Module Catalogue
for the Subject

Functional Materials
as a Master’s with 1 major
with the degree "Master of Science"
(120 ECTS credits)

Examination regulations version: 2022
Responsible: Faculty of Medicine
Responsible: Faculty of Chemistry and Pharmacy
Responsible: Chair of Chemical Technology of Material Synthesis
Responsible: Faculty of Physics and Astronomy
Responsible: University of Applied Sciences Würzburg- Schweinfurt (FHWS)
## Contents

The subject is divided into

### Content and Objectives of the Programme

### Abbreviations used, Conventions, Notes, In accordance with

### Compulsory Courses

- Mechanical and Thermal Material Properties
- Opto-Electronic Material Properties
- Materials Science 3
- Organic Functional Materials
- Research Project 1
- Research Project 2

### Compulsory Electives

#### Subfield Focus Topic

- **Focus Topic I: Functional Materials in Biology and Medicine**
  - Biopolymers
  - Biofabrication
  - Functional Materials in Implantology
  - Nano4Med
  - Tissue cells meet materials

- **Focus Topic II: Polymer Functional Materials**
  - Biofabrication
  - Polymer Materials 1: Technology of Polymer Modification
  - Additive Manufacturing
  - Polymer Materials 2: Technology of Filler Modification for Polymer Materials
  - Polymers II

- **Focus Topic III: Energy Technologies**
  - Electrochemical Energy Storage and Conversion
  - Structure-Properties Correlations of Light Materials - Experiments and Numerical Simulations
  - Materials for High Voltage insulation and High Voltage Systems
  - Nanotechnology in Energy Research
  - Principles of Energy Technologies
  - Optical Properties of Semiconductor Nanostructures

- **Focus Topic IV: Semiconductor Nanostructures**
  - Semiconductor Physics
  - Physics of Semiconductor Devices
  - Organic Semiconductors
  - Coating Technologies based on Vapour Deposition
  - Optical Properties of Semiconductor Nanostructures

- **Focus Topic V: Organic Functional Materials and Applications**
  - Chemical Nanotechnology: Analytics and Applications
  - Polymer Materials 1: Technology of Polymer Modification
  - Nanoscale Materials
  - Polymer Materials 2: Technology of Filler Modification for Polymer Materials
  - Supramolecular Chemistry (Basics)
  - Physical Chemistry of Supramolecular Assemblies

- **Focus Topic VI: Imaging und Spectroscopy**
  - Principles of Two- and Three-Dimensional Röntgen Imaging
  - Advanced Computer Tomography
  - Electron and Ion Microscopy
  - Laser Spectroscopy

#### Subfield General Compulsory Electives

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Content and Objectives of the Programme

The Functional Materials programme is offered by the Faculty of Chemistry and Pharmacy with the participation of the Faculty of Physics and Astronomy, the Medical Faculty of the JMU and the University of Applied Sciences Würzburg-Schweinfurt as a research-oriented course with the degree "Master of Science" (M.Sc.) as part of a consecutive Bachelor-Master study model.

The course prepares you for scientific work in the fields of functional materials and materials science and related fields as well as for a doctorate (Dr. re. of course before. The aim of the training is to provide students with both the basics of content and in-depth knowledge of scientific work according to the rules of good scientific practice in research and application. Through the education and training of independent thinking, the students acquire the ability to apply the basic knowledge they have acquired and to transfer it to new tasks, as well as to familiarize themselves with new areas of responsibility.
Abbreviations used

Course types: E = field trip, K = colloquium, O = conversatorium, P = placement/lab course, R = project, S = seminar, T = tutorial, Ü = exercise, V = lecture

Term: SS = summer semester, WS = winter semester

Methods of grading: NUM = numerical grade, B/NB = (not) successfully completed

Regulations: (L)ASPO = general academic and examination regulations (for teaching-degree programmes), FSB = subject-specific provisions, SFB = list of modules

Other: A = thesis, LV = course(s), PL = assessment(s), TN = participants, VL = prerequisite(s)

Conventions

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

Notes

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

In accordance with

the general regulations governing the degree subject described in this module catalogue:

ASPO2015

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

22-Mar-2022 (2022-9)

This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding. In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.
Compulsory Courses

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**Contents**
Physical laws of solids: Bonding and structure, lattice dynamics, thermal and mechanical properties.

**Intended learning outcomes**
The students have knowledge of mechanical/thermal material characteristics.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)
Module taught in: Ü: German or English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)

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**Contents**

Physical principles of optoelectronic material properties and applications..

**Intended learning outcomes**

The students know the principles of optoelectronic material characteristics.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

Module taught in: Ü: German or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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<td>holder of the Chair of Functional Materials in Medicine and Dentistry</td>
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### Contents

The module covers advanced topics in current areas of materials science, such as polymeric materials, nanoparticles, and solids.

### Intended learning outcomes

Students acquire a comprehensive understanding of modern materials. This includes the production, characterization, properties and application of materials.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) written examination (approx. 90 to 180 minutes) or
- b) oral examination of one candidate each (20 to 30 minutes) or
- c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or
- d) log (approx. 20 pages) or
- e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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### Module title
Organic Functional Materials

### Abbreviation
08-OCM-FM-161-m01

### Module coordinator
Lecturer of the seminar "Organische Funktionsmaterialien"

### Module offered by
Institute of Organic Chemistry

### ECTS
5

### Method of grading
Numerical grade

### Only after succ. compl. of module(s)
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### Duration
1 semester

### Module level
Graduate

### Other prerequisites
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### Contents
This module discusses advanced topics in organic functional materials. It focuses on basic physical effects, organic solids, the application of organic functional materials as well as organic and metal-organic polymer chemistry.

### Intended learning outcomes
Students are able to explain the basic physical properties of organic functional materials. They are able to name and characterise organic solids and their applications in modern chemistry. Students are able to outline the fundamental principles of organic and metal-organic polymer chemistry and to name polymers of technological importance.

### Courses
(type, number of weekly contact hours, language — if other than German)

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### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO 1
(examination regulations for teaching-degree programmes)

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<table>
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<tr>
<th>Module title</th>
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<td>08-FU-PR1-161-m01</td>
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<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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**Contents**

Independent laboratory course in the area of functional materials.

**Intended learning outcomes**

The students gain advanced knowledge in independent research and scientific documentation.

**Courses**

(type, number of weekly contact hours, language — if other than German)

R (10)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

report (approx. 25 pages)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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**Module coordinator**

degree programme coordinator Funktionswerkstoffe (Functional Materials)

**Module offered by**

Chair of Chemical Technology of Material Synthesis

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**Contents**

Independent laboratory course in the area of functional materials.

**Intended learning outcomes**

The students gain advanced knowledge in independent research and scientific documentation.

**Courses**

(type, number of weekly contact hours, language — if other than German)

| R (10) |

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Report (approx. 25 pages)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
Compulsory Electives
(50 ECTS credits)
Subfield Focus Topic
(30 ECTS credits)

Two focus topics are to be selected, from which modules of 15 ECTS credits each are to be completed.
Focus Topic I: Functional Materials in Biology and Medicine
(0 or 15 ECTS credits)
Module title | Abbreviation
--- | ---
Biopolymers | 03-BIOPOL-222-m01

Module coordinator | Module offered by
--- | ---
holder of the Chair of Macromolecular Chemistry | Faculty of Medicine

ECTS | Method of grading | Only after succ. compl. of module(s)
--- | --- | ---
5 | numerical grade | --

Duration | Module level | Other prerequisites
--- | --- | ---
1 semester | -- | --

Contents
Organisms produce biologically active macromolecules (polysaccharides, proteins, nucleic acids, etc.) that perform (survival) important functions in structure, movement, recognition, metabolic and information storage. These naturally occurring polymers can also be isolated, chemically modified and commercialized for further applications. In addition, novel macromolecules can additionally be synthetically derived from bio-based feedstocks, which are increasingly used as sustainable and degradable biopolymers.

Intended learning outcomes
The student will acquire fundamental knowledge of naturally occurring macromolecules, their production, function, modification, and application in various biological contexts and everyday areas.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + Ü (1) + P (1)
Module taught in: V, Ü: English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90) or
b) oral examination of one candidate each (20 to 30 minutes) or
c) talk (approx. 30)
Language of assessment: English

Allocation of places
--

Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module title
Biofabrication

Abbreviation
03-BIOFAB-222-m01

Module coordinator
holder of the Chair of Functional Materials in Medicine and Dentistry

Module offered by
Faculty of Medicine

ECTS
5

Method of grading
Numerical grade

Only after succ. compl. of module(s)
--

Duration
1 semester

Module level
Graduate

Other prerequisites
--

Contents
Definitions within biomaterials, tissue engineering and biofabrication, overview of medical device regulations and practices, description of extracellular matrix, bioprinting, continuous liquid interface polymerisation, two-photon polymerisation, fused deposition modelling, inorganic powder printing, stereolithography, selective laser sintering, melt electrospinning writing, self-healing hydrogels, polymers in 3D printing, introduction to rheology, scientific method and reproducibility, digital signal generation and quality control.

Intended learning outcomes
Students gain a thorough appreciation of the different additive manufacturing (3D printing) technologies available in the context of biofabrication. This includes how the polymers are processed and how each class of 3D printer works, with its strengths and weaknesses. A holistic view of biofabrication is taught, with an understanding of scientific methodology for each stage and the different regulations governing medical devices. Students will acquire the necessary skills to critique and develop opinions on the 3D printing industry and the resulting biomedical applications.

Courses
(V, Ü, P) (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + P (1)
Module taught in: V, Ü: English

Method of assessment
(a) written examination (approx. 90 minutes) or
(b) oral examination of one candidate each (20 to 30 minutes) or
(c) talk (approx. 30 minutes)

Language of assessment: English

Allocation of places
--

Additional information
--

Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title

**Functional Materials in Implantology**

**Abbreviation**

03-FU-IMPL-222-m01

### Module coordinator

holder of the Chair of Musculoskeletal Tissue Regeneration

### Module offered by

Chair of Chemical Technology of Material Synthesis

### ECTS

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### Contents

Anatomy and physiology of the cardiovascular system, sensory organs, skeletal system, jaw incl. tooth structure as well as pathological processes leading to functional impairment or even loss of function. Materials and use of medical implants in the respective area.

### Intended learning outcomes

Students receive in-depth basic knowledge in human physiology. They will also gain knowledge of pathological processes that can lead to the use of medical materials and implants. The students have knowledge of the application of implants in various organs and tissues and their compatibility and interaction with the organism.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + P (1)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) placement report / fieldwork report / report on practical training / report on practical course / project report / report on technical course (approx. 10 pages) or

b) presentation (approx. 30 minutes) or
c) written examination (approx. 60 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
### Module Catalogue for the Subject
**Functional Materials**

**Master's with 1 major, 120 ECTS credits**

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<td>Nano4Med</td>
<td>03-FU-DDEL-222-m01</td>
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### Contents

Incorporation and conjugation of active substances into particle systems, functionalization of the particle systems for transport, targeting and release of active ingredients.

### Intended learning outcomes

Incorporation and conjugation of active substances into particle systems, functionalization of the particle systems for transport, targeting and release of active ingredients.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (1) + Ü (1) + P (1)

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) placement report / fieldwork report / report on practical training / report on practical course / project report / report on technical course (approx. 10 pages) and  

b) presentation (approx. 30 minutes) or written examination (approx. 90 minutes)  

Language of assessment: German and/or English

### Allocation of places

--

### Additional information

--

### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
### Module title
Tissue cells meet materials

### Abbreviation
03-GEWMAT-222-m01

### Module coordinator
holder of the Chair of Tissue Engineering and Regenerative Medizin

### Module offered by
Chair of Chemical Technology of Material Synthesis

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
--

### Other prerequisites
--

### Contents
The module teaches the following contents: The cell culture techniques required for the construction of artificial tissues (tissue or also bioengineering), the basics of constructing such models using suitable (bio)materials, the use of such models as alternative test systems to animal experimentation. Another topic is the development of cell-based transplants, medical devices and drugs, as well as the regulatory basis for their approval (REACH, GLP, GMP, etc.).

### Intended learning outcomes
Students will gain content-related and methodological insights into current key topics in tissue engineering as well as the use of these tissues as substitutes for animal models or as transplants in regenerative medicine.

### Courses
(type, number of weekly contact hours, language — if other than German)
V (2) + P (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) placement report / fieldwork report / report on practical training / report on practical course / project report / report on technical course (approx. 10 pages) and
b) presentation (approx. 30 minutes) or written examination (approx. 90 minutes)
Language of assessment: German and/or English

### Allocation of places
--

### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
--
Focus Topic II: Polymer Functional Materials
(0 or 15 ECTS credits)
## Module Catalogue for the Subject
### Functional Materials
#### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
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<td>Biofabrication</td>
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### Contents

Definitions within biomaterials, tissue engineering and biofabrication, overview of medical device regulations and practices, description of extracellular matrix, bioprinting, continuous liquid interface polymerisation, two-photon polymerisation, fused deposition modelling, inorganic powder printing, stereolithography, selective laser sintering, melt electrospinning writing, self-healing hydrogels, polymers in 3D printing, introduction to rheology, scientific method and reproducibility, digital signal generation and quality control.

