Modulhandbuch

Master of Science Advanced Materials

Vertiefung:Biomaterials

Prüfungsordnungsdefinitionen 2008
Inhaltsverzeichnis

Materials Science

  Computational Methods in Materials Science .......................................................... 1
  Materials Science Lab I ............................................................................................. 3
  Materials Science Lab II ........................................................................................... 5
  Materials Science I ................................................................................................... 7
  Materials Science II ................................................................................................. 9

Chemistry

  General Chemistry .................................................................................................... 11
  Physical Chemistry .................................................................................................. 13
  Synthesis of Organic and Inorganic Materials ......................................................... 15

Physics

  Introductory Solid State Physics ............................................................................. 17
  Physics Lab ................................................................................................................ 19

Biology - Biomaterials

  Applications of Biomaterials ................................................................................... 21
  Biological Tissues ..................................................................................................... 23
  Classes of Biomaterials ............................................................................................ 25
  Degradation of Biomaterials ..................................................................................... 27
  Host Reactions to Biomaterials .................................................................................. 29
  Introductory Biology and Cell Biology ..................................................................... 31
  Production of Biomaterials ......................................................................................... 34
  Testing of Biomaterials ............................................................................................. 36

Elective Courses

  Biosensors ................................................................................................................ 38
  Cell Interaction with Biomaterials and Imaging Techniques ..................................... 40
  Cell Mechanics and Interactions with Biomaterials ................................................. 42
  Chemistry Lab .......................................................................................................... 44
  Compound Semiconductors (Verbindungshalbleiter) .................................................. 45
  Exploring the Nanoworld with X-Rays and High-Energy Electrons ....................... 47
  Innovation Management for Nanotechnology ....................................................... 50
  Introductory Engineering ......................................................................................... 53
  Laser, Laser-Matter Interactions ............................................................................. 56
  Materials in Cell and Tissue Engineering ................................................................ 59
  Mechanics of Materials ............................................................................................ 60
  Micro- and Nanostructured Optics ......................................................................... 62
  Micro- and Nanotechnology ..................................................................................... 64
  Nearfield Optics and Plasmonics ............................................................................. 66
  Polymers in Medicine ............................................................................................... 67
  Principles of Structure Formation in Nanomaterials ............................................... 69
  Semiconductor Sensors - Halbleitersensoren ......................................................... 71
Solid State Chemistry .................................................................................................................. 73
Surface Plasmon Photonics ........................................................................................................... 75
Theory in Materials Science ......................................................................................................... 77
Theory in Polymer Science .......................................................................................................... 79
Thin Films .................................................................................................................................. 80

ASQ und Masterarbeit

Additive Key Qualifications ........................................................................................................ 82
Additive Key Qualifications ........................................................................................................ 84
German Language ....................................................................................................................... 86
Master Thesis ............................................................................................................................... 88
Computational Methods in Materials Science
Modul zugeordnet zu Materials Science

Code 8822870462

ECTS-Punkte 4

Präsenzzeit 3

Unterrichtssprache Englisch

Dauer 1 Semester

Turnus jedes Wintersemester

Modulkoordinator Prof. Dr.-Ing. Ulrich Herr

Dozent(en) Prof. Dr.-Ing. Ulrich Herr
Prof. Carl Krill, Ph.D.
Dr. Ulrich Simon


Vorkenntnisse Materials Science I and II

Lernergebnisse Students should be able to recognize the interplay between length/time scales and the computational methods used for simulation in materials science. They can describe the theoretical underpinnings of the finite element method, the phase field method, molecular dynamics and the Monte Carlo method. They are able to explain the strengths and limitations of each of these simulation methods based on practical experience acquired during computer lab exercises. Finally, they can select an appropriate simulation method for solving a given materials science problem computationally.

