, cutting,drilling, hardening. They should know different methods of laser marking. Be able to work with systems for additive manufacturing like selective laser melting, laser metal deposition and two-photon polymerisation. The students should also understand the fields of application for ultrafast laser pulses in material processing

5.2 Course content

Laser interaction with metals and (transparent) dielectrics. Role of the thermal conductivity.
Beam delivery, shaping and scanning systems
Laser cutting: fusion, flame, sublimation cutting; cutting errors; laser drilling
Laser welding: parameters, role of thermal conductivity, deep welding, hydrodynamics of the melt flow
Laser hardening: temperature dynamics, systems, shock-wave peening.
Additive manufacturing: SLM, LMD, PLD, 2PP, LIFT
Laser marking
Application of ultrafast laser pulses, nano-patterning, processing of transparent materials.

→ details can be found in course syllabus, recommended study plan etc.

5	**5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms. Lasers provide a “green” tool for cutting, drilling, welding, hardening, nanopatterning and 3D-printing with less waste and usually less energy consumption comparing to classical material processing methods. It is used to cut diamond and to make nano-structures, opening new horizons for physics and engineering.
6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Laser Physics is strongly recommended
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing the final examination
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Oral exam or written exam
	6.4 Requirements for admission to examination Submitting all lab class reports
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐ **German** ☒ **English** ☐ **others, namely:**
	7.2 Contact person for module: Prof. Dr. Evgeny Gurevich
	7.3 Professors (optional) Prof. Dr. Evgeny Gurevich
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.7 Laser Metrology

1	1.1 Title of module (GER / ENG) **Laser Metrology**	1.2 Short description (optional)	1.3 Module code (from HIS-POS)
2	2.1 Cycle of module: ☒ each summer semester, ☐ each winter semester other cycle, namely:	2.2 Duration of module ☒ 1 semester ☐ 2 semesters	
3	3.1 Module offered in the following study programme(s):	3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)	3.3 Recommended semester:
	Master Photonics	Pf	2
	Master Materials Science and Engineering	W	2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	2	30	**180**	**6**
	Lab class	2	30		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 4	Sum contact hours in hrs. 60		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures, exercises, and lab class.		120		
	Sum		Sum self-study in hrs 120		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

Students should know basics of metrology, be able to develop a measurement method and know, how they should certify it. The students should know how to use lasers for measurements of distances, velocity and surface quality. Measurements of distribution functions of nanoparticles and thin films are also discussed. Besides the students learn different methods of laser spectroscopy such as laser-induced fluorescence, absorption and Raman spectroscopy.

5.2 Course content

Basics of metrology: metrological methods, standard reference materials, data processing
Laser measurements described with ray optics: distance to the Moon, LIDAR, scape measurements, AFM.
Laser measurements described with wave optics: interferometry, gravitational waves, laser-Doppler anemometry.
Measurements of nanoparticle distributions: limitations, flow, DLS, NTA, scattering methods, plasmonics
Thin layers: interference, ellipsometry, plasmonics, x-ray standing waves
Spectroscopy: LIF, laser absorption, laser-ablation mass-spectrometry, Raman, MALDI
Temperature measurements: Raman spectroscopy, scattering of light on electrons, Planks formula.
→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

Laser wavelength and the speed of light provide natural scales, which allow to extend the ranges of available measurements. Simple tricks enable measurements of single nanoparticles and even electrons, which are far beyond the limits of the classical optical resolution.

6 **6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Laser Physics is strongly recommended

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing the final examination

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

Oral exam or written exam

6.4 Requirements for admission to examination

Submitting all lab class reports

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐ **German** ☒ **English** ☐ **others, namely:**

7.2 Contact person for module:

Prof. Dr. Evgeny Gurevich

7.3 Professors (optional)

Prof. Dr. Evgeny Gurevich

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.8 Laser Physics

1	1.1 Title of module (GER / ENG) **Laser Physics**	1.2 Short description (optional)	1.3 Module code (from HIS-POS)
2	2.1 Cycle of module: ☐ each summer semester, ☒ each winter semester other cycle, namely:	2.2 Duration of module ☒ 1 semester ☐ 2 semesters	
3	3.1 Module offered in the following study programme(s):	3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)	3.3 Recommended semester:
	Master Photonics	Pf	1
	Master Materials Science and Engineering	W	1 / 3

4 Workload

	Teaching methods	Weekly teaching hours (“Semes-terwoch-enstunde”) per teaching method	Hours in semes-ter per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/intern-ship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lectures	2	30	180	6
	Exercises	1	15		
	Lab class	2	30		
	Sums	Sum contact hours in weekly teaching hours (“Semester-wochenstunden”) 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assign-ments and homeworks, research etc.)	Preparation and revision of lectures, exercises and lab class.		105		
	Sum		Sum self-study in hrs 105		

5 **5.1 Intended learning outcomes** (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

Students should understand basics of laser dynamics, know basic processes in the active medium, under-stand the role of the resonator in the laser design and how it changes the spectral properties of the laser radiation. They should be able to build cw and pulsed solid state lasers and know how to make lasers based on gas discharges, chemical reactions, free electrons and stimulated Raman scattering.

5.2 Course content

Laser dynamics: emission, absorption, Einstein coefficients, rate equations, 2-, 3- and 4- level lasers.
Laser resonators: configuration, stability, influence on the laser beam characteristics, longitudinal and trans-versal modes
Solid-state lasers: thermal effects, different active ions, different host materials, tin disk, fiber slab geometry
Pulsed lasers: Q-switching, mode locking materials, Ti:sapphire, chirped pulse amplification
Gas lasers: HeNe-, CO_2-, Ar-ion-, metal-vapour-, hollow-core fiber-, and far-IR-lasers.
Chemical lasers: HF-, photodissociation, gas-dynamic- and excimer- lasers
X-ray lasers: basic principles, lasers with nuclear pumping, free-electron lasers
Dye lasers and color-center lsers
Semiconductor and diode lasers, quantum cascade lasers
→ details can be found in course syllabus, recommended study plan etc.

5	**5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms. The course answers the following questions: What are the physical effects making it possible to build a laser? How the high-power and very monochromatic lasers are built? What the Nobel Prizes in physics in 1964, 2018 and 2023 were awarded for? How you can pump a laser with chemical reactions and nuclear explosions?
6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Basics of physics and optics
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing the final examination
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Oral exam or written exam
	6.4 Requirements for admission to examination Submitting all lab class reports
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐ **German** ☒ **English** ☐ **others, namely:**
	7.2 Contact person for module: Prof. Dr. Evgeny Gurevich
	7.3 Professors (optional) Prof. Dr. Evgeny Gurevich
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.9 Master thesis

1	**1.1 Title of module (GER / ENG)** Master thesis	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☒ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☐ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	Pf	4

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)					**25**
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden")	Sum contact hours in hrs.		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Self organized elaboration of a scientific task		750		
	Sum		Sum self-study in hrs 750		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The graduates can work on a topic independently within a specified period of time. They are able to develop solutions for a problem based on their knowledge and expertise in chemical engineering as well as on their understanding of the interdisciplinary contexts and practical methods.
They are able to present their compiled results clearly, understandable and plausible in written form.

5.2 Course content

The thesis should demonstrate that the candidate is competent in a specified period of a task from her or his field both in their technical details as well as in the interdisciplinary contexts of scientific and practical methods to work independently. The thesis is a written report. The benchmark for the length of the text part of the thesis is 50 pages DIN A 4 (with approx. 2000 characters per page).

The processing time (period from issue to submission of the Master's thesis) is up to four months. According to Section 19 paragraph 3 AT PO, an extension of the deadline is possi-ble upon request (max. four weeks).