### Intended learning outcomes

Students gain a thorough appreciation of the different additive manufacturing (3D printing) technologies available in the context of biofabrication. This includes how the polymers are processed and how each class of 3D printer works, with its strengths and weaknesses. A holistic view of biofabrication is taught, with an understanding of scientific methodology for each stage and the different regulations governing medical devices. Students will acquire the necessary skills to critique and develop opinions on the 3D printing industry and the resulting biomedical applications.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + P (1)
Module taught in: V, Ü: English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or
b) oral examination of one candidate each (20 to 30 minutes) or
c) talk (approx. 30 minutes)
Language of assessment: English

### Allocation of places

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### Additional information

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### Referred to in LPO I

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<table>
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<td>Polymer Materials 1: Technology of Polymer Modification</td>
<td>08-FU-PW1-161-m01</td>
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<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
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## Contents
Methods of polymer synthesis; composition of polymers and polymer compounds; properties of polymers; technologies for the production of polymers compound and polymer components; means of characterisation of polymer compounds and polymer components.

## Intended learning outcomes
The students possess knowledge of the special properties of polymers and polymer compounds (e.g. time and temperature dependent viscoelastic behaviour). They know the characteristics of important production technologies (methods of polymer synthesis, compounding technologies, processing methods e.g. injection moulding) and understands the different ways of influencing properties of materials and manufactured products. They have knowledge of ways to calculate complex flow conditions in polymer processing machines and tools.

## Courses
(type, number of weekly contact hours, language — if other than German)
V (2) + P (2)

## Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate)
Assessment offered: Once a year, winter semester
Language of assessment: German and/or English
P: creditable for bonus

## Allocation of places
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## Additional information
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## Referred to in LPO I
(examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
---|---
Additive Manufacturing | 03-ADFER-222-m01

**Module coordinator**

holder of the Chair of Functional Materials in Medicine and Dentistry

**Module offered by**

Chair of Chemical Technology of Material Synthesis

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**Contents**

The course will cover the basics of additive manufacturing (AM) focusing on the techniques and materials used in AM. All aspects of the 3D printing chain, starting from the CAD design followed by slicing, printer selection and preparation to post processing, will be discussed. Participants will get the possibility to have hand-on experience with different printing methods during practical sessions. Based on current examples, options to transfer the process from prototyping to manufacturing and concepts to implement sustainability into additive manufacturing will be highlighted. The course will also focus on biomedical applications and options how 3D printing can be used in Biofabrication.

**Intended learning outcomes**

The student has advanced knowledge of the synthesis, modification and characterization of polymers.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + P (1)

Module taught in: V, Ü: English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or
b) oral examination of one candidate each (20 to 30 minutes) or
c) talk (approx. 30 minutes)

Language of assessment: English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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<table>
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<td>Polymer Materials 2: Technology of Filler Modification for Polymer Materials</td>
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**Contents**

Principles and technologies for the functionalization of additives and their utilization for the modification of polymers and their properties, interaction between polymers and additives and determination of the particular properties of such functionalized polymers (e.g. electric, bactericidal, flame retardant properties). Also the influence on other properties such as mechanical and rheological properties, color, turbidity and surface finish will be discussed.

**Intended learning outcomes**

The students possess knowledge on the technologies to functionalize polymeric materials with additives. They know the possibilities and issues regarding of such modifications, the interaction between additives and polymers. Moreover, they are qualified to determine particular properties of functionalized polymers (e.g. flame retardancy) and understand the interactions with other properties of the polymers, such as rheology, mechanical properties, color, turbidity or surface finish.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + P (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — If not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate)

Assessment offered: Once a year, summer semester

Language of assessment: German and/or English

P: creditable for bonus

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
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**Contents**
Basics as well as advanced knowledge about contemporary issues of polymer synthesis, -modification and characterization.

**Intended learning outcomes**
The student has advanced knowledge of the synthesis, modification and characterization of polymers.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (2) + P (2)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) written examination (approx. 90 minutes) or
- b) oral examination of one candidate each (20 to 30 minutes) or
- c) talk (approx. 30 minutes)

Language of assessment: German and/or English
P: creditable for bonus
Assessment offered: Once a year, winter semester

**Allocation of places**
--

**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
--
Focus Topic III: Energy Technologies
(0 or 15 ECTS credits)
Module title | Abbreviation
---|---
Electrochemical Energy Storage and Conversion | 08-FU-EEW-222-m01

Module coordinator | Module offered by
holder of the Chair of Chemical Technology of Material Synthesis | Chair of Chemical Technology of Material Synthesis

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
5 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | undergraduate | --

Contents
Chemistry and application of battery systems (aqueous and non-aqueous systems like lead, nickel cadmium and nickel metal hydride, sodium sulfur, sodium nickel chloride, lithium ion accumulators), electrochemical double layer capacitors, redox-flow battery, fuel cell systems (AFC, PEMFC, DMFC, PAFC, SOFC), Solar cells (Si, CIS, CIGS, GaAs, organic and dye solar cell), thermoelectric devices.

Intended learning outcomes
The students gain comprehensive knowledge in the field of electrochemical energy storage and transformation and are able to apply this to scientific problems.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + S (2)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 minutes) or oral examination of one candidate each (approx. 30 minutes) and
b) talk (approx. 30 minutes); (weighted 65:35)
Language of assessment: German and/or English
Assessment offered: Once a year, summer semester

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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<table>
<thead>
<tr>
<th><strong>Module title</strong></th>
<th><strong>Abbreviation</strong></th>
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</thead>
<tbody>
<tr>
<td>Structure-Properties Correlations of Light Materials - Experiments and Numerical Simulations</td>
<td>08-FU-MW-222-m01</td>
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</tbody>
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<table>
<thead>
<tr>
<th><strong>Module coordinator</strong></th>
<th><strong>Module offered by</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
</tr>
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<tr>
<th><strong>Duration</strong></th>
<th><strong>Module level</strong></th>
<th><strong>Other prerequisites</strong></th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</tbody>
</table>

**Contents**

Material properties of metals and ceramics: Structur-property relationships through experiments and simulation.

**Intended learning outcomes**

The students gain fundamental knowledge about the properties of modern materials: aviation aluminum alloys and high performance ceramics. Analytical methods and predictions through numerical simulations will be presented. The relationship of mikro- and nanoscopic structure of materials and the resulting properties are emphasized.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or oral examination of one candidate each (approx. 30 minutes) and
b) talk (approx. 30 minutes); (weighted 60:40)

Language of assessment: German and/or English

Assessment offered: Once a year, summer semester

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Materials for High Voltage insulation and High Voltage Systems</td>
<td>99-HIS-222-m01</td>
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</table>

**Module coordinator**

Dean of the Faculty of Electrical Engineering at the University of Applied Sciences Würzburg-Schweinfurt

**Module offered by**

University of Applied Sciences Würzburg-Schweinfurt (FHWS)

<table>
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</table>

**Duration**

1 semester

**Module level**

graduate

**Other prerequisites**

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**Contents**

Electrical stress, electrical strength, dielectric material properties, technology and application of insulating materials and systems, diagnostics, measurements, simulation and tests of insulating systems.

**Intended learning outcomes**

The student gain basic knowledge about the electrical field and insulating systems with layering of different materials. They can design simple insulating systems by their own and approve the existing design. They have basic knowledge in the field of diagnosis and technology of insulating materials.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (3) + Ü (1)

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or
b) oral examination of one candidate each (approx. 20 to 30 minutes) or
c) oral examination in groups (groups of 2, approx. 30 minutes total)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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Module title | Abbreviation
--- | ---
Nanotechnology in Energy Research | 11-NTE-152-m01

| Module coordinator | Module offered by |
--- | ---
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

| ECTS | Method of grading | Other prerequisites |
--- | --- | ---
6 | Only after succ. compl. of module(s) | -- |

| Duration | Module level |
--- | ---
1 semester | graduate |

Contents

Nanotechnology is of great significance for energy research. Energy efficiency can be heightened in numerous processes or applications by using special functional materials. This module covers special materials, surfaces and structures that have optimised properties due to effects of nanotechnology. It explains the underlying physical contexts. It uses specific materials and components as examples, such as thermal insulation materials, heat accumulators, functional nanoscale layer and particle systems with spectral selective properties, nanoporous vacuum insulations and electrode materials.

Intended learning outcomes

The students have specific and advanced knowledge of the application of nanotechnology in the field of energy research. They know methods of nanotechnology to influence the properties of materials and their applications. They are able to apply their knowledge to specific questions.

Courses

V (3) + R (1)
Module taught in: German or English

Method of assessment

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: Once a year, summer semester
Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
--- | ---
Principles of Energy Technologies | 11-ENT-152-m01

Module coordinator | Module offered by
--- | ---
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

<table>
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<td>graduate</td>
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</table>

Contents


Intended learning outcomes

The students know the principles of different methods of energy technology, especially energy conversion, transport and storage. They understand the structures of corresponding installations and are able to compare them.

Courses (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Assessment offered: Once a year, winter semester
Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)
§ 22 II Nr. 2 f)
§ 22 II Nr. 3 f)
Module title: Optical Properties of Semiconductor Nanostructures
Abbreviation: 11-HNS-161-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: Only after succ. compl. of module(s)
Numerical grade: --

Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
Semiconductor nanostructures are frequently referred to as "artificial materials". In contrast to atoms, molecules or macroscopic crystals, their electronic, optical and magnetic properties can be systematically tailored by changing their size. The lecture addresses technological challenges in the preparation of semiconductor nanostructures of varying dimensions (2D, 1D, 0D). It provides the basic theoretical concepts to describe their properties, with a focus on optical properties and light-matter coupling. Moreover, it discusses the challenges and concepts of novel optoelectronic and quantum photonic devices based on such nanostructures, including building blocks for quantum communication and quantum computing architectures.

Intended learning outcomes:
The students know the theoretical principles and characteristics of semiconductor nanostructures. They have knowledge of the technological methods to fabricate such structures, and of their applications to novel photonic devices. They are able to apply their knowledge to problems in this field of research.

Courses:
V (3) + R (1)
Module taught in: German or English

Method of assessment:
Written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).
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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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Focus Topic IV: Semiconductor Nanostructures
(0 or 15 ECTS credits)
## Module Catalogue for the Subject
### Functional Materials
#### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Semiconductor Physics</td>
<td>11-HPH-201-m01</td>
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</tbody>
</table>

### Contents

The lecture deals with the fundamental properties of semiconductors. It begins with an analysis of the crystal structure, leading to methods for describing band structures. These form a basis for discussing optical and electronic properties of monolithic semiconductors. It then turns to examining semiconductor heterostructures, and studies how these can be used to modify and design optical and electrical properties, especially in the case of lowered dimensionality systems. Examples are selected from current research activities.

### Intended learning outcomes

To provide the student with a working knowledge of semiconductors pertaining to crystal structure, symmetries, and band structures, as well as electrical and optical properties. This establishes a solid basis preparing him for the more targeted specially lectures in the program.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 90-120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

Assessment offered: In the semester in which the course is offered and in the subsequent semester

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title: Physics of Semiconductor Devices  
Abbreviation: 11-SPD-152-m01

Module coordinator: Managing Director of the Institute of Applied Physics  
Module offered by: Faculty of Physics and Astronomy

ECTS: 6  
Method of grading: Only after succ. compl. of module(s)  
Numerical grade: --

Duration: 1 semester  
Module level: undergraduate  
Other prerequisites: --

Contents:
Based on the fundamentals of Semiconductor Physics, the lecture provides an insight into semiconductor key technologies and discusses the main components in the fields of electronics and photonics on the basis of examples. The basic part introduces the crystal structures and band and phonon dispersions of technologically relevant semiconductors. The following part discusses the principles of charge transport involving non-equilibrium effects based on the charge carrier density of the thermal equilibrium. The part on technology gives an insight into the methods of production of semiconductor materials and presents the most important methods of planar technology. It discusses the way of functioning of the following components, sorted according to volume components, interface components and application fields: Rectifier diodes, Zener diodes, varistor, varactor, tunnel diodes, IMPATT, Baritt- and Gunn diodes, photodiode, solar cell, LED, semiconductor injection laser, transistor, JFET, Thyristor, Diac, Triac, Schottky diode, MOSFET, MESFET, HFET. It highlights the importance of low-dimensional charge carrier systems for technology and basic research and shows recent developments in the components sector.

Intended learning outcomes:
The students know the characteristics of semiconductors, they have gained an overview of the electronic and phonon band structures of important semiconductors and the resulting electronic, optical and thermal properties. They know the principles of charge transport as well as the Poisson, Boltzmann and continuity equation for the solution of questions. They have gained insights into the methods of semiconductor production and are familiar with the theories of planar technology and recent developments in this field, they have a basic understanding of component production. They understand the structure and way of functioning of the main components of electronics (diode, transistor, field-effect transistor, thyristor, diac, triac), of microwave applications (tunnel, IMPATT, Baritt or Gunn diode) and of optoelectronics (photo diode, solar cell, light-emitting diode, semiconductor injection laser), they know the realisation possibilities of low-dimensional charge carrier systems on the basis of semiconductors and their technological relevance, they are familiar with current developments in the field of components.

Courses:
Type, number of weekly contact hours, language — if other than German:
V (3) + R (1)
Module taught in: German or English

Method of assessment:
Type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus:
Written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).
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Assessment offered: Once a year, summer semester
Language of assessment: German and/or English

Allocation of places:
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## Module Catalogue for the Subject
### Functional Materials
#### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Organic Semiconductors</td>
<td>11-OHL-161-m01</td>
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<table>
<thead>
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<th>Module coordinator</th>
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<td>1 semester</td>
<td>graduate</td>
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</tbody>
</table>

### Contents
Fundamentals of organic semiconductors, molecular and polymer electronics and sensor technology, applications.