Inhalt
– Introduction
– Modeling in materials science
– Numerical solution of differential equations
Finite element method (FEM)
– Introduction and fundamentals
– Linear variational functions
– Applications in one dimension
– General finite element approach
– Examples
Phase field method
– Introduction
– Allen-Cahn model
– Energy functional
– Numerical solution methods
– Application to grain growth
Molecular dynamics
– Introduction: statistical mechanics
– Interatomic potentials
– Equations of motion, integration
– Correlation functions
– Examples
Monte Carlo methods
– Introduction
– Metropolis Monte Carlo algorithm
– Ising model
– Resident time algorithm, diffusion

Literatur
- S. E. Koonin, D. C. Meredith: Computational Physics (Addison-Wesley, 1990)
- D. C. Rapaport: The Art of Molecular Dynamics Simulation (Cambridge, 2004)

Lehr- und Lernformen
Lecture “Computational Methods in Materials Science”, 2 SWS
Laboratory “Computational Methods in Materials Science”, 1 SWS

Arbeitsaufwand
lecture + computer lab (presence): 45 h
preparation and revision of lecture notes, lab reports: 55 h
exam preparation: 20 h
Total: 120 h

Bewertungsmethode
Die Vergabe der Leistungspunkte erfolgt aufgrund des Bestehens der schriftlichen Modulprüfung. Die Anmeldung zu dieser Prüfung setzt einen Leistungsnachweis voraus.

Notenbildung
Die Modulnote entspricht dem Ergebnis der Modulprüfung.

Grundlage für
-
### Materials Science Lab I
Modul zugeordnet zu Materials Science

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870908</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>5</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>4</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Dr. Hans Jörg Fecht</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Prof. Dr. HansJörg Fecht, Prof. Dr.Ing. Ulrich Herr, lecturers of the Faculty of Engineering and Computer Science</td>
</tr>
</tbody>
</table>

#### Einordnung in die Studiengänge
- Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
- Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester

#### Vorkenntnisse
BSc degree, attendance in Materials Science I

#### Lernergebnisse
Students should
- learn to operate modern instruments
- learn to apply their fundamental knowledge of Materials Science
- be able to present and report own experimental work/results

#### Inhalt
Laboratory experiments:
- Dynamic-mechanical analysis
- Nanoindentation
- X-ray diffraction
- Phase transformations
- Atomic force microscopy
- Microstructure (2 sessions)

Each experiment requires approximately 4 hours (1 session). In addition to carrying out the experiments listed above, students are required to attend three 2-hour seminars, during which members of the class give oral presentations of their experimental work to the remainder of the group

#### Literatur
### Lehr- und Lernformen

Lab Materials Science I (P), 4 h/week, compulsory

### Arbeitsaufwand

- 25 h laboratory (presence)
- 25 h preparation
- 100 h home writing report and revision
- Total: **150 h**

### Bewertungsmethode

Seminar, report, certificate

### Notenbildung

Passed or failed

### Grundlage für

MSc course of studies Advanced Materials, Materials Science II, Materials Science Lab II
Materials Science Lab II  
Modul zugeordnet zu Materials Science

**Code**  
8822870909

**ECTS-Punkte**  
5

**Präsenzzeit**  
4

**Unterrichtssprache**  
english

**Dauer**  
1 Semester

**Turnus**  
jedes Sommersemester

**Modulkoordinator**  
Prof. Dr. Ing. Ulrich Herr

**Dozent(en)**  
Prof. Dr. Ing. Ulrich Herr, lecturers of the Faculty of Engineering and Computer Science

**Einordnung in die Studiengänge**  
Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 2. semester  
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 2. semester

**Vorkenntnisse**  
Materials Science I, Materials Science Lab I, attendance in Materials Science II

**Lernergebnisse**  
Students should  
- learn to operate modern instruments  
- learn to apply their fundamental knowledge of Materials Science  
- be able to present and report own experimental work/results

**Inhalt**  
Laboratory experiments:  
- Lambda probe  
- Optical properties of ceramics  
- Vibrational sample magnetometry & Kerr microscopy  
- Thin film preparation  
- Magnetoresistance & Kerr magnetometry  
- Amorphous metals