The application for admission to the Master's thesis must be sent with the appropriate form in writing to the audit committee and submitted to the examination office before the start of the Master's thesis, the corresponding letter of admission will be sent to response.

→ details can be found in course syllabus, recommended study plan etc.

5	**5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms. Within a given period of time, you will work on a theoretical or practice-oriented task from your specialist area, both in its technical details and in the interdisciplinary context.
6	**6.1 Prerequisites** (*formal*: examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Students can be admitted to the Master thesis 1. who have to be enrolled in the Master's degree programme in Photonics at FH Münster or be admitted as a cross-registered student, 2. and has acquired at least 60 credit points from module examinations.
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Report – Evaluation and documentation of the master thesis
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Application or theory oriented, independent work on a scientific Problem (maximum duration 4 month) Master thesis (Report about 50 A4 pages with about 2000 characters per page) The thesis is evaluated by two examiners
	6.4 Requirements for admission to examination Enrollment in the programme, register for the examination at Exam office
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/ak-tuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☒**German** ☒ **English** ☐ **others, namely:**
	7.2 Contact person for module: Chairman of the examination board
	7.3 Professors (optional) Lecturers / Professors of Department of Engineering Physics at the University of Applied Sciences Münster
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.10 Optical Measurement Technology

1	**1.1 Title of module (GER / ENG)** Optical Measurement Technology	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☐ **each summer semester,** ☒ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	Pf	3
	Master Wirtschaftsingenieurwesen/Physikalische Technologie	WPf	3

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	2	30	**180**	**6**
	Exercise class	1	15		
	Lab class	2	30		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Lecture		30		
	Exercise class		30		
	Lab class		45		
	Sum		Sum self-study in hrs 105		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students should be familiar with a wide range of optical measurement methods. The methods should be mastered both in terms of their theoretical background and in their practical application, so that they can be applied to the measurement of various physical quantities as well as to the measurement of the basic parameters of optical systems. In particular, the testing of optical components and imaging systems should be mastered in terms of their methods and devices.

5.2 Course content

The course contents are as follows:

- Optical measuring techniques
  - Basics of technical optics
  - Detectors for optical radiation
  - Measurement eyepieces
  - Microscopic measurements
  - Telescopes and rangefinders
  - Optical measurement of geometric properties (distance, profile, structural widths, 3D shape)
  - Interferometric measurement techniques
  - Wavefront detection (PDI interferometer, SHS sensor, Foucault and Ronchi tests, ...)
  - Characterization of polarization states

- Testing of optical components and imaging systems
  - Measurement of optical basic parameters
    (Refractive index, dispersion, refractive power, focal length, radii, surface shape, centering)
  - Measurement of imaging defects
  - Point spread function and Strehl ratio
  - Wavefront
  - Imaging quality and resolution,
  - Modulation transfer function (MTF)

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

You are able to characterize the quality of light beams, optical samples, and lenses, employing techniques used in the optical industry.

6 **6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise; module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Knowledge in Physics and Optics should have been acquired.

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing the examination.

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

The module exam will be one or a combination of the following formats: written exam (120 min), oral exam (30 min), presentation (30 min), or written paper.

6.4 Requirements for admission to examination

Attendance to the lab classes and acceptance of the lab reports.

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐German ☒ English ☐ others, namely:

7.2 Contact person for module:

Prof. Dr. techn. Florian Vogelbacher

7.3 Professors (optional)

Prof. Dr. techn. Florian Vogelbacher

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.11 Quantum Sensors

1	1.1 Title of module (GER / ENG) Quantum Sensors	1.2 Short description (optional)	1.3 Module code (from HIS-POS)		
2	2.1 Cycle of module: ☒ each summer semester, ☐ each winter semester other cycle, namely:	2.2 Duration of module ☒ 1 semester ☐ 2 semesters			
3	3.1 Module offered in the following study programme(s):	3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)	3.3 Recommended semester:		
	Master Photonics	Pf			
	Master Materials Science and Engineering	W			
	Master Elektrotechnik	W			

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	1	15	180	6
	Exercise	1	15		
	Seminar	2	30		
	Laboratory class	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and review of laboratory experiments				
	Preparation and revision of lectures and exercises				
	Sum		Sum self-study in hrs 105		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

This course is an introduction to quantum sensors and their applications.

Students will be able to

- gain a basic understanding of quantum systems and the electronic detection of the sensor signal,
- read and discuss scientific papers for the applications of quantum sensors,
- write scientific summary texts using the correct terminology and outline complex subject matter in presentations.

5.2 Course content

Quantum sensors are an emerging class of sensor that promise substantial advantages over existing sensor concepts. Here, a single quantum system acts as the sensing element of the sensor. Possible sensors are highly sensitive magnetic or gravitational field sensors, that lead to applications in current sensing, chemical nuclear magnetic resonance probes, or deep brain imaging, etc. In order to detect changes in single quantum systems advanced electronic signal progressing techniques required to isolate the sensor signal.

The course will provide a basic understanding of quantum systems and the efficient electronic detection of the sensor signals.

The seminar part the course will look into some of the different sensor concepts described in the scientific literature and under investigation in the FH labs.

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

6 **6.1 Prerequisits** (_formal_: examination of module XY has to be passed or similar _content-wise_; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Enrollment to Master Photonics, Master Materials Science and Engineering or Master Elektrotechnik.

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Successful seminar work

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

The module exam will be one of the following formats: written exam, oral exam, oral presentation or a written paper. The exam format for the current semester will be published in advance by the Fachbereich Elektrotechnik und Informatik.

6.4 Requirements for admission to examination

Attendence to the module courses, enrollment in the degree programme, register for the examination

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐**German** ☒ **English** ☐ **others, namely:**

7.2 Contact person for module:

Prof. Dr. Glösekötter, Prof. Dr. Gregor

7.3 Professors (optional)

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

Literature: reading recommendations are given at the beginning of the lecture.

3.12 Theoretical Optics

1	1.1 Title of module (GER / ENG) Theoretical Optics		1.2 Short description (optional)		1.3 Module code (from HIS-POS)	
2	2.1 Cycle of module: ☐ each summer semester, ☒ each winter semester other cycle, namely:		2.2 Duration of module ☒ 1 semester ☐ 2 semesters			
3	3.1 Module offered in the following study programme(s): Master Photonics		3.2 Compulsory (Pf), compulsory elective (WPf), elective (W) Pf		3.3 Recommended semester: 6	

4 Workload				Workload in total	
	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in hours sum contact hours and self-study in hrs.	ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	lectures	4	60	180	6
	exercises	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)			105		
	Sum		Sum self-study in hrs 105		

5 **5.1 Intended learning outcomes** (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The knowledge of theoretical techniques of electrodynamics, classical optics and quantum mechanics should enable the students to solve practical problems of quantum optics. Basic techniques are trained to treat quantum states.

5.2 Course content

1. Laws of blackbody radiation (Stefan-Boltzmann, Wien, Rayleigh, Planck),
2. Electromagnetic waves (Maxwell equations and solutions, Fresnel formulas, metal optics, dielectrics)
3. Diffraction (Kirchhoff formula, Frauenhofer and Fresnel diffraction, Fourier optics)
4. Introduction into quantum mechanics (quantization of electromagnetic field, coherent and thermal light)
5. One-mode quantum optics (squeezed states, non-classical light)
6. Quantum information (entangled states, Bell inequalities, teleportation)
7. Introduction in statistical Optics (entropy, distribution function, connection to thermodynamics, density operator)

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

The students study basic theoretical techniques of electrodynamics, classical optics and quantum mechanics in order to be able to treat quantum optical problems.