### Intended learning outcomes
The students have advanced knowledge of organic semiconductors.

### Courses
(type, number of weekly contact hours, language — if other than German)

<table>
<thead>
<tr>
<th>V (3) + R (1)</th>
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<tbody>
<tr>
<td>Module taught in: German or English</td>
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</table>

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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<table>
<thead>
<tr>
<th>Module title</th>
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<tr>
<td>Coating Technologies based on Vapour Deposition</td>
<td>11-BVG-202-m01</td>
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</table>

**Contents**

Physical and technical basics of PVD and CVD systems and processes. Layer deposition and layer characterization. Application of coating materials on an industrial scale.

**Intended learning outcomes**

The student has in-depth knowledge in the field of gas-phase deposition processes and gains insights into their industrial significance and diversity.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- written examination (approx. 90 to 120 minutes) or
- oral examination of one candidate each (approx. 30 minutes) or
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- project report (approx. 8 to 10 pages) or
- presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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<table>
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<tr>
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<tbody>
<tr>
<td>Optical Properties of Semiconductor Nanostructures</td>
<td>11-HNS-161-m01</td>
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**Module coordinator**
Managing Director of the Institute of Applied Physics

**Module offered by**
Faculty of Physics and Astronomy

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**Contents**

Semiconductor nanostructures are frequently referred to as "artificial materials". In contrast to atoms, molecules or macroscopic crystals, their electronic, optical and magnetic properties can be systematically tailored by changing their size. The lecture addresses technological challenges in the preparation of semiconductor nanostructures of varying dimensions (2D, 1D, 0D). It provides the basic theoretical concepts to describe their properties, with a focus on optical properties and light-matter coupling. Moreover, it discusses the challenges and concepts of novel optoelectronic and quantum photonic devices based on such nanostructures, including building blocks for quantum communication and quantum computing architectures.

**Intended learning outcomes**

The students know the theoretical principles and characteristics of semiconductor nanostructures. They have knowledge of the technological methods to fabricate such structures, and of their applications to novel photonic devices. They are able to apply their knowledge to problems in this field of research.

**Courses**

(V (3) + R (1))
Module taught in: German or English

**Method of assessment**

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)

--
Focus Topic V: Organic Functional Materials and Applications
(0 or 15 ECTS credits)
### Module title
Chemical Nanotechnology: Analytics and Applications

### Abbreviation
08-FU-NT-AA-152-m01

### Module coordinator
degree programme coordinator Funktionswerkstoffe (Functional Materials)

### Module offered by
Chair of Chemical Technology of Material Synthesis

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
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### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

### Contents
Introduction to theory and application of characterisation methods in nano-chemistry. Thermoanalysis, rheological methods, dynamic light scattering, application of nano materials in industry and technology.

### Intended learning outcomes
The students possess advanced knowledge of characterisation and application of nano materials.

### Courses (type, number of weekly contact hours, language — if other than German)
V (4)

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Module title

| Polymer Materials 1: Technology of Polymer Modification |

### Abbreviation

| 08-FU-PW1-161-m01 |

### Module coordinator

degree programme coordinator Funktionswerkstoffe (Functional Materials)

### Module offered by

Chair of Chemical Technology of Material Synthesis

### ECTS

| 5 |

### Method of grading

| numerical grade |

### Only after succ. compl. of module(s)

| -- |

### Duration

| 1 semester |

### Module level

| graduate |

### Other prerequisites

| -- |

### Contents

Methods of polymer synthesis; composition of polymers and polymer compounds; properties of polymers; technologies for the production of polymers compound and polymer components; means of characterisation of polymer compounds and polymer components.

### Intended learning outcomes

The students possess knowledge of the special properties of polymers and polymer compounds (e.g. time and temperature dependent viscoelastic behaviour). They know the characteristics of important production technologies (methods of polymer synthesis, compounding technologies, processing methods e.g. injection moulding) and understands the different ways of influencing properties of materials and manufactured products. They have knowledge of ways to calculate complex flow conditions in polymer processing machines and tools.

### Courses

(type, number of weekly contact hours, language — if other than German)

| V (2) | P (2) |

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

| a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) |

Assessment offered: Once a year, winter semester

Language of assessment: German and/or English

P: creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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<tbody>
<tr>
<td>Module title</td>
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<tr>
<td>Nanoscale Materials</td>
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<tbody>
<tr>
<td>lecturer of the seminar &quot;Nanoskalige Materialien&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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</table>

**Contents**

This module discusses advanced topics in nanoscale materials. It focuses on the structure, properties, fabrication, modern characterisation methods and application areas of nanoscale materials.

**Intended learning outcomes**

Students are able to characterise nanoscale materials. They are able to name analytical methods and application areas of nanoscale materials.

**Courses**

(type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

Module taught in: German or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes)

Language of assessment: German and/or English creditable for bonus

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
## Module title
Polymer Materials 2: Technology of Filler Modification for Polymer Materials

## Abbreviation
08-FU-PW2-161-m01

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<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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<td>1 semester</td>
<td>graduate</td>
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### Contents
Principles and technologies for the functionalization of additives and their utilization for the modification of polymers and their properties, interaction between polymers and additives and determination of the particular properties of such functionalized polymers (e.g. electric, bactericidal, flame retardant properties). Also the influence on other properties such as mechanical and rheological properties, color, turbidity and surface finish will be discussed.

### Intended learning outcomes
The students possess knowledge on the technologies to functionalize polymeric materials with additives. They know the possibilities and issues regarding of such modifications, the interaction between additives and polymers. Moreover, they are qualified to determine particular properties of functionalized polymers (e.g. flame retardancy) and understand the interactions with other properties of the polymers, such as rheology, mechanical properties, color, turbidity or surface finish.

### Courses
(type, number of weekly contact hours, language — if other than German)

V (2) + P (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate)

Assessment offered: Once a year, summer semester
Language of assessment: German and/or English
P: creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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<td>Supramolecular Chemistry (Basics)</td>
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**Module coordinator**

Lecturer of lecture "Organischen Chemie"

**Module offered by**

Faculty of Chemistry and Pharmacy

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**Duration**

1 semester

**Module level**

Graduate

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**Contents**

This module introduces students to the fundamental principles of supramolecular chemistry. It focuses on interactions between molecules, molecular recognition by receptors, complexes, supramolecular polymers, coordination polymers and networks, liquid crystals, self-assembly in aqueous media, synthetic ion channels and modern applications of supramolecular chemistry.

**Intended learning outcomes**

Students are able to explain interactions between molecules demonstrating a high degree of expertise in the field as well as to describe the formation, structure and polymers of coordination compounds. They are able to describe the self-assembly of polymers in aqueous media as well as to identify the characteristics of synthetic ion channels. They can name modern applications of supramolecular chemistry.

**Courses**

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**Module taught in:** German or English

**Method of assessment**

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**Language of assessment:** German and/or English

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**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<td>Physical Chemistry of Supramolecular Assemblies</td>
<td>08-PCM5-161-m01</td>
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<td>lecturer of the seminar &quot;Physikalische Chemie Supramolekularer Strukturen&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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</table>

**Contents**

This module examines the basic interactions between molecules. It discusses the formation and physical-chemical properties of aggregates as well as key applications of supramolecular chemistry.

**Intended learning outcomes**

Students are able to explain the basic interactions between molecules demonstrating a high degree of expertise in the field. They can describe the formation and physical-chemical properties of aggregates. They can name modern applications of supramolecular chemistry.

**Courses**

(type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

Module taught in: German or English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
Focus Topic VI: Imaging und Spectroscopy
(0 or 15 ECTS credits)
Module title: Principles of Two- and Three-Dimensional Röntgen Imaging
Abbreviation: 11-ZDR-152-m01

Module coordinator: Managing Director of the Institute of Applied Physics
Module offered by: Faculty of Physics and Astronomy

ECTS: 6
Method of grading: numerical grade
Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
Physics of X-ray generation (X-ray tubes, synchrotron). Physics of the interaction between X-rays and matter (photon absorption, scattering) physics of X-ray detection. Mathematics of reconstruction algorithms (filtered back projection, Fourier reconstruction, iterative methods). Image processing (image data pre-processing, feature extraction, visualisation, ...). Applications of X-ray imaging in the industrial sector (component testing, material characterisation, metrology, biology, ...). Radiation protection and biological radiation effect (dose, ...).

Intended learning outcomes:
The students know the principles of generating X-rays and of their interactions with matter. They know imaging techniques using X-rays and methods of image processing as well as application areas of these methods.

Courses:
V (3) + R (3)
Module taught in: German or English

Method of assessment:
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).
If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this four weeks prior to the original examination date at the latest.
Assessment offered: Once a year, summer semester
Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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<td>Advanced Computer Tomography</td>
<td>11-CTA-212-m01</td>
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<td>of Applied Physics</td>
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### Contents

This advanced course focuses on the details of modern computed tomography (CT), which is employed both in medical and industrial imaging applications. In addition to the technicalities of CT systems and their application to various tasks in engineering and medical science, this lecture emphasizes on the mathematics of “inverting the Radon transform”. Starting with the simple Filtered Back Projection method which is applied to a variety of standard recording geometries (parallel, fan, cone, helix) the advanced course lays out the strategies for algebraic reconstruction techniques (ART) along with many types of regularization schemes which may accompany these methods. Students will have the opportunity to see how Radon data is recorded and how different error sources as well as the corresponding correction schemes influence the outcome of the reconstructed volume images. Finally, the most common tools for volume image analysis are presented, such as distance transforms, watersheds, labelling and fiber orientation analysis.

### Intended learning outcomes

The student know the concept of Computed tomography (CT) and its applications. From the formulation of the basic inverse problem posed by this technique the students are able to derive strategies for different numerical solutions, based on Fourier analysis and/or based on probability theory. Most importantly the students have a firm impression (first-hand experience) of the various sources of measurement errors in CT which can impede any wellprepared reconstruction.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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<table>
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<td>Electron and Ion Microscopy</td>
<td>11-EIM-211-m01</td>
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<td>1 semester</td>
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</table>

**Contents**


**Intended learning outcomes**

The student has specific and immersed knowledge in electron and ion microscopy. He/she knows the theoretical and instrumental basics and principles of detectors and contrast mechanisms. He/she knows different modi of electron microscopy and their applications. He/she knows ongoing developments in this field.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

Teaching cycle: annually, after announcement

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

Prüfungsturnus: im Semester der LV und im Folgesemester

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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**Module title**  
Laser Spectroscopy

**Abbreviation**  
o8-PCM1a-161-m01

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**Duration**  
1 semester

**Module level**  
graduate

**Other prerequisites**  
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**Contents**

This module introduces students to the fundamental principles of laser spectroscopy. It discusses absorption and emission spectroscopy.

**Intended learning outcomes**

Students are able to explain the components and operating principles of lasers as well as the optical principles of laser technology. They are able to describe the principles of absorption and emission spectroscopy.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)  
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes)  
Language of assessment: German and/or English

**Allocation of places**  
--

**Additional information**  
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Subfield General Compulsory Electives
(20 ECTS credits)

The 20 ECTS points can be taken from the following modules.

Alternatively, within these 20 ECTS credits, modules of the "Subfield Focus Topic (I to V)" can also be completed, whereby the modules already taken in the selected "Subfield Focus Topic" and introduced there cannot be used again in the "Subfield General Compulsory Electives".
Module Group Material Sciences
(ECTS credits)
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<td>Sol-Gel Chemistry</td>
<td>08-FU-SGC-222-m01</td>
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<td>Chair of Chemical Technology of Material Synthesis</td>
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</table>

### Contents

This module provides an introduction to the synthesis methods of sol-gel chemistry and discusses the methods of analysis used to characterise the generated materials.

### Intended learning outcomes

Students have developed an advanced knowledge of sol-gel chemistry.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3)

Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 180 minutes) or  
b) oral examination of one candidate each (20 to 30 minutes) or  
c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or  
d) log (approx. 20 pages) or  
e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
## Analytical Methods - Examples from Practical Failure Analysis

**Module title**
Analytical Methods - Examples from Practical Failure Analysis

**Abbreviation**
08-FU-ANA-161-m01

**Module coordinator**
Dean of Studies Funktionswerkstoffe (Functional Materials)

**Module offered by**
Chair of Chemical Technology of Material Synthesis

**ECTS**
5

**Method of grading**
Only after succ. compl. of module(s)

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
--

### Contents
This module treats special topics in the area damage analysis of materials (Ceramics, semiconductors, metals and polymers). The students become acquainted to different methods for the characterization of the different material classes. They deepen this knowledge in a practical part.

### Intended learning outcomes
The students gain fundamental knowledge in measuring methods in the physical / chemical laboratory.

### Courses
- **V (2) + P (2)**

### Method of assessment
- **a)** written examination (approx. 90 to 180 minutes)
- **b)** oral examination of one candidate each (20 to 30 minutes)
- **c)** oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate)
- **d)** log (approx. 20 pages)
- **e)** presentation (approx. 30 minutes)

Assessment offered: Once a year, summer semester

Language of assessment: German and/or English

P: creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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</table>

**Contents**

Based on the fundamentals of Semiconductor Physics, the lecture provides an insight into semiconductor key technologies and discusses the main components in the fields of electronics and photonics on the basis of examples. The basic part introduces the crystal structures and band and phonon dispersions of technologically relevant semiconductors. The following part discusses the principles of charge transport involving non-equilibrium effects based on the charge carrier density of the thermal equilibrium. The part on technology gives an insight into the methods of production of semiconductor materials and presents the most important methods of planar technology. It discusses the way of functioning of the following components, sorted according to volume components, interface components and application fields: Rectifier diodes, Zener diodes, varistor, varactor, tunnel diodes, IMPATT, Baritt- and Gunn diodes, photodiode, solar cell, LED, semiconductor injection laser, transistor, JFET, Thyristor, Diac, Triac, Schottky diode, MOSFET, MESFET, HFET. It highlights the importance of low-dimensional charge carrier systems for technology and basic research and shows recent developments in the components sector.