Each experiment requires approximately 4 hours (1 session). In addition to carrying out the experiments listed above, students are required to attend three 2-hour seminars, during which members of the class give oral presentations of their experimental work to the remainder of the group

**Literatur**
<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
<th>Lab Materials Science II (P), 4 h/week, compulsory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbeitsaufwand</td>
<td>25 h laboratory (presence)</td>
</tr>
<tr>
<td></td>
<td>25 h preparation</td>
</tr>
<tr>
<td></td>
<td>100 h home writing report and revision</td>
</tr>
<tr>
<td></td>
<td>Total: <strong>150 h</strong></td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>Seminar, report, certificate</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>Passed or failed</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>MSc course of studies Advanced Materials</td>
</tr>
</tbody>
</table>
**Materials Science I**
Modul zugeordnet zu Materials Science

**Code**
8822870905

**ECTS-Punkte**
5

**Präsenzzeit**
4

**Unterrichtssprache**
english

**Dauer**
1 Semester

**Turnus**
jedes Wintersemester

**Modulkoordinator**
Prof. Dr. Ulrich Herr

**Dozent(en)**
Prof. Dr. Ulrich Herr

**Einordnung in die Studiengänge**
Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
Energy Science and Technology MSc, begin of study WiSe, compulsory modul, 1. semester

**Vorkenntnisse**
Materials Science I; Solid State Physics and Physical Chemistry

**Lernergebnisse**
Students should
- understand the basics of materials science
- be able to apply this knowledge to optimize materials properties, especially mechanical properties.

**Inhalt**

1. **Introduction**
   - structure and bonding
   - classification of materials

2. **Crystal structure**
   - symmetry classes, lattices
   - reciprocal lattice, diffraction
   - band structure

3. **Defects in solids**
   - point defects, dislocations, grain and phase boundaries
   - microstructure of materials

4. **Characterization of the microstructure**
   - microscopic methods (optical, SEM, FIM)
   - diffraction techniques (XRD, TEM)
• scanning probe techniques (introduction)

5. Phase diagrams
• thermodynamics of solutions
• chemical potential, phase equilibrium
• basic types of phase diagrams
• important examples

6. Transport
• diffusion: macroscopic and microscopic description
• diffusion at surfaces and interfaces
• electromigration
• thermotransport

7. Phase Transformations
• thermodynamics and kinetics
• diffusive transformations
• non-diffusive transformation

8. Mechanical properties
• elastic properties
• plastic deformation
• viscous flow and creep
• fracture

Literatur
• W. D. Callister: Materials Science and Engineering An Introduction (Wiley)
• Atkins: Physical Chemistry for chemical potential, thermodynamics of mixtures and thermodynamics of phase transformations
• M. F. Ashby, D.R.H. Jones: Engineering Materials 1&2 (Butterworth)

Lehr- und Lernformen
Materials Science I (L), 3 h/week, compulsory
Materials Science I (E), 1 h/week, compulsory
lecture with demonstrations, exercises

Arbeitsaufwand
42 h lecture (presence)
14 h exercises (presence)
50 h preparation and postprocessing lecture
28 h solution of exercises, postprocessing
16 h exam preparation lecture
Total: 150 h

Bewertungsmethode
written examination of 120 min., precondition: successful participation in exercises

Notenbildung
Exam result

Grundlage für
MSc course of studies Advanced Materials
MSc course of studies Energy Science and Technology
Materials Science II
Materials Science Lab I
Materials Science II
Modul zugeordnet zu Materials Science

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870906</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>5</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>4</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Sommersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Ulrich Herr</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Prof. Ulrich Herr</td>
</tr>
</tbody>
</table>

Einordnung in die Studiengänge
Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 2. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 2. semester
Energy Science and Technology MSc, begin of study WiSe, compulsory modul, 2. semester

Vorkenntnisse
Materials Science I, Introductory Solid State Physics, Physical Chemistry