6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Knowledge of mathematics I-III, Fourier transform, vector calculus
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing of exam or defence of project work
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Written exam of 90 minutes or oral presentation of project work about 20 minutes
	6.4 Requirements for admission to examination none
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/ak-tuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐**German** ☒ **English** ☐ **others, namely:**
	7.2 Contact person for module: Prof. Klaus Morawetz
	7.3 Professors (optional) Prof. Klaus Morawetz
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

3.12 Wave and Quantum Optics

1	**1.1 Title of module (GER / ENG)** Wave and Quantum Optics		**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)	
2	**2.1 Cycle of module:** ☒ each summer semester, ☐ each winter semester other cycle, namely:		**2.2 Duration of module** ☐ 1 semester ☒ 2 semesters		
3	**3.1 Module offered in the following study programme(s):** Master Photonics		**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)** Pf	**3.3 Recommended semester:** 2 + 3	

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture (2+2)	4	30 + 30	**330**	**12**
	Exercise (1+1)	2	15 +15		
	Practical Course (2+0)	2	30 + 0		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 8	Sum contact hours in hrs. 120		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Lecture		50 + 50		
	Exercise		30 + 30		
	Practical Course		50 + 0		
	Sum		Sum self-study in hrs 210		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

Students will have a solid foundation in our current understanding of light. Students will be well-prepared for working at companies or research institutions in the fields of optics, photonics, lasers, and quantum technologies. Our case study of a gravitational wave interferometer makes use of many of the intended learning outcomes. The students receive first training in scientific writing due to critical feedback for their lab reports.

5.2 Course content

The course starts with an introduction to thin-film interference followed by elastic, inelastic, coherent, and incoherent scattering of light scattering. Optically anisotropic materials and their applications are treated in depth and this leads us to magneto-optical and electro-optical effects. The first semester concludes with the mathematical description of polarization and first-order coherence. In the second semester emphasizes the quantum aspects of light by treating subjects such as the nonlinear susceptibility, parametric fluorescence and amplification, quantum cryptography, interaction-free measurements, second order coherence and squeezed light.

→ details can be found in course syllabus, recommended study plan etc.

5 5.3 Short information about module (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

Students who successfully passed this course will have a solid foundation in the current understanding of light. This enables them to delve into more specific areas of photonics and quantum technologies and understand corresponding research papers.

6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise; module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Students should have attended the module "Theoretical Optics" from the M.Sc. Photonics programme. Furthermore, knowledge of geometrical optics, wave optics, and elementary quantum physics is necessary. Hands-on experimental skills in an optics laboratory are required.
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing examination.
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Written or oral examination.
	6.4 Requirements for admission to examination Regular participation in the practical course class and accepted reports.
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐German ☒ English ☐ others, namely:
	7.2 Contact person for module: Prof. Dr. Ulrich Wittrock
	7.3 Professors (optional) Prof. Dr. Ulrich Wittrock
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

4 Optional Modules

4.1 Chemical Technology of Materials

1	1.1 Title of module (GER / ENG) Chemical Technology of Materials	1.2 Short description (optional)	1.3 Module code (from HIS-POS)
2	2.1 Cycle of module: ☐ each summer semester, ☒ each winter semester other cycle, namely:	2.2 Duration of module ☒ 1 semester ☐ 2 semesters	
3	3.1 Module offered in the following study programme(s):	3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)	3.3 Recommended semester:
	Master Chemical Engineering Chemical Processing	W	1 / 3
	Master Chemical Engineering Applied Chemistry	W	1 / 3
	Master Photonics	WPf	1 / 3
	Master Materials Science and Engineering	W	1 / 3

4 Workload

	Teaching methods	Weekly teaching hours (“Semesterwochenstunde”) per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	3	45	180	6
	Exercise	1	15		
	Lab class	1	15		
	Sums	Sum contact hours in weekly teaching hours (“Semesterwochenstunden”) 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and review of laboratory experiments		60		
	Preparation and revision of lectures and exercises		45		
	Sum		Sum self-study in hrs 105		

5 **5.1 Intended learning outcomes** (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

After complete the module, students can classify phenomena that can be traced back to electronic structures of solids. The students are able to reflect on basic principles such as solid state, ceramic, powder and colloid chemistry in relation to technical applications and to analyse them from the chemist’s point of view. By participating in a lab course the theoretical knowledge is put into practice and students are able to carry out projects and tasks based on current R&D issues of materials independently.

5.2 Course content

Free electron approach' :
Time-independent Schrödinger-equation for stationary systems, Eigenvalue, Eigenfunction, k-Vector, density of states in metals

'Tight binding approach':
Bloch-functions of one-, two- and threedimensional systems, density of states, Brillouin-zones, band structure

Semiconductors:
Boltzmann-, Fermi-Dirac-statistics, conductivity, band structures in semiconductors, LED's, solar cells, semiconductor lasers

Interfaces:
Thermodynamic background, vapour pressure of small droplets, mono- and polydispersed systems, methods to prepare monodispersed dispersions, kinetic vs. steric stabilization, Ostwald-ripening, hydrophobic interaction, lyotropic mesophases, rheology (viscosity, measurement , applications)
Ceramic processes:
Green body processing, raw materials, thermal processe (Sintering: transport, fluxes, gas phases)

Lab:
Practical tasks / projects within current R&D work on materials of the department, to be concluded with a written report and presentation of the accomplishments

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

You get to know the concepts and technologies exhibiting and using size-dependent properties. In most cases, the associated spatial dimensions will be on the nm-scale. You gain knowledge about chemistry-driven control of phenomena and applications.

6 **6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Topics of Inorganic and Physical Chemistry from a B.Sc.-programme in Chemistry, Chemical Engineeringor similar course programmmes

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Written report and oral presentation on the laboratory work conducted, literature review and successful exam

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

Exam (180 minutes) or oral exam

6.4 Requirements for admission to examination

Enrollment in the programme, registration for examination (via myFH-Portal)

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**
☐**German** ☒ **English** ☐ **others, namely:**

7.2 Contact person for module:

Prof. Dr. Jüstel

7.3 Professors (optional)

Prof. Dr. Jüstel, Prof. Dr. Breternitz

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

Literature:
Textbooks on Materials Science, Ceramics and Physical Chemistry. Transcripts of the lectures (partially) and additional materials are made available on the net.

4.2 Functional Materials

1	**1.1 Title of module (GER / ENG)** Funktionsmaterialien / Functional Materials	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Bachelor Chemieingenieurwesen	WPf	4.
	Bachelor Wirtschaftsingenieurwesen Chemietechnik	WPf	4.
	Master Photonics	WPf	

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	3	45	**180**	**6**
	Exercise	2	30		
	Lab class	2	30		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 7	Sum contact hours in hrs. 105		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and review of laboratory experiments		30		
	Preparation and revision of lectures and exercises		30		
	Exam preparation		15		
	Sum		Sum self-study in hrs 75		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

Das Modul vermittelt theoretische Kenntnisse und praktische Anwendungen von in Technik und Alltag wichtigen Funktionsmaterialien. Im Mittelpunkt stehen dabei Materialien mit thermischen, optischen, elektrischen oder magnetischen Eigenschaften. Die Studierenden verstehen die Wechselwirkungen zwischen Licht und Materie, die elektrischen, optischen und thermischen Eigenschaften von (Halbleiter)Materialien und den Zusammenhang zwischen Materialzusammensetzung und Eigenschaften bzw. Funktion.