**Intended learning outcomes**

The students know the characteristics of semiconductors, they have gained an overview of the electronic and phonon band structures of important semiconductors and the resulting electronic, optical and thermal properties. They know the principles of charge transport as well as the Poisson, Boltzmann and continuity equation for the solution of questions. They have gained insights into the methods of semiconductor production and are familiar with the theories of planar technology and recent developments in this field, they have a basic understanding of component production. They understand the structure and way of functioning of the main components of electronics (diode, transistor, field-effect transistor, thyristor, diac, triac), of microwave applications (tunnel, IMPATT, Baritt or Gunn diode) and of optoelectronics (photo diode, solar cell, light-emitting diode, semiconductor injection laser), they know the realisation possibilities of low-dimensional charge carrier systems on the basis of semiconductors and their technological relevance, they are familiar with current developments in the field of components.

**Courses**

(V (3) + R (1) )

Module taught in: German or English

**Method of assessment**

Module is creditable for bonus

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: Once a year, summer semester

Language of assessment: German and/or English

**Allocation of places**

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<th>Additional information</th>
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
---|---
Semiconductor Lasers and Photonics | 11-HLF-152-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
6 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | --

Contents
This lecture discusses the principles of laser physics, based on the example of semiconductor lasers, and current developments regarding components. The principles of lasers are described on the basis of a general laser model, which will then be extended to special aspects of semiconductor lasers. Basic concepts such as threshold condition, characteristic curve and laser efficiency are derived from coupled rate equations for charge carriers and photons. Other topics of the lecture are optical processes in semiconductors, layer and ridge waveguides, laser resonators, mode selection, dynamic properties as well as technology for the generation of semiconductor lasers. The lecture closes with current topics of laser research such as quantum dot lasers, quantum cascade lasers, terahertz lasers or high-performance lasers.

Intended learning outcomes
The students have advanced knowledge of the principles of semiconductor-laser physics. They can apply their knowledge to modern questions and know the applications in the current development of components.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
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Assessment offered: Once a year, summer semester
Language of assessment: German and/or English

Allocation of places
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Additional information
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<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Quantum Transport</td>
<td>11-QTH-161-m01</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

The lecture addresses the fundamental transport phenomena of electrons in nanostructures. This includes the topics of: ballistic and diffuse transport, electron interference effects, quantisation of conductivity, interaction phenomena between electrons, Coulomb blockade, thermoelectric properties, description of spin-dependent transport phenomena, topological insulators, solid-state quantum computers.

**Intended learning outcomes**

The students have mastered the basics of electronics of nanostructures in theory and practice. They know functions and applications of respective components.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
# Module Catalogue for the Subject

## Functional Materials

### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Methods of Non-Destructive Material Testing</td>
<td>11-ZMB-152-m01</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</table>

## Contents


## Intended learning outcomes

The students have basic knowledge of the generation and interaction processes of different types of radiation (heat, X-ray, terahertz), particles (neutrons) or ultrasound waves with materials. They know the applied methods for the detection of radiation types, particles and ultrasound waves and are able to apply them to basic problems of material testing and characterisation.

## Courses

<table>
<thead>
<tr>
<th>Type, number of weekly contact hours, language — if other than German</th>
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<tr>
<td>V (2) + R (1)</td>
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Module taught in: German or English

## Method of assessment

<table>
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<tr>
<th>Type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus</th>
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## Allocation of places

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## Additional information

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<table>
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<tr>
<th>Module title</th>
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<td>Laboratory and Measurement Technology</td>
<td>11-LMT-152-m01</td>
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<td>1 semester</td>
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</table>

**Contents**

Introduction to electronic and optical measuring methods of physical metrology, vacuum technology and cryogenics, light sources, spectroscopic methods and measured value acquisition.

**Intended learning outcomes**

The students have competencies in the field of electronic and optical measuring methods of physical metrology, vacuum technology and cryogenics, light sources, spectroscopic methods and measured value acquisition.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

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Assessment offered: Once a year, winter semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Biophysical Measurement Technology in Medical Science

### Abbreviation
11-BMT-161-m01

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<th>ECTS</th>
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### Duration
1 semester

### Module level
graduate

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### Contents
The lecture covers the physical principles of imaging techniques and their application in Biomedicine. The main topics are conventional X-ray technique, computer tomography, imaging techniques of nuclear medicine, ultrasound and MR-tomography. The lecture additionally addresses the systems theory of imaging systems and digital image processing.

### Intended learning outcomes
The students know the physical principles of imaging techniques and their application in Biomedicine. They understand the principles of image generation and are able to explain different techniques and interpret simple images.

### Courses
(V (3) + R (1)
Module taught in: German or English

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### Method of assessment

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
--
## Module title

**Semiconductor Physics**

**Abbreviation**

11-HPH-201-m01

## Module coordinator

Managing Director of the Institute of Applied Physics

## Module offered by

Faculty of Physics and Astronomy

## ECTS

6

## Method of grading

Only after succ. compl. of module(s)

## Duration

1 semester

## Module level

graduate

## Other prerequisites

--

### Contents

The lecture deals with the fundamental properties of semiconductors. It begins with an analysis of the crystal structure, leading to methods for describing band structures. These form a basis for discussing optical and electronic properties of monolithic semiconductors. It then turns to examining semiconductor heterostructures, and studies how these can be used to modify and design optical and electrical properties, especially in the case of lowered dimensionality systems. Examples are selected from current research activities.

### Intended learning outcomes

To provide the student with a working knowledge semiconductors pertaining to crystal structure, symmetries, and band structures, as well as electrical and optical properties. This establishes a solid basis preparing him for the more targeted specially lectures in the program.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

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Language of assessment: German and/or English

Assessment offered: In the semester in which the course is offered and in the subsequent semester

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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### Principles of Two- and Three-Dimensional Röntgen Imaging

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<tr>
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<tbody>
<tr>
<td>Principles of Two- and Three-Dimensional Röntgen Imaging</td>
<td>11-ZDR-152-m01</td>
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<td>1 semester</td>
<td>graduate</td>
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**Contents**

Physics of X-ray generation (X-ray tubes, synchrotron). Physics of the interaction between X-rays and matter (photon absorption, scattering), physics of X-ray detection. Mathematics of reconstruction algorithms (filtered back projection, Fourier reconstruction, iterative methods). Image processing (image data pre-processing, feature extraction, visualisation,...). Applications of X-ray imaging in the industrial sector (component testing, material characterisation, metrology, biology,...). Radiation protection and biological radiation effect (dose,...).

**Intended learning outcomes**

The students know the principles of generating X-rays and of their interactions with matter. They know imaging techniques using X-rays and methods of image processing as well as application areas of these methods.

**Courses**

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<th>V (3) + R (1)</th>
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- Assessment offered: Once a year, summer semester
- Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)
### Module title

**Physics of Advanced Materials**

### Abbreviation

11-PMM-161-m01

### Module coordinator

Managing Director of the Institute of Applied Physics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

6

### Method of grading

Numerical grade

### Only after succ. compl. of module(s)

--

### Duration

1 semester

### Module level

Graduate

### Other prerequisites

--

### Contents

General properties of various material groups such as liquids, liquid crystals and polymers; magnetic materials and superconductors; thin films, heterostructures and superlattices. Methods of characterising these material groups; two-dimensional layer materials.

### Intended learning outcomes

The students know the properties and characterization methods of some modern materials.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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## Module: Laboratory and Measurement Technology in Biophysics

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<tr>
<td>Laboratory and Measurement Technology in Biophysics</td>
<td>11-LMB-152-m01</td>
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</table>

### Module Coordinator
Managing Director of the Institute of Applied Physics

### Module Offered by
Faculty of Physics and Astronomy

### ECTS
6

### Method of Grading
Only after succ. compl. of module(s)

### Duration
1 semester

### Module Level
Graduate

### Other Prerequisites
--

### Contents
The lecture covers relevant principles of molecular and cellular biology as well as the physical principles of biophysical procedures for the examination and manipulation of biological systems. The main topics are optical measuring techniques and sensors, methods of single-particle detection, special microscoping techniques and methods of structure elucidation of biomolecules.

### Intended Learning Outcomes
The students know the principles of molecular and cellular biology as well as the physical principles of biophysical procedures for the examination and manipulation of biological systems. They have knowledge of optical measuring techniques and their applications and are able to apply techniques of structure elucidation to simple biomolecules.

### Courses
- **(type, number of weekly contact hours, language — if other than German)**
  - V (3) + R (1)

### Module Taught in:
German or English

### Method of Assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
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Assessment offered: Once a year, summer semester

Language of assessment: German and/or English

### Allocation of Places
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### Additional Information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
---|---
Computational Materials Science (DFT) | 11-CMS-161-m01

**Module coordinator**
Managing Director of the Institute of Theoretical Physics and Astrophysics

**Module offered by**
Faculty of Physics and Astronomy

<table>
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<th>ECTS</th>
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**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
--

**Contents**
1. Density functional theory (DFT)
2. Wannier functions and localized basis functions
3. Numerical evaluation of topological invariants
4. Hartree-Fock and static mean-field theory
5. Many-body methods for solid state physics
6. Anderson impurity model (AIM) and Kondo physics
7. Dynamical mean-field theory (DMFT)
8. DFT + DMFT methods for realistic modeling of solids
9. Strongly correlated electrons

**Intended learning outcomes**
Aside from the theoretical discussion of these topics, the students carry out hands-on exercises from the CIP pool. The participants are introduced to the use of DFT software packages such as VASP or Wien2k and to the construction of maximally localised Wannier functions through the projection of DFT results on atom orbitals with the software wannier90. Furthermore, the students learn how to construct many-particle solutions of AIM and observe border cases such as the Kondo regime. Impurity solvers such as exact diagonalisation or continuous-time quantum Monte Carlo are utilised to solve the self consistency equations of dynamic molecular field theory (DMFT). These steps are necessary to reach the peak of the lecture: a DFT-DMFT calculation of a strongly correlated transition metal oxide such as SrVO3.

**Courses** (type, number of weekly contact hours, language — if other than German)
V (4) + R (2)
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
--
Module title | Abbreviation
--- | ---
Solid State Physics 2 | 11-FK2-201-m01

| Module coordinator | Module offered by |
--- | ---
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

| ECTS | Method of grading | Module level |
--- | --- | ---
8 | numerical grade | graduate |

Duration | Other prerequisites
--- | ---
1 semester | Approval from examination committee required.

Contents

1. Electrons in a periodic potential - the band structure
   a. Electrical and thermal transport
   b. Bloch theorem
   c. Electrons
2. Semi-classical models of dynamic processes
   a. Electrical transport in partially and completely filled bands
   b. Fermi surfaces; measurement techniques
   c. Electrical transport in external magnetic fields
   d. Boltzmann-equations of transport
3. The dielectric function and ferroelectrics
   a. Macroscopic electrodynamics and microscopic theory
   b. Polarizability of solids, of lattices, of valence electrons and quasi-free electrons; optical phonons, polaritons, plasmons, inter-band transitions, Wannier-Mott excitons
   c. Ferromagnetism
4. Semiconductors
   a. Characteristics
   b. Intrinsic semiconductors
   c. Doped semiconductors
   d. Physics and applications of p-n junctions
   e. Heterostructures
5. Magnetism
   a. Atomic dia- and paramagnetism
   b. Dia- and paramagnetism in metals
   c. Ferromagnetism
6. Superconductivity
   a. Phenomena
   b. Models of superconductivity
   c. Tunnel experiments und applications

Intended learning outcomes

Knowledge of effects, concepts and models in advanced solid state physics. Familiarity with the theoretical principles and with applications of experimental methods.

Courses (type, number of weekly contact hours, language — if other than German)

V (4) + R (2)

Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

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of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.
Language of assessment: German and/or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester

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</table>
Module title: Imaging Methods at the Synchrotron

Abbreviation: 11-BMS-152-m01

Module coordinator: Managing Director of the Institute of Applied Physics

Module offered by: Faculty of Physics and Astronomy

ECTS: 6

Method of grading: numerical grade

Duration: 1 semester

Module level: undergraduate

Other prerequisites: --

Contents:

Intended learning outcomes:
The students know the principles of digital image and signal processing. They know the ways of functioning and applications of different image processing methods and are able to apply them in practice.

Courses:
V (3) + R (1)

Module taught in: German or English

Method of assessment:
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: Once a year, summer semester

Language of assessment: German and/or English

Allocation of places:
--

Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Image and Signal Processing in Physics</td>
<td>11-BSV-161-m01</td>
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<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
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</thead>
<tbody>
<tr>
<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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<th>ECTS</th>
<th>Method of grading</th>
<th>Only after succ. compl. of module(s)</th>
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<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
<td></td>
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</tbody>
</table>

**Contents**

Periodic and aperiodic signals; principles of discreet and exact Fourier transformation; principles of digital signal and image processing; discretisation of signals/sampling theorem (Shannon); homogeneous and linear filters, convolution product; tapering functions and interpolation of images; the Parsival theorem, correlation and energetic observation; statistical signals, image noise, moments, stationary signals; tomography: Hankel and Radon transformation.