Lernergebnisse
Students should be able to
• describe the process of fatigue and the basic causes of fatigue failure
• classify metallic, ceramic and polymeric materials based on atomic level structures, characteristic microstructures and macroscopic properties
• understand and interpret the influence of materials processing on the microstructure and properties of metallic alloys, ceramics and polymers relate the structure of a composite material to improvements in strength and toughness
• understand the physical basis for the observed thermal, electrical and magnetic properties of solid materials
• be able to select appropriate materials and processing routes for the realization of engineering design goals, based on property and performance characteristics

Inhalt
The concepts of materials science are applied to a variety of materials types, including both conventional and novel classes of materials. Topics include materials processing and optimization, heat treatment, structureproperty relationships and the stability of microand nanostructure.
Syllabus:
1) Selected metallic alloys
2) Ceramics and glass
3) Polymers
4) Electrical Properties  
5) Semiconductors  
6) Magnetic Properties  
7) Nanostructured Materials


| Lehr- und Lernformen | Materials Science II (L), 3 h/week, compulsory  
| | Materials Science II (E), 1 h/week, compulsory lecture with demonstrations, exercises |

| Arbeitsaufwand | 42 h lecture (presence)  
| | 14 h exercises (presence)  
| | 50 h preparation and postprocessing lecture  
| | 28 h solution of exercises, postprocessing  
| | 16 h exam preparation lecture  
| | Total: **150 h** |

| Bewertungsmethode | written examination of 120 min., Successful participation in the exercises is a prerequisite for the final examination. |

| Notenbildung | Exam result |

| Grundlage für | MSc course of studies Advanced Materials  
| | MSc course of studies Energy Science and Technology  
| | Materials Science II |
General Chemistry
Modul zugeordnet zu Chemistry

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870912</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>2</td>
</tr>
<tr>
<td>Unterrichtsprach</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Dr. Gerhard Taubmann</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Prof. Dr. Gerhard Taubmann</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester Energy Science and Technology MSc, begin of study WiSe, elective modul, 1. semester (no credits)</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>BSc degree</td>
</tr>
</tbody>
</table>
| Lernergebnisse | The students should
|              | • learn and understand the fundamentals of general chemistry and chemical synthesis with respect to the preparation of organic, polymeric and inorganic materials |
| Inhalt       | Atoms:
|              | • properties of the atoms,
|              | • hydrogen, many electron atoms,
|              | • periodic table
|              | Hydrogen:
|              | • isotopes, chemical kinetics
|              | • gas laws, ideals gas, van der Waals
|              | • synthesis and properties of hydrogen
|              | • metal hydrides
|              | • acids and bases
|              | Halogens:
|              | • synthesis and properties
|              | • oxidation and reduction, oxidation numbers
|              | • balancing redox reactions |
• hydrogen halides, hydrogen bond, azeotropes,
• mass action law, principle of least restraint
• dissociation of water, pH

Chalcogens:
• synthesis and properties of oxygen
• liquefaction of gases, fractionation by distillation
• diamagnetism and paramagnetism
• ozone, mesomerism
• water, phase diagram, phase law
• colligative properties
• hydrogen sulphide
• oxides and oxo acids of sulfur
• shape of molecules: VSEPR (valence shell electron pair repulsion
• weak acids and bases, pKa, pKb
• indicators, buffers, Henderson-Hasselbalch equation
• acidity of oxoacids: Bell-Pauling rules
• electromotive series, Nernst’s equation
• coordination chemistry

Literatur
• Handouts

Lehr- und Lernformen
General Chemistry (L), 2 h/week, compulsory

Arbeitsaufwand
20 h lecture (presence)
24 h preparation and postprocessing lecture
16 h exam preparation
Total: 60h

Bewertungsmethode
written examination

Notenbildung
Passed or failed

Grundlage für
MSc course of studies Advanced Materials
Synthesis of Inorganic and Organic Chemistry
Physical Chemistry
Physical Chemistry
Modul zugeordnet zu Chemistry