Die Studierenden verfügen über einen umfassenden Überblick über verschiedene Materialtypen, von klassischen anorganischen kristallinen und keramischen Materialien bis zu organischen Materialien, die immer mehr an praktischer Bedeutung gewinnen, z.B. in O(LED), Solarzellen oder LCDs. Neben den materialchemischen und physikochemischen Grundlagen verfügen die Studierenden über Kenntnisse wie Funktionsmaterialien mit ihrer Umgebung interagieren und für praktische Anwendungen in technischen Einrichtungen (Lichtquellen, Solar- und Batteriezellen, Bildschirme, Anzeigetafeln, Sensoren) integriert werden können, und können die Vor- und Nachteile verschiedener Materialtypen für bestimmte Anwendungen beurteilen.

5.2 Course content

Wechselwirkungen zwischen Licht und Materie
Absorptionsprozesse, Auswahlregeln, Übergangsdipolmoment, strahlende und nicht-strahlende Relaxation, Lumineszenzphänomene, Reflexion, Lichtstreuung, Polarisation, Kubelka-Munk-Funktion, Tauc-Plot

Defektchemie
Klassifizierung und Notation (Kröger-Vink) der Punktdefekte, effektive Ladungen, Bildungsgleichungen der Defekte, Bilanzen (Ladung, Stoffmengen, Gitterplätze), Thermodynamik der Punktdefekte, Verbindungshalbleiter und nichtstöchiometrische Verbindungen, Darstellung von Defekten in Bandlücken als Redox-Gleichgewichte, Dotierungen in Halbleitern, Transportprozesse in Festkörpern

Thermische Funktionsmaterialien
Molare Wärmekapazität, Wärmeübertragungsmechanismen, Wärmeleitfähigkeit, thermische Ausdehnung, negative thermische Ausdehnung, thermische Isolatoren und Leiter

Elektrische Funktionsmaterialien
Anorganische Element- und Verbindungshalbleiter, Photovoltaik, metallische Leiter, Ionenleiter, Supraleiter, Dipole und Dielektrika, Piezoelektrizität und Elektrostriktion, Ferroelektrizität

Elektrisch leitfähige Polymere
Struktur, Synthese, Dotierung, Charakterisierung, optoelektronische und sensorische Anwendungen

Magnetische Funktionsmaterialien
Elementarmagnete und Bohr'sches Magneton, magn. Suszeptibilität, Dia- und Paramagnetismus, kooperativer Magnetismus, Anwendungen magnetischer Werkstoffe

Optische Funktionsmaterialien
Brechungsindex, Farb- und Leuchtpigmente, Elektrolumineszenzmaterialien, Laserschemata und -materialien (Gläser, Kristalle, Keramiken), LED und Laserdioden, anorganische Gläser, Lichtleiter, magnetooptische Schalter, photoelektrischer Effekt

Organische Materialien für Displays und Photovoltaik
Flüssigkristalle, Aufbau und Funktionsweise von LCDs, niedermolekulare organische Verbindungen für OLEDs und Solarzellen, Aufbau und Funktionsweise der Zellen

Chemisch-sensitive kristalline Materialien und Halbleiter
Feststoffmembranen für die Sensorik von Ionen und Gasen

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

Optische und elektronische Funktionsmaterialien sind unverzichtbare Bausteine für eine Vielzahl von technischen Lösungen für aktuelle Probleme und auch im Alltag allgegenwärtig. Praktische Beispiele, die in diesem Modul behandelt werden, sind anorganische und organische Materialien für Laser, (O)LED, Photovoltaik, Bildschirme sowie für die chemische Sensorik.

6 **6.1 Prerequisits** (_formal_: examination of module XY has to be passed or similar _content-wise_; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Formal: Immatrikulation, Bestandenes Modul „Material- und Werkstoffwissenschaften“
Inhaltlich: Grundkenntnisse in anorganischer, organischer, physikalischer und makromolekularer Chemie

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Bestehen der Prüfung und Anerkennung der Studienleistungen (erfolgreiche Teilnahme an Laborprojekt und Anfertigung der Versuchsprotokolle)

	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Klausur (180 min) oder mündliche Prüfung.
	6.4 Requirements for admission to examination Immatrikulation und fristgerechte Online-Anmeldung über das myFH-Portal innerhalb des Anmeldezeit-raums.
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☒German ☐ English ☐ others, namely:
	7.2 Contact person for module: Prof. Dr. Thomas Jüstel
	7.3 Professors (optional) Prof. Dr. Thomas Jüstel, Prof. Dr. Michael Schäferling, N.N.
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.) Vorlesungsskripte (weitere Literatur wird über ILIAS zur Verfügung gestellt.

4.3 German as Foreign Language

1	**1.1 Title of module (GER / ENG)** German as a Foreign Language	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS) ITB.2.0042.0
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Materials Science and Engineering	Pf	2
	Master Photonics	WPf	2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecuture	2	30	**90**	**3**
	Exercise	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 3	Sum contact hours in hrs. 45		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and review of laboratory experiments		30		
	Preparation and revision of lectures and exercises		15		
	Sum		Sum self-study in hrs 45		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

Students can understand slowly asked questions and simply formulated instructions and react to them in brief words in order to be able to formulate and react to common requests in everyday life. In addition, students can extract relevant information from written and oral statements and answer simple questions on private and work related topics. Simple sentences regarding everyday life and job can be formed. The linguistic competence is increased by exercises so that the students can react to common challenges verbally correct and thus communicate with other people.

5.2 Course content

Introducing themselves: statements about name, age, family, language, country, job, hobby's, numbers

- First contact at university and working station: office departments, hobby's, activities in leisure time and name all days of the week.
- In the city: reserve hotel rooms, point out problems in the hotel room, developing a sense of orientation in the city, tell the time of the day
- Having something to eat: order meals and drinks, food, name different types of packages, describe simple recipes and eating habits

→ details can be found in course syllabus, recommended study plan etc.

	5.3 Short information about module (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms. The course provides communicative skills and forms the basis for the functional use of German language skills in everyday life, studies and later professional life.
6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise; module XY should have been attended, the following knowledge and skills should have been acquired: ….)* None
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Recognitions can be submitted to the examination office by language courses enrolments in the Pluspunkt programme or other language providers.
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) 20% tests during semester 30% oral contribution 50% exam (120 min)
	6.4 Requirements for admission to examination Attendance in class is mandatory.
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☒**German** ☐ **English** ☐ **others, namely:**
	7.2 Contact person for module: Prof. Dr. Markus Schwering
	7.3 Professors (optional) NN
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

4.4 Incoherent Light Sources

1	1.1 Title of module (GER / ENG) Incoherent Ligh Sources	1.2 Short description (optional)	1.3 Module code (from HIS-POS) **CIW.2.0029.0**
2	2.1 Cycle of module: ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	2.2 Duration of module ☒ **1 semester** ☐ **2 semesters**	
3	3.1 Module offered in the following study programme(s):	3.2 Compulsory **(Pf)**, compulsory elective **(WPf)**, elective **(W)**	3.3 Recommended semester:
	Master Chemical Engineering Applied Chemistry	Wpf	2
	Master Materials Science and Engineering	Wpf	2
	Master Photonics	Wpf	2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lectures	3	45	**180**	**6**
	Excercise	1	15		
	Seminar	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures, excercises and seminar		105		
	Sum		Sum self-study in hrs 105		

5

5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students will know the physical concepts of light generation and the technical realization of these concepts as practical light sources. Moreover, they will learn the application areas of light sources also beyond illumination and about the design of luminaires and information displays. Students will be able to select light sources and proper materials with respect to the application area aimed at.