**Intended learning outcomes**

The students have advanced knowledge of digital image and signal processing. They know the physical principles of image processing and are familiar with different methods of signal processing. They are able to explain different methods and to implement them, especially in the field of tomography.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (2)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module Group Chemistry

(ECTS credits)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Bioorganic Chemistry</td>
<td>08-SCM3-152-m01</td>
</tr>
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<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>lecturer of lecture &quot;Bioorganische Chemie&quot; (Bioorganic Chemistry)</td>
<td>Institute of Organic Chemistry</td>
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<tr>
<td>1 semester</td>
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</table>

**Contents**

This module discusses topics at the interface of organic chemistry, biology and medicine. It focuses on molecular interactions and recognition, molecular diversity, active agent development, new aspects of DNA, RNA, proteins and carbohydrates.

**Intended learning outcomes**

Students are able to describe molecular interactions and detection mechanisms of bioorganic chemistry. They can explain the molecular diversity of biological systems. They can characterise the fabrication of agents. They can describe modern aspects of DNA, RNA, proteins and carbohydrates.

**Courses** (type, number of weekly contact hours, language — if other than German)

| S (3) |

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 45 to 90 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (15 to 30 minutes per candidate)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title
Molecular Biology for Advanced Students

### Abbreviation
08-BC-MOLMC-161-m01

### Module coordinator
holder of the Chair of Biochemistry

### Module offered by
Chair of Biochemistry

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
graduate

### Other prerequisites
--

## Contents
The module covers specific topics of molecular physiology and functional biochemistry in lectures and exercises.

## Intended learning outcomes
After attending the module events, students have solid knowledge in molecular biology.

## Courses
(type, number of weekly contact hours, language — if other than German)

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Weekly Contact Hours</th>
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<tr>
<td>Ü</td>
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## Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

## Allocation of places
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## Additional information
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## Referred to in LPO I
(examination regulations for teaching-degree programmes)

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## Module title
- **Modern Synthetic Methods**

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<th>Abbreviation</th>
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<tr>
<td>08-OCM-SYNT-161-m01</td>
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### Module coordinator
- lecturer of the seminar

### Module offered by
- Institute of Organic Chemistry

### ECTS
- 5

### Method of grading
- numerical grade

### Only after succ. compl. of module(s)
- --

### Duration
- 1 semester

### Module level
- graduate

### Other prerequisites
- --

### Contents
This module discusses modern stereoselective synthesis methods. It focuses on selected total syntheses, organometallic chemistry and catalysis.

### Intended learning outcomes
Students are able to stereoselectively plan complex chemical syntheses and to stereochemically analyse them. They can explain total syntheses. They can describe aspects of organometallic chemistry and catalysis in synthesis chemistry.

### Courses
- **S (2) + Ü (1)**

Module taught in: German or English

### Method of assessment
(a) written examination (approx. 90 to 180 minutes) or (b) oral examination of one candidate each (20 to 30 minutes) or (c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or (d) log (approx. 20 pages) or (e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO 1
(examination regulations for teaching-degree programmes)
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<table>
<thead>
<tr>
<th>Module title</th>
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<tbody>
<tr>
<td>Ultrafast spectroscopy and quantum-control</td>
<td>08-PCM4-161-m01</td>
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<table>
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<th>Module coordinator</th>
<th>Module offered by</th>
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<tbody>
<tr>
<td>lecturer of the seminar &quot;Nanoskalige Materialien&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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<td>graduate</td>
<td>Prior completion of modules 08-PCM1a and 08-PCM1b recommended.</td>
</tr>
</tbody>
</table>

**Contents**

This module discusses advanced topics in ultrafast spectroscopy and quantum control. It focuses on ultrashort laser pulses, time-resolved laser spectroscopy and coherent control.

**Intended learning outcomes**

Students are able to describe the generation of ultrashort laser pulses and to characterise them. They can explain the theory of time-resolved laser spectroscopy and name experimental methods. They can describe the principles and applications of quantum control.

**Courses**

<table>
<thead>
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<th>Type, number of weekly contact hours, language — if other than German</th>
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<td>S (2) + Ü (1) German or English</td>
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**Method of assessment**

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<tr>
<th>Type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus</th>
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<tbody>
<tr>
<td>a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes) Language of assessment: German and/or English</td>
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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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</table>
Module title | Abbreviation
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Statistical Mechanics and Reaction Dynamics | 08-PCM2-161-m01

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<tr>
<th>Module coordinator</th>
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<tbody>
<tr>
<td>lecturer of seminar &quot;Chemische Dynamik&quot; (Chemical Dynamics)</td>
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<tr>
<th>Module offered by</th>
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<td>Institute of Physical and Theoretical Chemistry</td>
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<td>graduate</td>
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</table>

Contents

The module deals with selected contents of statistical mechanics and reaction dynamics. It introduces the basic principles of statistical thermodynamics and conveys the transition state theory. Other topics are uni- and bimolecular reactions as well as charge and energy transfer.

Intended learning outcomes

The students are familiar with selected contents of statistical mechanics and reaction dynamics. They know the basic principles of statistical thermodynamics and can apply them.

Courses (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes)
Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module Group Theory of Chemistry / Numerics (Mathematics / Computer Science)
(ECTS credits)
### Module Catalogue for the Subject
**Functional Materials**

**Master's with 1 major, 120 ECTS credits**

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Basics and Applications of Quantum Chemistry</td>
<td>08-TCM2-161-m01</td>
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</table>

**Module coordinator**
lecturer of lecture "Computational Chemistry"

**Module offered by**
Institute of Physical and Theoretical Chemistry

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</table>

**Duration**
1 semester

**Module level**
graduate

**Other prerequisites**
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### Contents
The module introduces students to computational chemistry.

### Intended learning outcomes
Students are able to explain the theoretical principles of computational chemistry and to apply methods in computational chemistry.

### Courses
(type, number of weekly contact hours, language — if other than German)

S (2) + Ü (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) written examination (approx. 90 to 180 minutes) or
- b) oral examination of one candidate each (20 to 30 minutes) or
- c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or
- d) log (approx. 20 pages) or
- e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)
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<table>
<thead>
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<th>Module title</th>
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<tr>
<td>Numerical Methods and Programming</td>
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<th>Module coordinator</th>
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<tbody>
<tr>
<td>lecturer of lecture &quot;Programmieren in Theoretischer Chemie&quot;</td>
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<th>Module offered by</th>
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<tbody>
<tr>
<td>Institute of Physical and Theoretical Chemistry</td>
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<td>1 semester</td>
<td>graduate</td>
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</table>

### Contents

This module provides an introduction to the fundamentals of programming in theoretical chemistry and discusses its application areas.

### Intended learning outcomes

Students are able to explain and use one of the programming languages typically used in theoretical chemistry as well as to name its application areas.

### Courses

(type, number of weekly contact hours, language — if other than German)

\[ S (2) + Ü (2) \]

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) written examination (approx. 90 to 180 minutes) or
- b) oral examination of one candidate each (20 to 30 minutes) or
- c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or
- d) log (approx. 20 pages) or
- e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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<table>
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<th>Module title</th>
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<td>Quantum Dynamics</td>
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<tr>
<td>lecturer of lecture &quot;Quantendynamik&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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<tr>
<td>1 semester</td>
<td>graduate</td>
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</tbody>
</table>

**Contents**

Time-dependent Schrödinger equation, propagators, time-dependent perturbation theory, adiabatic theorem, diabatic and adiabatic states, non-adiabatic dynamics, mixed quantum-classical dynamics.

**Intended learning outcomes**

The students possess knowledge about the time-dependent description of the nuclear and electronic dynamics in molecules. Their insight into the methods and the numerical realizations allow them to carry out applications in the field of theoretical chemistry.

**Courses**

<table>
<thead>
<tr>
<th>(type, number of weekly contact hours, language — if other than German)</th>
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<tbody>
<tr>
<td>S (2) + Ü (2)</td>
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**Method of assessment**

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<tr>
<th>(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)</th>
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<td>a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)</td>
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</table>

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
Module title: Selected Topics in Theoretical Chemistry
Abbreviation: 08-TCM1-161-m01

Module coordinator: Lecturer of lecture "Theoretische Chemie"
Module offered by: Institute of Physical and Theoretical Chemistry

ECTS: 5
Method of grading: numerical grade
Duration: 1 semester
Module level: graduate
Other prerequisites: --

Contents:
The module introduces students to theoretical chemistry.

Intended learning outcomes:
Students are able to describe the mathematical and physical principles underlying the quantum chemical and quantum dynamical approaches of theoretical chemistry.

Courses:
S (2) + Ü (2)

Method of assessment:
- a) written examination (approx. 90 to 180 minutes) or
- b) oral examination of one candidate each (20 to 30 minutes) or
- c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or
- d) log (approx. 20 pages) or
- e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

Allocation of places:
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Additional information:
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Referred to in LPO I (examination regulations for teaching-degree programmes):
--
**Module title**
Practical Course in Programming

<table>
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<tr>
<th>Abbreviation</th>
<th>10-I-PP-152-m01</th>
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**Module coordinator**
Dean of Studies Informatik (Computer Science)

**Module offered by**
Institute of Computer Science

**ECTS**
10

**Method of grading**
Only after succ. compl. of module(s)

**Duration**

**Module level**
undergraduate

**Other prerequisites**
--

**Contents**
The programming language Java. Independent creation of small to middle-sized, high-quality Java programs.

**Intended learning outcomes**
The students are able to independently develop small to middle-sized, high-quality Java programs.

**Courses**
(type, number of weekly contact hours, language — if other than German)
P (6)

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 60 to 120 minutes).
If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate).

**Allocation of places**
--

**Additional information**
--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)
§ 49 Nr. 1c
§ 69 Nr. 1d
**Module title**
Modelling and Computational Science

**Abbreviation**
10-M-MWR-222-m01

**Module coordinator**
Dean of Studies Mathematik (Mathematics)

**Module offered by**
Institute of Mathematics

**ECTS**
10

**Method of grading**
Numerical grade

**Duration**
1 semester

**Module level**
Undergraduate

**Other prerequisites**
--

**Contents**

**Intended learning outcomes**
The student masters the fundamental mathematical methods and techniques to simulate processes from natural and engineering sciences on a computer.

**Courses**
(type, number of weekly contact hours, language — if other than German)
V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment**
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 180 minutes, usually chosen) or
b) oral examination of one candidate each (15 to 30 minutes) or
c) oral examination in groups (groups of 2, 10 to 15 minutes per candidate)
Language of assessment: German and/or English
Assessment offered: Only when announced in the semester in which the courses are offered and in the subsequent semester creditable for bonus

**Allocation of places**
--

**Additional information**
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**Referred to in LPO I**
(examination regulations for teaching-degree programmes)
--
Module Group Biology
(ECTS credits)
Module title | Abbreviation
---|---
Aspects of Molecular Biotechnology | 07-451MOLB-152-m01

Module coordinator | Module offered by
holder of the Chair of Biotechnology and Biophysics | Faculty of Biology

<table>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
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</table>

Contents
Fundamental principles of "white" biotechnology, bioreactors, biocatalysis, immobilisation of cells and enzymes, production of biomolecules, molecular biology, recombinant DNA technology, protein engineering, biosensor design, drug design, drug targeting, molecular diagnostics, recombinant antibodies, hybridoma technology, electromanipulation of cells.

Intended learning outcomes
Students will gain an overview of traditional and modern methods in biotechnology and their respective advantages and disadvantages. They will learn to decide what method is most suitable for addressing a particular issue. Students will acquire a knowledge of fundamental methods in biotechnology that will enable them to independently review relevant literature. In addition, they will become acquainted with - or, where necessary, will be able to independently acquaint themselves with - relevant mechanisms.

Courses (type, number of weekly contact hours, language — if other than German)
V (2) + S (2)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
written examination (approx. 30 to 60 minutes)
creditable for bonus

Allocation of places
25 places. Should the number of applications exceed the number of available places, places will be allocated as follows:

Students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits will be given preferential consideration. Should the module be used in other subjects, there will be two quotas: 95% of places will be allocated to students of the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits and 5% of places (a minimum of one place in total) will be allocated to students of the Bachelor’s degree subject Biologie (Biology) with 60 ECTS credits and to students of the Bachelor’s degree subjects Computational Mathematics and Mathematik (Mathematics), each with 180 ECTS credits, as part of the application-oriented subject Biology (as well as potentially to students of other 'importing' subjects). Should the number of places available in one quota exceed the number of applications, the remaining places will be allocated to applicants from the other quota. Should there be, within one module component, several courses with a restricted number of places, there will be a uniform regulation for the courses of one module component. In this case, places on all courses of a module component that are concerned will be allocated in the same procedure. In this procedure, applicants who already have successfully completed at least one other module component of the respective module will be given preferential consideration.

A waiting list will be maintained and places re-allocated as they become available.

Selection process group 1 (95%): Places will primarily be allocated according to the applicants' previous academic achievements. For this purpose, applicants will be ranked according to the number of ECTS credits they have achieved and their average grade of all assessments taken during their studies or of all module components in the subject of Biologie (Biology) (excluding Chemie (Chemistry), Physik (Physics), Mathematik (Mathematics)) at the time of application. This will be done as follows: First, applicants will be ranked, firstly, according to their average grade weighted according to the number of ECTS credits (qualitative ranking) and, secondly, according to their total number of ECTS credits achieved (quantitative ranking). The applicants' position in a third ranking will be calculated as the sum of these two rankings, and places will be allocated according to this third ranking.
Among applicants with the same ranking, places will be allocated according to the qualitative ranking or otherwise by lot.