5.2 Course content

History of light sources, radiometric and photometric quantities, perception of light, color coordinates, color temperature, and color rendering, additive and subtractive color mixing, physical concepts of light generation, incandescent and halogen lamps, low-pressure discharge lamps (Hg and Na), high-pressure discharge lamp (Hg, Na, metal halide, Xe), Luminescent materials, mechanisms of luminescence, Inorganic LEDs, OLEDs and PLEDs, gas discharge displays, UV radiation sources

→ details can be found in course syllabus, recommended study plan etc.

5.3 Short information about module (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

The physical concepts of light generation as well
as the technical application of light sources will be presented. Students will be able to select suitable light sources, optical materials and other components according to the specific requirements.

6 **6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Bachelor degree in chemistry, chemical engineering, physics, or electrical engineering

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Proof of a seminar presentation and pass the exam

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

Written exam (180 minutes) or oral exam

6.4 Requirements for admission to examination

Enrollment in the programme, registration for examination (via myFH-Portal)

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/ak-tuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐German ☒ English ☐ others, namely:

7.2 Contact person for module:

Prof. Dr. T. Jüstel

7.3 Professors (optional)

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

Literature:

1. Scriptum, online @ www.fh-muenster.de/juestel and at ILIAS
2. K.H. Butler, Fluorescent Lamp Phosphors, University Park, PA (1980)
3. A.H. Kitai, Solid State Luminescence, Chapman & Hall, London (1993)
4. G. Blasse, B.C. Grabmeier, Luminescent Materials, Springer Verlag Berlin Heidelberg (1994)
5. W. Schmidt, Optische Spektroskopie, VCH (1995)
6. J.R. Coaton, A.M. Marsden, Lamps and Lighting, Arnold, London (1997)
7. D.R. Vij, Luminescence of Solids, Plenum Press, New York and London (1998)
8. S. Shinoya, W.M. Yen, Phosphor Handbook, CRC Press (1999)
9. Zukauskas, M.S. Shur, R. Caska, Introduction to Solid-State Lighting, John Wiley & Sons, Inc. (2002)
10. E.F. Schubert, Light Emitting Diodes, Cambridge Univ. Press (2003)
11. C.R. Ronda, Luminescence, Wiley-VCH (2008)
12. R. Pöttgen, T. Jüstel, C. Strassert, Rare Earth Chemistry, De Gruyter (2020)

4.5 Intercultural Communication and Competence

1	**1.1 Title of module (GER / ENG)** Intercultural Communication and Competence	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS) **ITB.2.0051.0**
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Materials Science and Engineering	Pf	2
	Master Photonics	WPf	2
	Master Wirtschaftsingenieurwesen	Pf	2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecuture	1	15	**90**	**3**
	Excercise	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 2	Sum contact hours in hrs. 30		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures and exercises		60		
	Sum		Sum self-study in hrs 60		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

Students will develop the capacity for intercultural sensitivity in order to navigate international business relationships, whether in technical or commercial projects. After completion of the module, students will be able to describe different cultural dimensions and general terms within the framework of Intercultural Communication. They will be able to analyse various cultural spaces according to this structure. In addition to this, they will be able to compare organisational cultures, especially in multi-nationals.
Comparative cultural management will be explored, especially in the area of intercultural leadership and effective multi-cultural teamwork.
Self-awareness is an important factor in cross-cultural work processes in order to deal with global demands. The activities in this course offer students a practical training in team and communication skills. Through practical activities, students will learn culturally different approaches to presentation, negotiation, problem-solving strategies as well as planning and decision-making strategies.

5.2 Course content

Students will receive an overview of different cultural dimensions and general terms within the framework of Intercultural Communication. Various cultural spaces will then be analysed according to this structure. Following this organisational culture, especially in multi-nationals will be compared.
Comparative cultural management will be explored, especially in the area of intercultural leadership and effective multi-cultural teamwork.
→ details can be found in course syllabus, recommended study plan etc.

	5.3 Short information about module (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.) The global market has challenges. In order to be able to deal with this, you will learn in this module how to confidently conduct intercultural business.
6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise; module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Advanced English
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Regular participation in the course. Passing of the exam.
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Seminar paper in English.
	6.4 Requirements for admission to examination Course participation
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐German ☒ English ☐ others, namely:
	7.2 Contact person for module: Dr. Erika Auschner
	7.3 Professors (optional)
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.) Literature: A list of suggested literature as well different essays to the topic is available on the ILIAS platform.

4.6 Microscopy and Surface Science

1	**1.1 Title of module (GER / ENG)** Microscopy and Surface Science	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Materials Science and Engineering	Wpf	2
	Master Photonics	Wpf	2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Seminaristic	3	45	**180**	**6**
	Pracitce	2	30		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of seminar and exam		105		
	Sum		Sum self-study in hrs 105		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

After the participation in the module "Microscopy and Surface Science" the participants can explain the different approaches and the procedures of microscopy, electron microscopy and surface analysis. Furthermore the students are able to carry out scanning electron microscopic procedures on their own by getting practical exercises at an electron microscope. This allows analysis to be performed in which the surface of the object is imaged with electrons and the material of a sample can be determined.

5.2 Course content

- Optical microscopy
- Elektronenmikroskopie / Electron microscopy (REM, TEM)
- X-Ray micro analysis (EDX. WDX)
- Atomic Force microscopy (AFM, STM, SNOM)
- Techniques of surface analysis (UPS, AES, XPS)

→ details can be found in course syllabus, recommended study plan etc.

5 5.3 Short information about module (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

The module "Microscopy and Surface Science" enables the participants to explain different approaches and the procedures of microscopy, electron microscopy, Atomic Force Microscopy and Photoelectron based surface analysis.

6	**6.1 Prerequisits** (*formal*: examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Bachelor degree in chemistry, chemical engineering, physics, engineering physics or similar bachelor programms
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing practical and passing the examination
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Oral / written examination
	6.4 Requirements for admission to examination Enrollment in the programme, register for the examination (myFH-Portal) and passing practical
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐German ☒ English ☐ others, namely:
	7.2 Contact person for module: Prof. Dr. Hans-Christoph Mertins
	7.3 Professors (optional)
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.) Literature - lecture notes - J.I. Goldstein et al, Scanning Electron Microscopy and X-ray Microanalysis, Springer (2018) - B. Fultz, J.M. NHowe, Transmission Electron Microscopy and Diffractometry of Materials, Springer - J. Thomas, T. Gemming, Analytische Transmissions-Elektronenmikroskopie, Springer 2013iteratur:

4.7 Modelling and Simulation

1	**1.1 Title of module (GER / ENG)** Modellierung und computergestützte Simulation / Modelling and Simulation	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	WPf	2
	Master Biomedizinische Technik	WPf	2
	Master Materials Science and Engineering	WPf	2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	2	30	**180**	**6**
	Practical course	2	30		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden")	Sum contact hours in hrs. 60		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	preparation and follow-up work		40		
	work on the project		40		
	preparation for assignments		40		
	Sum		Sum self-study in hrs 120		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

After successful completion of the module, students will be able to ...

... describe systems from natural sciences and engineering by mathematical modelling and implement numerical simulations of these models.

... carry out numerical simulation studies by selecting a suitable modelling in order to investigate engineering problems.

... consider limitations as well as possible sources of error of the numerical simulation in the interpretation of simulation results.

... set up and carry out a simulation study in a team for a given or self-selected task, critically analyse and present the results.