Selection process group 2 (5%): Places will be allocated according to the following quotas: Quota 1 (50 % of places): total number of ECTS credits already achieved in modules/module components of the Faculty of Biology; among applicants with the same number of ECTS credits achieved, places will be allocated by lot. Quota 2 (25 % of places): number of subject semesters of the respective applicant; among applicants with the same number of subject semesters, places will be allocated by lot. Quota 3 (25 % of places): lottery.

Should the module be used only in the Bachelor's degree subject Biologie (Biology) with 180 ECTS credits, places will be allocated according to the selection process of group 1.

Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

--
Module Group Biology
(ECTS credits)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tr>
<td>Foreign Studies</td>
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<table>
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<th>Module offered by</th>
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<thead>
<tr>
<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
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<tbody>
<tr>
<td>1 semester</td>
<td>undergraduate</td>
<td>Please consult with course advisory service in advance.</td>
</tr>
</tbody>
</table>

**Contents**

Practical work related to functional materials in a foreign country.

**Intended learning outcomes**

The students apply their knowledge in practical laboratory word and gain basic understanding of the language and the culture of the country visited.

**Courses** (type, number of weekly contact hours, language — if other than German)

P (o)

Module taught in: German and/or English and potentially language of the respective country

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) report (10 to 20 pages) or
b) talk (10 to 20 minutes)

Language of assessment: German and/or English and potentially language of the respective country

**Allocation of places**

--

**Additional information**

Block internship abroad with at least 20 working days

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
---|---
Foreign Studies with a focus on Materials Science | 08-FU-ALS-222-m01

Module coordinator | Module offered by
---|---
degree programme coordinator Funktionswerkstoffe (Functional Materials) | Chair of Chemical Technology of Material Synthesis

<table>
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</tbody>
</table>

Duration | Module level | Other prerequisites
---|---|---
1 semester | -- | Please consult with course advisory service in advance.

Contents

The internship is carried out at universities abroad and can be embedded within offered study programs (e.g., Erasmus). The content requirements should comply with those of the electives of the Chemistry Master program at the University of Würzburg (what has to be ascertained in advance with the study coordinator).

Intended learning outcomes

The students are familiar with working methods at universities abroad. Besides professional competences they have also acquired language and intercultural skills.

Courses (type, number of weekly contact hours, language — if other than German)

Course(s) as specified by respective institution

Module taught in: German and/or English and potentially language of the respective country

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 180 minutes) or
b) oral examination of one candidate each (20 to 30 minutes) or
c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or
d) log (approx. 20 pages) or
e) presentation (approx. 30 minutes)

Language of assessment: German and/or English and potentially language of the respective country

Allocation of places

--

Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Special Topics of Materials Science</td>
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<tr>
<th>Duration</th>
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<th>Other prerequisites</th>
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</thead>
<tbody>
<tr>
<td>1 semester</td>
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</tbody>
</table>

### Contents

The module covers current and/or special topics in Materials Chemistry.

### Intended learning outcomes

The student has advanced knowledge of selected topics in Materials Chemistry. He/she is able to classify the acquired knowledge in the subject-specific contexts, knows the synthetic methods, the properties, the characterization methods und the application areas.

### Courses

(type, number of weekly contact hours, language — if other than German)

<table>
<thead>
<tr>
<th>(type, number of weekly contact hours, language — if other than German)</th>
<th>Language of assessment: German and/or English</th>
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</thead>
<tbody>
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<td>V (3)</td>
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</table>

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

- a) written examination (approx. 90 to 180 minutes) or
- b) oral examination of one candidate each (20 to 30 minutes) or
- c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or
- d) log (approx. 20 pages) or
- e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

### Allocation of places

--

### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
Module Group Focus Topic I: Functional Materials in Biology and Medicine

(ECTS credits)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Biopolymers</td>
<td>03-BIOPOL-222-m01</td>
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</table>

**Module coordinator**

Holder of the Chair of Macromolecular Chemistry

**Module offered by**

Faculty of Medicine

<table>
<thead>
<tr>
<th>ECTS</th>
<th>Method of grading</th>
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</thead>
<tbody>
<tr>
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<td>numerical grade</td>
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</tbody>
</table>

**Duration**

1 semester

**Contents**

Organisms produce biologically active macromolecules (polysaccharides, proteins, nucleic acids, etc.) that perform (survival) important functions in structure, movement, recognition, metabolic and information storage. These naturally occurring polymers can also be isolated, chemically modified and commercialized for further applications. In addition, novel macromolecules can additionally be synthetically derived from bio-based feedstocks, which are increasingly used as sustainable and degradable biopolymers.

**Intended learning outcomes**

The student will acquire fundamental knowledge of naturally occurring macromolecules, their production, function, modification, and application in various biological contexts and everyday areas.

**Courses**

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + P (1)

Module taught in: V, Ü: English

**Method of assessment**

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90) or
b) oral examination of one candidate each (20 to 30 minutes) or
c) talk (approx. 30)

Language of assessment: English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

--
## Module Title: Biofabrication

### Abbreviation: 03-BIOFAB-222-m01

<table>
<thead>
<tr>
<th>Module Coordinator</th>
<th>Module Offered by</th>
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</thead>
<tbody>
<tr>
<td>holder of the Chair of Functional Materials in Medicine and Dentistry</td>
<td>Faculty of Medicine</td>
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<tr>
<th>Duration</th>
<th>Module Level</th>
<th>Other Prerequisites</th>
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<tbody>
<tr>
<td>1 semester</td>
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</table>

### Contents

Definitions within biomaterials, tissue engineering and biofabrication, overview of medical device regulations and practices, description of extracellular matrix, bioprinting, continuous liquid interface polymerisation, two-photon polymerisation, fused deposition modelling, inorganic powder printing, stereolithography, selective laser sintering, melt electrospinning writing, self-healing hydrogels, polymers in 3D printing, introduction to rheology, scientific method and reproducibility, digital signal generation and quality control.

### Intended Learning Outcomes

Students gain a thorough appreciation of the different additive manufacturing (3D printing) technologies available in the context of biofabrication. This includes how the polymers are processed and how each class of 3D printer works, with its strengths and weaknesses. A holistic view of biofabrication is taught, with an understanding of scientific methodology for each stage and the different regulations governing medical devices. Students will acquire the necessary skills to critique and develop opinions on the 3D printing industry and the resulting biomedical applications.

### Courses

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of Weekly Contact Hours</th>
<th>Language</th>
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<tr>
<td>Ü</td>
<td>1</td>
<td>English</td>
</tr>
<tr>
<td>P</td>
<td>1</td>
<td>English</td>
</tr>
</tbody>
</table>

Module taught in: V, Ü: English

### Method of Assessment

- a) written examination (approx. 90 minutes)
- b) oral examination of one candidate each (20 to 30 minutes)
- c) talk (approx. 30 minutes)

Language of assessment: English

### Allocation of Places

--

### Additional Information

--

### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
## Module Catalogue for the Subject
### Functional Materials
#### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Materials in Implantology</td>
<td>03-FU-IMPL-222-m01</td>
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<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
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</thead>
<tbody>
<tr>
<td>holder of the Chair of Musculoskeletal Tissue Regeneration</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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<tr>
<th>Duration</th>
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<tbody>
<tr>
<td>1 semester</td>
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</table>

### Contents
Anatomy and physiology of the cardiovascular system, sensory organs, skeletal system, jaw incl. tooth structure as well as pathological processes leading to functional impairment or even loss of function. Materials and use of medical implants in the respective area.

### Intended learning outcomes
Students receive in-depth basic knowledge in human physiology. They will also gain knowledge of pathological processes that can lead to the use of medical materials and implants. The students have knowledge of the application of implants in various organs and tissues and their compatibility and interaction with the organism.

### Courses
(type, number of weekly contact hours, language — if other than German)

V (3) + P (1)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) placement report / fieldwork report / report on practical training / report on practical course / project report / report on technical course (approx. 10 pages) or
b) presentation (approx. 30 minutes) or
c) written examination (approx. 60 minutes)
Language of assessment: German and/or English

### Allocation of places
--

### Additional information
--

### Referred to in LPO I
(examination regulations for teaching-degree programmes)
--
### Module title
Nano4Med

### Abbreviation
03-FU-DDEL-222-m01

### Module coordinator
holder of the Chair of Functional Materials in Medicine and Dentistry

### Module offered by
Chair of Chemical Technology of Material Synthesis

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
--

### Other prerequisites
--

### Contents
Incorporation and Conjugation of active substances into particle systems, functionalization of the particle systems for transport, targeting and release of active ingredients.

### Intended learning outcomes
Incorporation and Conjugation of active substances into particle systems, functionalization of the particle systems for transport, targeting and release of active ingredients.

### Courses
(V (1) + Ü (1) + P (1))

### Method of assessment
a) placement report / fieldwork report / report on practical training / report on practical course / project report / report on technical course (approx. 10 pages) and
b) presentation (approx. 30 minutes) or written examination (approx. 90 minutes)

Language of assessment: German and/or English

### Allocation of places
--

### Additional information
--

### Referred to in LPO I
(examination regulations for teaching-degree programmes)
--
### Module title
Tissue cells meet materials

### Abbreviation
03-GEWMAT-222-m01

### Module coordinator
holder of the Chair of Tissue Engineering and Regenerative Medizin

### Module offered by
Chair of Chemical Technology of Material Synthesis

### ECTS
5

### Method of grading
numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
--

### Other prerequisites
--

### Contents
The module teaches the following contents: The cell culture techniques required for the construction of artificial tissues (tissue or also bioengineering), the basics of constructing such models using suitable (bio)materials, the use of such models as alternative test systems to animal experimentation. Another topic is the development of cell-based transplants, medical devices and drugs, as well as the regulatory basis for their approval (REACH, GLP, GMP, etc.).

### Intended learning outcomes
Students will gain content-related and methodological insights into current key topics in tissue engineering as well as the use of these tissues as substitutes for animal models or as transplants in regenerative medicine.

### Courses
(type, number of weekly contact hours, language — if other than German)

V (2) + P (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) placement report / fieldwork report / report on practical training / report on practical course / project report / report on technical course (approx. 10 pages) and
b) presentation (approx. 30 minutes) or written examination (approx. 90 minutes)

Language of assessment: German and/or English

### Allocation of places
--

### Additional information
--

### Referred to in LPO I
(examination regulations for teaching-degree programmes)

--
Module Group Focus Topic II: Polymer Functional Materials

(ECTS credits)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Biofabrication</td>
<td>03-BIOFAB-222-m01</td>
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<tbody>
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<td>Faculty of Medicine</td>
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<table>
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<tbody>
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<td>1 semester</td>
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</table>

**Contents**

Definitions within biomaterials, tissue engineering and biofabrication, overview of medical device regulations and practices, description of extracellular matrix, bioprinting, continuous liquid interface polymerisation, two-photon polymerisation, fused deposition modelling, inorganic powder printing, stereolithography, selective laser sintering, melt electrospinning writing, self-healing hydrogels, polymers in 3D printing, introduction to rheology, scientific method and reproducibility, digital signal generation and quality control.

**Intended learning outcomes**

Students gain a thorough appreciation of the different additive manufacturing (3D printing) technologies available in the context of biofabrication. This includes how the polymers are processed and how each class of 3D printer works, with its strengths and weaknesses. A holistic view of biofabrication is taught, with an understanding of scientific methodology for each stage and the different regulations governing medical devices. Students will acquire the necessary skills to critique and develop opinions on the 3D printing industry and the resulting biomedical applications.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + P (1)

Module taught in: V, Ü: English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or
b) oral examination of one candidate each (20 to 30 minutes) or
c) talk (approx. 30 minutes)

Language of assessment: English

**Allocation of places**

--

**Additional information**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Polymer Materials 1: Technology of Polymer Modification</td>
<td>08-FU-PW1-161-m01</td>
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<table>
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<tbody>
<tr>
<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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</table>

### Contents
Methods of polymer synthesis; composition of polymers and polymer compounds; properties of polymers; technologies for the production of polymers compound and polymer components; means of characterisation of polymer compounds and polymer components.

### Intended learning outcomes
The students possess knowledge of the special properties of polymers and polymer compounds (e.g. time and temperature dependent viscoelastic behaviour). They know the characteristics of important production technologies (methods of polymer synthesis, compounding technologies, processing methods e.g. injection moulding) and understands the different ways of influencing properties of materials and manufactured products. They have knowledge of ways to calculate complex flow conditions in polymer processing machines and tools.

### Courses
(type, number of weekly contact hours, language — if other than German)
V (2) + P (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate)
Assessment offered: Once a year, winter semester
Language of assessment: German and/or English
P: creditable for bonus

### Allocation of places
--

### Additional information
--

### Referred to in LPO I
(examination regulations for teaching-degree programmes)
--
### Module Catalogue for the Subject
#### Functional Materials
##### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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</thead>
<tbody>
<tr>
<td>Additive Manufacturing</td>
<td>03-ADFER-222-m01</td>
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<table>
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<tbody>
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<td>holder of the Chair of Functional Materials in Medicine and Dentistry</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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</table>

### Contents

The course will cover the basics of additive manufacturing (AM) focusing on the techniques and materials used in AM. All aspects of the 3D printing chain, starting from the CAD design followed by slicing, printer selection and preparation to post processing, will be discussed. Participants will get the possibility to have hand-on experience with different printing methods during practical sessions. Based on current examples, options to transfer the process from prototyping to manufacturing and concepts to implement sustainability into additive manufacturing will be highlighted. The course will also focus on biomedical applications and options how 3D printing can be used in Biofabrication.