5.2 Course content

In this module, students learn the basics of modelling and computer-aided simulation in lectures and practical exercises. The following contents are taught:

- Mathematical description of systems using continuum models and discrete models

	- Implementation of numerical standard procedures - Numerical simulation schemes for ordinary and partial differential equations (initial value and boundary value problems) and discrete systems - Stochastic methods - Estimation of numerical errors and analysis of convergence behaviour The students work in small groups on a final project that takes up the above-mentioned aspects. They develop a model for a given or self-selected problem, carry out the simulation and evaluation and present their approach and the result in a final lecture and a paper. → details can be found in course syllabus, recommended study plan etc.
5	**5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms. In this course, you will employ modelling and computer-aided simulation to investigate engineering problems. You will learn to perform numerical simulation studies and interpret the simulation results.
6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* The following knowledge and skills should have been acquired: programming and basic knowledge of mathematics, e.g. about differential equations
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Successful completion of the project and passing final examination
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) Presentation of the final project (30 min) and written exam (120 min) or oral exam (30 min)
	6.4 Requirements for admission to examination Regular participation in the practical course
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐German ☒ English ☐ others, namely:
	7.2 Contact person for module: Prof. Dr. Sarah Trinschek
	7.3 Professors (optional) Prof. Dr. Sarah Trinschek
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

4.8 Optical Coherence Tomography

1	**1.1 Title of module (GER / ENG)** Optical Coherence Tomography	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☐ **each summer semester,** ☒ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	WPf	3
	Master Materials Science and Engineering	WPf	3
	Master Biomedical Engineering	WPf	3

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	3	45	**180**	**6**
	Exercise class	1	15		
	Lab class	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures, exercises, and lab class.		105		
	Sum		Sum self-study in hrs 105		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students know the different flavours of optical coherence tomography (OCT) and they can orally present their key properties from the underlying math. The students can present the optical key components to achieve OCT and use them to sketch general OCT systems. The students can explain the noise figures relevant to OCT and how they degrade the image quality. The students can explain the benefits of OCT compared to other imaging techniques based on applications.

The students are trained to use a laboratory OCT system and can conduct experiments with different samples. They are able to share their results with a broader audience.

5.2 Course content

The course introduces the mathematical background of optical coherence tomography (OCT). The theory is used to describe the major flavours of OCT, namely time-domain and Fourier-domain OCT. Scanning techniques and the latest trends in this field are discussed. Imaging of samples is performed in the laboratory to understand the strengths and weaknesses of this imaging technique.

→ details can be found in course syllabus, recommended study plan etc.

5	**5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms. After completing the course, you will know the underlying working principle of the high-resolution interferometric imaging technique called OCT with applications in medical diagnostics, life science, and material inspection.
6	**6.1 Prerequisits** (*formal*: examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* Knowledge of math (Analysis), physics (electromagnetic waves), and signals (Fourier transformation) should have been acquired.
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing the examination.
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) The module exam will be one or a combination of the following formats: written exam (120 min), oral exam (30 min), presentation (30 min), or written paper.
	6.4 Requirements for admission to examination Attendance and successful completion of the lab class work, enrollment in the degree programme, and register for the examination.
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐German ☒ English ☐ others, namely:
	7.2 Contact person for module: Prof. Dr. techn. Vogelbacher
	7.3 Professors (optional) Prof. Dr. techn. Vogelbacher
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

4.9 Optical Communications

1	1.1 Title of module (GER / ENG)	1.2 Short description (optional)	1.3 Module code (from HIS-POS)
	Optical Communications		

2	2.1 Cycle of module:	2.2 Duration of module
	☐ each summer semester, ☒ each winter semester other cycle, namely:	☒ 1 semester ☐ 2 semesters

3	3.1 Module offered in the following study programme(s):	3.2 Compulsory **(Pf)**, compulsory elective **(WPf)**, elective **(W)**	3.3 Recommended semester:
	Master Eletrotechnik	Wpf	1 / 3
	Master Informatik	Wpf	1 / 3
	Master Photonics	Wpf	1 / 3

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Seminaristic	2	30		
	Exercise	1	15		
	Lab cours	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 4	Sum contact hours in hrs. 60	**6**	**180**
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation, revision of seminar, exercise and lab cours, preparation of exam		120		
	Sum		Sum self-study in hrs 120		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students know well the composition and the function of components, systems and applications of optical communications. They can distinguish the different fiber types and know, which transmission system should be used in a specific communication task. They have learned how to measure source spectra, how to splice fibers, how to assemble fiber connectors and how to use optical time domain reflectometry to analyze fiber links.

In summary: the students are able to design optical communication systems, to build them up and to characterize them.

5.2 Course content

Introduction:
Historical development of optical communications, advantages and disadvantages of fiber optics

Optical basics:
The nature of light, propagation velocity, refractive index, ray optics, polarization, interference, coherence, dielectric filters

Optical fibers:

Basics, multi-mode fibers, mode formation in waveguides, single mode fibers, attenuation, dispersion, bandwidth-length-product, optical cables

Fiber connection technology:
Optical splices, optical connectors, coupling losses, reflection losses

Optical transmitters and receivers:
Light emitting diodes, laser diodes, transmitter circuits, optical amplifiers, photo diodes, receiver circuits

Optical measurement technology:
Basic attenuation measurements, optical time domain reflectometry

System technology and components:
Wavelength division multiplexing technology, photonic components, integrated optics

Real optical communication systems:
Wide area networks, metropolitan area networks, local area networks, fibers to the customer

Laboratory experiments:
Optical sources, optical time domain reflectometry, optical splices, connector assembling and attenuation measurements

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

The students learn to know the composition and the function of components, systems and applications of optical communications. In the practical courses they will be able to design optical systems, to build them up and to characterize them.

6 **6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Knowledge of physics, semiconductor devices, electronic circuits

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing the written examination

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

Written examination, 2 hours

6.4 Requirements for admission to examination

Attestation of successfully finished laboratory experiments

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/ak-tuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐**German** ☒ **English** ☐ **others, namely:**

7.2 Contact person for module:

Prof. Dr.-Ing. Konrad Mertens

7.3 Professors (optional)

Prof. Dr.-Ing. Konrad Mertens

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

4.10 Photonic Crystals and Materials

1	**1.1 Title of module (GER / ENG)** Photonic Crystals and Materials	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	WPf	2
	Master Materials Science and Engineering	WPf	2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	3	45	**180**	**6**
	Exercise class	1	15		
	Lab class	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures, exercises, and lab class		105		
	Sum		Sum self-study in hrs 105		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students know the properties of selected materials to suggest their application in specific scenarios. They can explain the underlying physics of materials that show specific optical properties. The students can orally describe the assumptions for material models (Drude/Drude-Lorentz model, nonlinear materials), and they can present the working principle of photonic crystals and metamaterials to a technical audience. The students are able to read a band diagram of a photonic crystal to estimate the band gap. Furthermore, the students know about engineered refractive indices and how to achieve them.

5.2 Course content

The course covers advanced photonic materials for applications beyond the visible range and with special properties from microscale/nanoscale structures.

The topics are as follows:

- Conventional optical materials (technical glasses)
- Materials in optics outside the visible spectrum
  - EUV, UV, NIR, THz
- Metals (plasmonics)
  - Drude and Drude-Lorentz material model
  - Surface plasmon resonance (SPR)

- Localized Surface Plasmon Resonance (LSPR)
- Nonlinear materials
- Physics of (nano-)structured surfaces and volumes
    - Bioinspired structures
    - Antireflection
    - Light harvesting enhancement
    - SERS: Surface enhanced Raman spectroscopy
    - Photonic crystals
- Metamaterials
- Optical vortex generation

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

You know advanced photonic materials with tailored optical properties, for example, structured surfaces and metamaterials, so you can successfully employ them for demanding technical applications.

6 **6.1 Prerequisits** (*formal*: examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

The following knowledge and skills should have been acquired: electromagnetic waves.

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing the examination.

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

The module exam will be one or a combination of the following formats: written exam (120 min), oral exam (30 min), presentation (30 min), or written paper.

6.4 Requirements for admission to examination

Attendance to the module courses, passing the exercise and lab classes, enrollment in the degree programme, register for the examination.

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐ **German** ☒ **English** ☐ **others, namely:**

7.2 Contact person for module:

Prof. Dr. techn. Florian Vogelbacher

7.3 Professors (optional)

Prof. Dr. techn. Florian Vogelbacher

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

4.11 Photonic Integrated Circuits

1	1.1 Title of module (GER / ENG) Photonic Integrated Circuits	1.2 Short description (optional)	1.3 Module code (from HIS-POS)
2	2.1 Cycle of module: ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	2.2 Duration of module ☒ **1 semester** ☐ **2 semesters**	
3	3.1 Module offered in the following study programme(s): Master Photonics	3.2 Compulsory **(Pf)**, compulsory elective **(WPf)**, elective **(W)** WPf	3.3 Recommended semester: 2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Seminar	3	45	**180**	**6**
	Exercise class	1	15		
	Lab class	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures, exercises, and lab class.		105		
	Sum		Sum self-study in hrs 105		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students are familiar with major optical components used in photonic integrated circuits and can orally explain the working principle of these components. The corresponding fabrication methods can be schematically sketched. The students understand the underlying electromagnetic theory of waveguiding and can use this knowledge to explain the key properties of theoretical results/formulas/diagrams. The students are able to use specialized software tools to calculate eigenmodes of waveguides, extract the electromagnetic fields, calculate the propagation in 3D structures, and optimize the performance. They are able to explain the benefits and limitations of specific electrodynamic solvers. The students can design small-scale photonic integrated circuits employing CAD tools.

The students are able to independently find a solution to a given problem by sharing tasks in a group and establishing a task-orientated project group. The students can present their results to a technical audience/person. The students can transfer their acquired knowledge to specific industrial applications.

5.2 Course content

Built on knowledge about integrated devices, for example, electronic integrated circuits, the course specializes in the design of advanced photonic integrated circuits. Software tools, such as finite-difference time-domain (FDTD) and finite-element method (FEM), are introduced to calculate the eigenmodes of optical waveguides with different cross-sections and the propagation in extended structures. Integrated optical components are introduced and optimization approaches are used to improve the performance for specific situations. Central topics that will be covered are dielectric and plasmonic waveguides, photonic crystal waveguides, integrated optical components, integrated light sources and modulators, and couplers. The applications covered by the course include data- and telecommunication, sensors, and quantum computing.

→ details can be found in course syllabus, recommended study plan etc.

5	**5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms. The module includes theoretical and practical aspects of designing advanced photonic integrated circuits. This prepares you to work on photonic projects in the semiconductor industry and in applied research.
6	**6.1 Prerequisits** (*formal:* examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)* The module “Integrated Devices” should have been attended. The students should have a basic understanding of electrodynamics and optics.
	6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation) Passing the examination.
	6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes) The module exam will be one or a combination of the following formats: written exam (120 min), oral exam (30 min), presentation (30 min), or written paper.
	6.4 Requirements for admission to examination Attendance and successful completion of the lab class work, enrollment in the degree programme, and register for the examination.
	6.5 Weighing of module grade when calculating final grade see examination regulations for aforementioned study programmes (line 3).* *You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.
7	**7.1 Languages used in the module:** ☐German ☒ English ☐ others, namely:
	7.2 Contact person for module: Prof. Dr. techn. Vogelbacher, Prof. Dr. Gregor
	7.3 Professors (optional) Prof. Dr. techn. Vogelbacher, Prof. Dr. Gregor
	7.4 Maximum number of participants (optional)
	7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.) Literature: reading recommendations are given at the beginning of the lecture.

4.12 Photovoltaic Systems

1	**1.1 Title of module (GER / ENG)** Photovoltaic Systems	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)	
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**		
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**	
	Master Elektrotechnik	Pf	2	
	Master Elektrotechnik (dual)	Pf	4	
	Master Photonics	Wpf	2	

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Seminaristic	2	30	**180**	**6**
	Exercise	1	15		
	Lab cours	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 4	Sum contact hours in hrs. 60		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of seminar, exercise and lab		110		
	Preparation of seminar paper		10		
	Sum		Sum self-study in hrs 120		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

The students know the fundamentals, the technologies, the systems and areas of application of photovoltaics and are able to design and characterise photovoltaic systems.

They can measure photovoltaic systems with suitable equipment and optimise the wiring of solar generators. They also know common simulation programmes and can use them to dimension photovoltaic systems.

The students are able to prepare and present a technical problem in photovoltaics by means of the prepare, document and present a technical issue in photovoltaics.

5.2 Course content

Introduction and overview:
What is energy? Structure of energy supply, problems of energy supply, overview of renewable energies, advantages and disadvantages of renewable energies.

Radiation from the sun:
Solar constant, global radiation, diffuse radiation, direct radiation, radiation on inclined surfaces, measurement of solar radiation, radiation supply and world energy consumption

Basics of photovoltaics:

History, absorption in semiconductors, reflection coefficient, anti-reflective coating, quantum efficiency, direct and indirect semiconductors, pn junction, photodiode, solar cell, characteristic curve, equivalent circuit diagrams, parameters, temperature behaviour

Cell technologies:
Crystalline silicon cells: Wafer and cell production, module production, cell interconnection.
Thin-film cells: Amorphous silicon cells, other cell materials,
high-efficiency cells, concentrator cells

System technology:
Solar generator and load: resistive load, DC-DC converter, MPP tracker,
Grid-connected systems: system design, inverters, system types, system yields, system monitoring.
Off-grid systems: Accumulators, charge controllers, solar home systems, hybrid systems, dimensioning of off-grid systems

Ecological issues:
Energy payback time, emissions from photovoltaics

Future development:
Market and price development, efficient promotion instruments, technical potential of photovoltaics, scenarios of a future energy policy

Practical course:
Characteristic curve recording and parameter determination

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

The students learn the fundamentals and technologies, the systems and areas of application of photovoltaics and are able to design and characterise photovoltaic systems. They also learn to know current simulation tools.

6 **6.1 Prerequisits** (*formal*: examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Bachelor's degree in electrical engineering, physics, engineering physics or similar programme

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing the exam

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

Written or oral exam

6.4 Requirements for admission to examination

Successful participation of the lab cours, successful completition of the seminar paper

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☒German ☒ English ☐ others, namely:

7.2 Contact person for module:

Prof. Dr.-Ing. Konrad Mertens

7.3 Professors (optional)

Prof. Dr.-Ing. Konrad Mertens

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

Technical literature (selection):

[1] Mertens, K: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis, Hanser
[2] Häberlin, H.: Photovoltaics - Electricity from sunlight for interconnected and stand-alone systems, VDE
[3] Quaschning, V.: Regenerative Energy Systems, Hanser
[4] Wagner, A.: Photovoltaic Engineering, Springer

4.12 Quantum Statistical Physics

1	**1.1 Title of module (GER / ENG)** Quantum Statistical Physics	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☒ **each summer semester,** ☐ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):** Master Photonics	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)** WPf	**3.3 Recommended semester:** 2

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	lecture	4	60	**180**	**6**
	exercise	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semesterwochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)			105		
	Sum		Sum self-study in hrs 105		

5 5.1 Intended learning outcomes (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

After completion of the module, the students can calculate thermodynamic properties with the help of microscopic statistical ensembles. The students will be able to determine simple distributions and to apply them in different fields of physics. Basic knowledge of statistical and quantum physics will be acquired on the basis of which the students will work in modern topics of materials science. To this aim the own work on notes of the lecture will be practiced and the ability for self-responsible study will be learned. Practical exercises and programming with MATHEMATICA allows to become acquainted with main algorithms.