### Intended learning outcomes

The student has advanced knowledge of the synthesis, modification and characterization of polymers.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (2) + Ü (1) + P (1)

Module taught in: V, Ü: English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or
b) oral examination of one candidate each (20 to 30 minutes) or
c) talk (approx. 30 minutes)

Language of assessment: English

### Allocation of places

--

### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

--
### Module Catalogue for the Subject
Functional Materials
Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
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<th>Abbreviation</th>
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<tbody>
<tr>
<td>Polymer Materials 2: Technology of Filler Modification for Polymer Materials</td>
<td>08-FU-PW2-161-m01</td>
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<table>
<thead>
<tr>
<th>Module coordinator</th>
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<tbody>
<tr>
<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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<tr>
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<tr>
<th>Duration</th>
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<th>Other prerequisites</th>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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<table>
<thead>
<tr>
<th>Contents</th>
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</thead>
<tbody>
<tr>
<td>Principles and technologies for the functionalization of additives and their utilization for the modification of polymers and their properties, interaction between polymers and additives and determination of the particular properties of such functionalized polymers (e.g. electric, bactericidal, flame retardant properties). Also the influence on other properties such as mechanical and rheological properties, color, turbidity and surface finish will be discussed.</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Intended learning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>The students possess knowledge on the technologies to functionalize polymeric materials with additives. They know the possibilities and issues regarding of such modifications, the interaction between additives and polymers. Moreover, they are qualified to determine particular properties of functionalized polymers (e.g. flame retardancy) and understand the interactions with other properties of the polymers, such as rheology, mechanical properties, color, turbidity or surface finish.</td>
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<table>
<thead>
<tr>
<th>Courses</th>
<th>(type, number of weekly contact hours, language — if other than German)</th>
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<tbody>
<tr>
<td>V (2) + P (2)</td>
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<thead>
<tr>
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<th>(type, scope, language — if other than German, examination offered — If not every semester, information on whether module is creditable for bonus)</th>
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<tr>
<td>a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) Assessment offered: Once a year, summer semester</td>
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<td>Language of assessment: German and/or English</td>
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<td>P: creditable for bonus</td>
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<th>Allocation of places</th>
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<table>
<thead>
<tr>
<th>Additional information</th>
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<table>
<thead>
<tr>
<th>Referred to in LPO I</th>
<th>(examination regulations for teaching-degree programmes)</th>
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</table>
### Module: Polymers II

**Abbreviation:** 03-FU-PM2-222-m01

<table>
<thead>
<tr>
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<tr>
<td>holder of the Chair of Functional Materials in Medicine and Dentistry</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</tbody>
</table>

**Contents**
Basics as well as advanced knowledge about contemporary issues of polymer synthesis, -modification and characterization.

**Intended learning outcomes**
The student has advanced knowledge of the synthesis, modification and characterization of polymers.

**Courses**
(type, number of weekly contact hours, language — if other than German)

V (2) + P (2)

**Method of assessment**
type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or
b) oral examination of one candidate each (20 to 30 minutes) or
c) talk (approx. 30 minutes)
Language of assessment: German and/or English
P: creditable for bonus
Assessment offered: Once a year, winter semester

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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Module Group Focus Topic III: Energy Technologies
(ECTS credits)
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<tr>
<th>Module title</th>
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<tr>
<td>Electrochemical Energy Storage and Conversion</td>
<td>08-FU-EEW-222-m01</td>
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<tbody>
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<tbody>
<tr>
<td>1 semester</td>
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</table>

**Contents**

Chemistry and application of battery systems (aqueous and non-aqueous systems like lead, nickel cadmium and nickel metal hydride, sodium sulfur, sodium nickel chloride, lithium ion accumulators), electrochemical double layer capacitors, redox-flow battery, fuel cell systems (AFC, PEMFC, DMFC, PAFC, SOFC), Solar cells (Si, CIS, CIGS, GaAs, organic and dye solar cell), thermoelectric devices.

**Intended learning outcomes**

The students gain comprehensive knowledge in the field of electrochemical energy storage and transformation and are able to apply this to scientific problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or oral examination of one candidate each (approx. 30 minutes) and
b) talk (approx. 30 minutes); (weighted 65:35)

Language of assessment: German and/or English

Assessment offered: Once a year, summer semester

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
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<td>Structure-Properties Correlations of Light Materials - Experiments and Numerical Simulations</td>
<td>08-FU-MW-222-m01</td>
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**Contents**

Material properties of metals and ceramics: Structur-property relationships through experiments and simulation.

**Intended learning outcomes**

The students gain fundamental knowledge about the properties of modern materials: aviation aluminum alloys and high performance ceramics. Analytical methods and predictions through numerical simulations will be presented. The relationship of mikro- and nanoscopic structure of materials and the resulting properties are emphasized.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or oral examination of one candidate each (approx. 30 minutes) and b) talk (approx. 30 minutes); (weighted 60:40)

Language of assessment: German and/or English

Assessment offered: Once a year, summer semester

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
### Module title
Materials for High Voltage insulation and High Voltage Systems

### Abbreviation
99-HIS-222-m01

### Module coordinator
Dean of the Faculty of Electrical Engineering at the University of Applied Sciences Würzburg-Schweinfurt

### Module offered by
University of Applied Sciences Würzburg-Schweinfurt (FHWS)

### ECTS
5

### Method of grading
Numerical grade

### Only after succ. compl. of module(s)
--

### Duration
1 semester

### Module level
Graduate

### Other prerequisites
--

### Contents
Electrical stress, electrical strength, dielectric material properties, technology and application of insulating materials and systems, diagnostics, measurements, simulation and tests of insulating systems.

### Intended learning outcomes
The student gain basic knowledge about the electrical field and insulating systems with layering of different materials. They can design simple insulating systems by their own and approve the existing design. They have basic knowledge in the field of diagnosis and technology of insulating materials.

### Courses
(V (3) + Ü (1))

### Method of assessment
A) written examination (approx. 90 minutes) or
B) oral examination of one candidate each (approx. 20 to 30 minutes) or
C) oral examination in groups (groups of 2, approx. 30 minutes total)

Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

--
Module title | Abbreviation
---|---
Nanotechnology in Energy Research | 11-NTE-152-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

<table>
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</table>

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | --

Contents
Nanotechnology is of great significance for energy research. Energy efficiency can be heightened in numerous processes or applications by using special functional materials. This module covers special materials, surfaces and structures that have optimised properties due to effects of nanotechnology. It explains the underlying physical contexts. It uses specific materials and components as examples, such as thermal insulation materials, heat accumulators, functional nanoscale layer and particle systems with spectral selective properties, nanoporous vacuum insulations and electrode materials.

Intended learning outcomes
The students have specific and advanced knowledge of the application of nanotechnology in the field of energy research. They know methods of nanotechnology to influence the properties of materials and their applications. They are able to apply their knowledge to specific questions.

Courses
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<td>Module taught in: German or English</td>
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Method of assessment
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: Once a year, summer semester
Language of assessment: German and/or English

Allocation of places
--

Additional information
--

Referred to in LPO I (examination regulations for teaching-degree programmes)
--
### Module title

**Principles of Energy Technologies**

| Abbreviation | 11-ENT-152-m01 |

### Module coordinator

Managing Director of the Institute of Applied Physics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

| 6 | -- |

### Method of grading

Only after succ. compl. of module(s)

### Duration

| 1 semester | graduate | -- |

### Contents


### Intended learning outcomes

The students know the principles of different methods of energy technology, especially energy conversion, transport and storage. They understand the structures of corresponding installations and are able to compare them.

### Courses

(type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

### Method of assessment

(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Assessment offered: Once a year, winter semester

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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### Referred to in LPO I

( examination regulations for teaching-degree programmes)

§ 22 II Nr. 1 h)

§ 22 II Nr. 2 f)

§ 22 II Nr. 3 f)
Module title
Optical Properties of Semiconductor Nanostructures

Abbreviation
11-HNS-161-m01

Module coordinator
Managing Director of the Institute of Applied Physics

Module offered by
Faculty of Physics and Astronomy

ECTS
6

Method of grading
numerical grade

Only after succ. compl. of module(s)
--

Duration
1 semester

Module level
graduate

Other prerequisites
--

Contents
Semiconductor nanostructures are frequently referred to as "artificial materials". In contrast to atoms, molecules or macroscopic crystals, their electronic, optical and magnetic properties can be systematically tailored by changing their size. The lecture addresses technological challenges in the preparation of semiconductor nanostructures of varying dimensions (2D, 1D, 0D). It provides the basic theoretical concepts to describe their properties, with a focus on optical properties and light-matter coupling. Moreover, it discusses the challenges and concepts of novel optoelectronic and quantum photonic devices based on such nanostructures, including building blocks for quantum communication and quantum computing architectures.

Intended learning outcomes
The students know the theoretical principles and characteristics of semiconductor nanostructures. They have knowledge of the technological methods to fabricate such structures, and of their applications to novel photonic devices. They are able to apply their knowledge to problems in this field of research.

Courses
V (3) + R (1)

Module taught in: German or English

Method of assessment
written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
--
Module Group Focus Topic IV: Semiconductor Nanostructures

(ECTS credits)
Module title | Abbreviation
---|---
Semiconductor Physics | 11-HPH-201-m01

Module coordinator | Module offered by
Managing Director of the Institute of Applied Physics | Faculty of Physics and Astronomy

ECTS | Method of grading | Only after succ. compl. of module(s)
---|---|---
6 | numerical grade | --

Duration | Module level | Other prerequisites
---|---|---
1 semester | graduate | --

Contents
The lecture deals with the fundamental properties of semiconductors. It begins with an analysis of the crystal structure, leading to methods for describing band structures. These form a basis for discussing optical and electronic properties of monolithic semiconductors. It then turns to examining semiconductor heterostructures, and studies how these can be used to modify and design optical and electrical properties, especially in the case of lowered dimensionality systems. Examples are selected from current research activities.

Intended learning outcomes
To provide the student with a working knowledge of semiconductors pertaining to crystal structure, symmetries, and band structures, as well as electrical and optical properties. This establishes a solid basis preparing him for the more targeted specially lectures in the program.

Courses (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: German or English

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
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Language of assessment: German and/or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester

Allocation of places
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Additional information
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Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Module title

Physics of Semiconductor Devices

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### Module coordinator

Managing Director of the Institute of Applied Physics

### Module offered by

Faculty of Physics and Astronomy

### ECTS

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</table>

### Duration

1 semester

### Module level

Undergraduate

### Other prerequisites

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### Contents

Based on the fundamentals of Semiconductor Physics, the lecture provides an insight into semiconductor key technologies and discusses the main components in the fields of electronics and photonics on the basis of examples. The basic part introduces the crystal structures and band and phonon dispersions of technologically relevant semiconductors. The following part discusses the principles of charge transport involving non-equilibrium effects based on the charge carrier density of the thermal equilibrium. The part on technology gives an insight into the methods of production of semiconductor materials and presents the most important methods of planar technology. It discusses the way of functioning of the following components, sorted according to volume components, interface components and application fields: Rectifier diodes, Zener diodes, varistor, varactor, tunnel diodes, IMPATT, Baritt- and Gunn diodes, photodiode, solar cell, LED, semiconductor injection laser, transistor, JFET, Thyristor, Diac, Triac, Schottky diode, MOSFET, MESFET, HFET. It highlights the importance of low-dimensional charge carrier systems for technology and basic research and shows recent developments in the components sector.

### Intended learning outcomes

The students know the characteristics of semiconductors, they have gained an overview of the electronic and phonon band structures of important semiconductors and the resulting electronic, optical and thermal properties. They know the principles of charge transport as well as the Poisson, Boltzmann and continuity equation for the solution of questions. They have gained insights into the methods of semiconductor production and are familiar with the theories of planar technology and recent developments in this field, they have a basic understanding of component production. They understand the structure and way of functioning of the main components of electronics (diode, transistor, field-effect transistor, thyristor, diac, triac), of microwave applications (tunnel, IMPATT, Baritt or Gunn diode) and of optoelectronics (photo diode, solar cell, light-emitting diode, semiconductor injection laser), they know the realisation possibilities of low-dimensional charge carrier systems on the basis of semiconductors and their technological relevance, they are familiar with current developments in the field of components.

### Courses

V (3) + R (1)

Module taught in: German or English

### Method of assessment

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: Once a year, summer semester

Language of assessment: German and/or English

### Allocation of places

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### Additional information

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Module Catalogue for the Subject
### Functional Materials
#### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
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<td>Organic Semiconductors</td>
<td>11-OHL-161-m01</td>
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</table>

### Contents
Fundamentals of organic semiconductors, molecular and polymer electronics and sensor technology, applications.

### Intended learning outcomes
The students have advanced knowledge of organic semiconductors.

### Courses
(V (3) + R (1))
Module taught in: German or English

### Method of assessment
(type, scope, language — if other than German)

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

### Allocation of places
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### Additional information
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<td>Coating Technologies based on Vapour Deposition</td>
<td>11-BVG-202-m01</td>
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**Contents**

Physical and technical basics of PVD and CVD systems and processes. Layer deposition and layer characterization. Application of coating materials on an industrial scale.

**Intended learning outcomes**

The student has in-depth knowledge in the field of gas-phase deposition processes and gains insights into their industrial significance and diversity.