Applications:
Problems of pattern formation, development of clusters, transport properties in solid state physics, practical programming examples in *Mathematica*.

5.2 Course content

1. Entropy, distribution functions, description of many-particle systems
(i) Calculation of thermodynamic potentials, statistical distributions of molecules and photons
(ii) Chaotic behavior of dynamical systems, decay processes
(iii) Molecular dynamics and Monte-Carlo simulations
(iv) Ising model, metropolis algorithm, testparticle method
(v) Cellular automates
(vi) Percolation and cluster recognition
(vii) Growth and patteern formation

2. Introduction into quantum mechanics
(i) concepts (ii) Schroedinger equation (iii) second quantization (iv) quantum statistics

3. Properties and application of Boltzmann equation
(i) hydrodynamcs equations (ii) transport in gases, liquids, metals and solid states (iii) applications in optical physics, biology, photonics

<u>4. Materials properties</u>
(i) transition rates and selection rules (ii) Landau theory of Fermi liquids (iiI) superconductivity and Bose-Einstein condensation (iv) localization in disordered systems

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

The students learn to calculate thermodynamic properties with the help of microscopic statistical ensembles and will be able to determine simple distributions to apply them in different fields of physics. Basic knowledge of statistical and quantum physics will be acquired on the basis of which the students can work in modern topics of materials science. To this aim the own work on notes of the lecture will be practiced and the ability for self-responsible study will be learned. Practical exercises and programming with MATHEMATICA allows to become acquainted with main algorithms.

6 **6.1 Prerequisits** (<u>*formal*</u>*:* examination of module XY has to be passed or similar <u>*content-wise*</u>; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Knowledge of mathematics I-III, Fourier transform, vector calculus

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing of exam or defence of project work

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

Written exam of 90 minutes or oral presentation of project work about 20 minutes

6.4 Requirements for admission to examination

none

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐German ☒ English ☐ others, namely:

7.2 Contact person for module:

Prof. Dr. Klaus Morawetz

7.3 Professors (optional)

Prof. Dr. Klaus Morawetz

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

4.12 Solid State Physics and Semiconductors

1	**1.1 Title of module (GER / ENG)** Solid State Physics and Seminconductors	**1.2 Short description (optional)**	**1.3 Module code** (from HIS-POS)
2	**2.1 Cycle of module:** ☐ **each summer semester,** ☒ **each winter semester** **other cycle, namely:**	**2.2 Duration of module** ☒ **1 semester** ☐ **2 semesters**	
3	**3.1 Module offered in the following study programme(s):**	**3.2 Compulsory (Pf), compulsory elective (WPf), elective (W)**	**3.3 Recommended semester:**
	Master Photonics	Wpf	1 / 3
	Master Materials Science and Engineering	Pf	1 / 3

4 Workload

	Teaching methods	Weekly teaching hours ("Semesterwochenstunde") per teaching method	Hours in semester per teaching method 1 weekly teaching hour per semester can be indicated as 15 hours, i.e. 1 weekly teaching hour = 1 hour x 15 semester weeks	Workload in total: Workload in hours sum contact hours and self-study in hrs.	Workload in total: ECTS (credit points) generally 30 hrs. = 1 credit point; only full numbers allowed
Contact hours (e.g. lecture, seminar, practical course, practical phase/internship, group work, project work, case study, simulation game, credited tutorial (addtional lines possible)	Lecture	4	60	**180**	**6**
	Exercise	1	15		
	Sums	Sum contact hours in weekly teaching hours ("Semester-wochenstunden") 5	Sum contact hours in hrs. 75		
Self-study (e.g. tutorial, preparation, follow-up work, preparation for assignments and homeworks, research etc.)	Preparation and revision of lectures and excerise		105		
	Sum		Sum self-study in hrs 105		

5 **5.1 Intended learning outcomes** (What should students be able to do after having accomplished the module? Does the module provide the opportunity to acquire soft skills in addition to professional knowledge? For which other modules and prospective tasks in the labour market are the acquired knowledge and skills relevant?)

After the participation in the module "Solid State Physics and Semiconductors" the students have a basic knowledge of solid state and semiconductor physics which they can apply to any concrete case in materials science. During the seminar they are enabled to operate with current research areas and to present the knowledge in scientific papers and presentations and to solve problems and develop materials.

5.2 Course content

- Principles of crystalline structure
- Diffraction and reciprocal lattice
- Bonding processes
- Phonons
- Free electron gas
- Bandstructure
- Semiconductors and doping
- Superconductivity
- Magnetism
- Interaction of light and matter
- Physics of surfaces and interfaces
- Experimental spectroscopy techniques
- Nano structures

→ details can be found in course syllabus, recommended study plan etc.

5 **5.3 Short information about module** (This paragraph [max. 250 characters] will be published on the website of FH Münster to support persons interested in studying at FH Münster to choose the appropriate study programme. Please focus on the main intended learning outcomes and course content, ideally also comprising information about the relevance of the module for the further course of study and the labour market. Please formulate whole sentences, address your (prospective) students directly and avoid technical terms.

The module “Solid State Physics and Semiconductors" enables students to apply basic knowledge of solid state and semiconductor physics to any practical case in materials science.

6 **6.1 Prerequisits** (*formal*: examination of module XY has to be passed or similar *content-wise*; *module XY should have been attended, the following knowledge and skills should have been acquired: ….)*

Bachelor degree in chemistry, chemical engineering, physics, engineering physics or similar bachelor programme

6.2 Requirements for awarding credit points (e.g. passing final examination, successful accomplishment of assignments in the course of study, regular active participation)

Passing the exam

6.3 Type and extent of examination (e.g. written exam, oral exam, term paper, presentation, portfolio, duration of examination in minutes)

Oral / written exam

6.4 Requirements for admission to examination

Enrollment in the programme, register for the examination (myFH-Portal)

6.5 Weighing of module grade when calculating final grade

see examination regulations for aforementioned study programmes (line 3).*

*You will find the examination regulations of all study programmes in the official announcements of the FH Münster: https://www.fh-muenster.de/hochschule/aktuelles/amtliche_bekanntmachungen/index.php?p=2,7.

7 **7.1 Languages used in the module:**

☐ **German** ☒ **English** ☐ **others, namely:**

7.2 Contact person for module:

Prof. Dr. Hans-Christoph Mertins

7.3 Professors (optional)

Prof. Dr. Hans-Christoph Mertins

7.4 Maximum number of participants (optional)

7.5 Further information (optional) (e.g. literature recommendations, other persons involved, etc.)

- Script
- C. Kittel, Introduction to solid state physics, Wiley 2004
- H. Ibach, H. Lüth, Solid state physics, Springer, 1996
- R. Gross, A. Marx, Festkörperphysik, De Gruyter, 2018

4.12 Free Optional Module

As elective module, students can choose a module according to their interests from the range of modules offered by the master's degree programs at Münster University of Applied Sciences. The selected module must have at least six credit points.

When freely choosing from the module offerings of the Master's degree programs at Münster University of Applied Sciences, the following must be taken into account:

- The Department of Engineering Physics cannot guarantee that courses and examinations for this module will not overlap
- The student is responsible for planning lectures and examinations for the elective module
- Regarding modules form other deparments, the student must obtain permission from the lecturer and the department to attend the courses und to take the exam.