**Courses**

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<th>Type</th>
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<th>Language</th>
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<tbody>
<tr>
<td>V</td>
<td>(3)</td>
<td>German or English</td>
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**Module taught in:** German or English

**Method of assessment**

- written examination (approx. 90 to 120 minutes) or
- oral examination of one candidate each (approx. 30 minutes) or
- oral examination in groups (groups of 2, approx. 30 minutes per candidate) or
- project report (approx. 8 to 10 pages) or
- presentation/talk (approx. 30 minutes).

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**Allocation of places**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Optical Properties of Semiconductor Nanostructures</td>
<td>11-HNS-161-m01</td>
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<th>Module coordinator</th>
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<tr>
<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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<tbody>
<tr>
<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

Semiconductor nanostructures are frequently referred to as "artificial materials". In contrast to atoms, molecules or macroscopic crystals, their electronic, optical and magnetic properties can be systematically tailored by changing their size. The lecture addresses technological challenges in the preparation of semiconductor nanostructures of varying dimensions (2D, 1D, 0D). It provides the basic theoretical concepts to describe their properties, with a focus on optical properties and light-matter coupling. Moreover, it discusses the challenges and concepts of novel optoelectronic and quantum photonic devices based on such nanostructures, including building blocks for quantum communication and quantum computing architectures.

**Intended learning outcomes**

The students know the theoretical principles and characteristics of semiconductor nanostructures. They have knowledge of the technological methods to fabricate such structures, and of their applications to novel photonic devices. They are able to apply their knowledge to problems in this field of research.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (3) + R (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — If not every semester, information on whether module is creditable for bonus)

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Assessment offered: In the semester in which the course is offered and in the subsequent semester

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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Module Group Focus Topic V: Organic Functional Materials and Applications
(ECTS credits)
<table>
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<tr>
<td>Chemical Nanotechnology: Analytics and Applications</td>
<td>08-FU-NT-AA-152-m01</td>
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<tbody>
<tr>
<td>degree programme coordinator Funktionswerkstoffe (Functio-</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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<td>1 semester</td>
<td>graduate</td>
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</table>

**Contents**

Introduction to theory and application of characterisation methods in nano-chemistry. Thermoanalysis, rheological methods, dynamic light scattering, application of nano materials in industry and technology.

**Intended learning outcomes**

The students possess advanced knowledge of characterisation and application of nano materials.

**Courses** (type, number of weekly contact hours, language — if other than German)

| V (4) |

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 180 minutes) or b) oral examination of one candidate each (20 to 30 minutes) or c) oral examination in groups of up to 3 candidates (approx. 15 minutes per candidate) or d) log (approx. 20 pages) or e) presentation (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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### Module title
Polymer Materials 1: Technology of Polymer Modification

### Abbreviation
08-FU-PW1-161-m01

### Module coordinator
degree programme coordinator Funktionswerkstoffe (Functional Materials)

### Module offered by
Chair of Chemical Technology of Material Synthesis

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</table>

### Contents
Methods of polymer synthesis; composition of polymers and polymer compounds; properties of polymers; technologies for the production of polymers compound and polymer components; means of characterisation of polymer compounds and polymer components.

### Intended learning outcomes
The students possess knowledge of the special properties of polymers and polymer compounds (e.g. time and temperature dependent viscoelastic behaviour). They know the characteristics of important production technologies (methods of polymer synthesis, compounding technologies, processing methods e.g. injection moulding) and understands the different ways of influencing properties of materials and manufactured products. They have knowledge of ways to calculate complex flow conditions in polymer processing machines and tools.

### Courses
(type, number of weekly contact hours, language — if other than German)

V (2) + P (2)

### Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate)

Assessment offered: Once a year, winter semester

Language of assessment: German and/or English

P: creditable for bonus

### Allocation of places
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### Additional information
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### Referred to in LPO I
(examination regulations for teaching-degree programmes)

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### Nanoscale Materials

<table>
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<td>Nanoscale Materials</td>
<td>08-PCM3-161-m01</td>
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#### Module coordinator
Lecturer of the seminar "Nanoskalige Materialien"  
Institute of Physical and Theoretical Chemistry

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### Contents

This module discusses advanced topics in nanoscale materials. It focuses on the structure, properties, fabrication, modern characterisation methods and application areas of nanoscale materials.

### Intended learning outcomes

Students are able to characterise nanoscale materials. They are able to name analytical methods and application areas of nanoscale materials.

### Courses

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Module taught in: German or English

### Method of assessment

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Language of assessment: German and/or English  
Creditable for bonus

### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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<table>
<thead>
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<td>Polymer Materials 2: Technology of Filler Modification for Polymer Materials</td>
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<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
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### Contents

Principles and technologies for the functionalization of additives and their utilization for the modification of polymers and their properties, interaction between polymers and additives and determination of the particular properties of such functionalized polymers (e.g. electric, bactericidal, flame retardant properties). Also the influence on other properties such as mechanical and rheological properties, color, turbidity and surface finish will be discussed.

### Intended learning outcomes

The students possess knowledge on the technologies to functionalize polymeric materials with additives. They know the possibilities and issues regarding of such modifications, the interaction between additives and polymers. Moreover, they are qualified to determine particular properties of functionalized polymers (e.g. flame retardancy) and understand the interactions with other properties of the polymers, such as rheology, mechanical properties, color, turbidity or surface finish.

### Courses

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### Method of assessment

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<td>Assessment offered: Once a year, summer semester</td>
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<td>Language of assessment: German and/or English</td>
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<td>P: creditable for bonus</td>
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### Allocation of places

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### Additional information

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### Referred to in LPO I

(examination regulations for teaching-degree programmes)

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Module title | Abbreviation
---|---
Supramolecular Chemistry (Basics) | 08-SCM1-161-m01

Module coordinator | Module offered by
lecturer of lecture "Organischen Chemie" | Faculty of Chemistry and Pharmacy

ECTS | Method of grading | Only after succ. compl. of module(s)
5 | numerical grade | --

Duration | Module level | Other prerequisites
1 semester | graduate | --

Contents

This module introduces students to the fundamental principles of supramolecular chemistry. It focuses on interactions between molecules, molecular recognition by receptors, complexes, supramolecular polymers, coordination polymers and networks, liquid crystals, self-assembly in aqueous media, synthetic ion channels and modern applications of supramolecular chemistry.

Intended learning outcomes

Students are able to explain interactions between molecules demonstrating a high degree of expertise in the field as well as to describe the formation, structure and polymers of coordination compounds. They are able to describe the self-assembly of polymers in aqueous media as well as to identify the characteristics of synthetic ion channels. They can name modern applications of supramolecular chemistry.

Courses

(type, number of weekly contact hours, language — if other than German)

S (3)
Module taught in: German or English

Method of assessment
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes)
Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO 1 (examination regulations for teaching-degree programmes)

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<table>
<thead>
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<tr>
<td>Physical Chemistry of Supramolecular Assemblies</td>
<td>08-PCM5-161-m01</td>
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<tr>
<td>lecturer of the seminar &quot;Physikalische Chemie Supramolekularer Strukturen&quot;</td>
<td>Institute of Physical and Theoretical Chemistry</td>
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</table>

**Contents**

This module examines the basic interactions between molecules. It discusses the formation and physical-chemical properties of aggregates as well as key applications of supramolecular chemistry.

**Intended learning outcomes**

Students are able to explain the basic interactions between molecules demonstrating a high degree of expertise in the field. They can describe the formation and physical-chemical properties of aggregates. They can name modern applications of supramolecular chemistry.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)

Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) talk (approx. 30 minutes)

Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--
Module Group Focus Topic VI: Imaging und Spectroscopy
(ECTS credits)
Module title | Abbreviation
--- | ---
Principles of Two- and Three-Dimensional Röntgen Imaging | 11-ZDR-152-m01

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<td>Faculty of Physics and Astronomy</td>
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</table>

Contents

Physics of X-ray generation (X-ray tubes, synchrotron). Physics of the interaction between X-rays and matter (photon absorption, scattering), physics of X-ray detection. Mathematics of reconstruction algorithms (filtered rear projection, Fourier reconstruction, iterative methods). Image processing (image data pre-processing, feature extraction, visualisation,...). Applications of X-ray imaging in the industrial sector (component testing, material characterisation, metrology, biology, ...). Radiation protection and biological radiation effect (dose, ...).

Intended learning outcomes

The students know the principles of generating X-rays and of their interactions with matter. They know imaging techniques using X-rays and methods of image processing as well as application areas of these methods.

Courses

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Module taught in: German or English

Method of assessment

Written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).

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Assessment offered: Once a year, summer semester

Language of assessment: German and/or English

Allocation of places

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Additional information

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Referred to in LPO I (examination regulations for teaching-degree programmes)

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## Module Catalogue for the Subject Functional Materials

### Master's with 1 major, 120 ECTS credits

<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Advanced Computer Tomography</td>
<td>11-CTA-212-m01</td>
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### Module coordinator
Managing Director of the Institute of Applied Physics

### Module offered by
Faculty of Physics and Astronomy

### ECTS | Method of grading | Only after succ. compl. of module(s) |
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### Duration | Module level | Other prerequisites |
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<tr>
<td>1 semester</td>
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</table>

### Contents
This advanced course focuses on the details of modern computed tomography (CT), which is employed both in medical and industrial imaging applications. In addition to the technicalities of CT systems and their application to various tasks in engineering and medical science, this lecture emphasizes on the mathematics of “inverting the Radon transform”. Starting with the simple Filtered Back Projection method which is applied to a variety of standard recording geometries (parallel, fan, cone, helix) the advanced course lays out the strategies for algebraic reconstruction techniques (ART) along with many types of regularization schemes which may accompany these methods. Students will have the opportunity to see how Radon data is recorded and how different error sources as well as the corresponding correction schemes influence the outcome of the reconstructed volume images. Finally, the most common tools for volume image analysis are presented, such as distance transforms, watersheds, labelling and fiber orientation analysis.

### Intended learning outcomes
The student know the concept of Computed tomography (CT) and its applications. From the formulation of the basic inverse problem posed by this technique the students are able to derive strategies for different numerical solutions, based on Fourier analysis and/or based on probability theory. Most importantly the students have a firm impression (first-hand experience) of the various sources of measurement errors in CT which can impede any wellprepared reconstruction.

### Courses (type, number of weekly contact hours, language — if other than German)
V (3) + R (1)
Module taught in: German or English

### Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).
If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.
Language of assessment: German and/or English

### Allocation of places
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### Additional information
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### Referred to in LPO I (examination regulations for teaching-degree programmes)
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### Module Catalogue for the Subject
#### Functional Materials
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**Master's with 1 major, 120 ECTS credits**

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<thead>
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<td>Electron and Ion Microscopy</td>
<td>11-EIM-211-m01</td>
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### Contents


### Intended learning outcomes

The student has specific and immersed knowledge in electron and ion microscopy. He/she knows the theoretical and instrumental basics and principles of detectors and contrast mechanisms. He/she knows different modi of electron microscopy and their applications. He/she knows ongoing developments in this field.

### Courses

V (3) + R (1)

Module taught in: German or English

Teaching cycle: annually, after announcement

### Method of assessment

a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).

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Language of assessment: German and/or English

Prüfungsturnus: im Semester der LV und im Folgesemester

### Allocation of places

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### Additional information

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### Referred to in LPO I (examination regulations for teaching-degree programmes)

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<table>
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<td>Laser Spectroscopy</td>
<td>08-PCM1a-161-m01</td>
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**Module coordinator**  
Lecturer of seminar "Laserspektroskopie" (Laser Spectroscopy)

**Module offered by**  
Institute of Physical and Theoretical Chemistry

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</table>

**Contents**  
This module introduces students to the fundamental principles of laser spectroscopy. It discusses absorption and emission spectroscopy.

**Intended learning outcomes**  
Students are able to explain the components and operating principles of lasers as well as the optical principles of laser technology. They are able to describe the principles of absorption and emission spectroscopy.

**Courses**  
(type, number of weekly contact hours, language — if other than German)

S (2) + Ü (1)  
Module taught in: German or English

**Method of assessment**  
(type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes)  
Language of assessment: German and/or English

**Allocation of places**  
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**Additional information**  
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**Referred to in LPO I**  
(examination regulations for teaching-degree programmes)  
--
Thesis
(30 ECTS credits)
<table>
<thead>
<tr>
<th>Module title</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>Master Thesis Functional Materials</td>
<td>08-FU-MT-161-m01</td>
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<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
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<tr>
<td>degree programme coordinator Funktionswerkstoffe (Functional Materials)</td>
<td>Chair of Chemical Technology of Material Synthesis</td>
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<tr>
<th>Duration</th>
<th>Module level</th>
<th>Other prerequisites</th>
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<tbody>
<tr>
<td></td>
<td>graduate</td>
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</table>

**Contents**

Working on a defined problem from the field of technology of functional materials using scientific methods.

**Intended learning outcomes**

The students are able to work on a defined problem using scientific methods and to document the results in written form.

**Courses** (type, number of weekly contact hours, language — if other than German)

No courses assigned to module

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

Master’s thesis (approx. 70 pages)  
Language of assessment: German and/or English

**Allocation of places**

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**Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<table>
<thead>
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<td>Chair of Chemical Technology of Material Synthesis</td>
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<td>1 semester</td>
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**Contents**
Presentation and defense of the results of the Master-Thesis

**Intended learning outcomes**
The students learn how to present and defend a scientific piece of work.

**Courses** (type, number of weekly contact hours, language — if other than German)
K (0)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)
final colloquium (approx. 60 minutes): talk (approx. 30 minutes) with subsequent discussion (approx. 30 minutes)
Language of assessment: German and/or English

**Allocation of places**
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**Additional information**
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)
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