Code 8822870910

ECTS-Punkte 4

Präsenzzeit 2

Unterrichtssprache Englisch

Dauer 1 Semester

Turnus jedes Wintersemester

Modulkoordinator Dr. Elisabeth Santos

Dozent(en) Dr. Elisabeth Santos

Einordnung in die Studiengänge Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
Energy Science and Technology MSc, begin of study WiSe, compulsory modul, 1. semester

Vorkenntnisse Minor or major subject in Chemistry or General Chemistry (accompanying)

Lernergebnisse The students will learn and understand
• the fundamentals of general chemistry and chemical synthesis with respect to the preparation of organic polymeric and inorganic materials
• the principles of quantum chemistry
• practical aspects of thermodynamics
• basics of reaction kinetics
• fundamental principles of modern solid state chemistry like structures, properties, syntheses and applications of solid materials

Inhalt A) Quantum Chemistry
1) Problems with Newton's Classical World
2) The properties of waves and the wave-nature of matter
3) Quantum mechanical description of a simple system - The particle in a box
4) Extension of the model to examples closer to reality, a. The harmonic oscillator (basic model for a vibrating molecule), b. The hydrogen atom, hydrogen-like ions and atomic orbitals
5) Molecular orbitals

B) Practical Aspects of the Laws of Thermodynamics

1) The first law: Enthalpy
2) The second law: Entropy, Free-energy and Chemical equilibrium
3) The third law

C) Reaction Kinetics

1) The order of a reaction
2) Temperature, the rate of reaction and the position of equilibrium
3) Catalyzed reactions, enzyme reactions

Literatur
Peter Atkins, Julio de Paula "Physical Chemistry"
Handouts

Lehr- und Lernformen
Physical Chemistry (L), 2 h/week, compulsory

Arbeitsaufwand
28 h lecture (presence)
76 h preparation and postprocessing lecture
16 h exam preparation

Total: 120 h

Bewertungsmethode
The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration.

Notenbildung
Die Modulnote entspricht dem Ergebnis der Modulprüfung.

Grundlage für
MSc course of studies Advanced Materials
MSc course of studies Energy Science and Technology
Synthesis of Organic and Inorganic Materials
Modul zugeordnet zu Chemistry

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870911</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>4</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>2</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Dr. Ulrich Ziener</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Dr. Björn Bredenkötter, Prof. Dr. Dirk Volkmer, Dr. Ulrich Ziener</td>
</tr>
</tbody>
</table>

Einordnung in die Studiengänge
Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
Energy Science and Technology MSc, begin of study WiSe, compulsory modul, 1. semester

Vorkenntnisse
Minor or major subject in Chemistry or General Chemistry

Lernergebnisse
The students should
- understand the fundamentals of general chemistry and chemical synthesis with respect to the preparation of organic polymeric and inorganic materials

Inhalt

First part:
Topics of the course are the basics in Organic Chemistry (nomenclature, functional groups, reactivity) as well as some fundamental applications of standard analytical methods (e.g. UV-, IR- and NMR-spectroscopy, HPLC and mass spectrometry).

Second part:
fundamental terms of polymer chemistry, chemical structure of polymers, molar mass and its distribution, configuration and stereoisomers, step- and chain-growth polymerisation, anionic polymerisation, insertion polymerisation, metathesis polymerisation, free radical polymerisation, polymerisation techniques (solution,
suspension, emulsion), copolymerisations, polyaddition, polycondensation, networks, technical polymers.

<table>
<thead>
<tr>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Handouts</td>
</tr>
<tr>
<td>• J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers, A. Jones: <em>Practical Skills in Chemistry</em> PEARSON</td>
</tr>
<tr>
<td>• and basic textbooks of Organic Chemistry.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthesis of Organic and Inorganic Materials (L), 2 h/week, compulsory</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arbeitsaufwand</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 h lecture (presence)</td>
</tr>
<tr>
<td>76 h preparation and postprocessing lecture</td>
</tr>
<tr>
<td>16 h exam preparation</td>
</tr>
<tr>
<td><strong>Total: 120 h</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bewertungsmethode</th>
</tr>
</thead>
<tbody>
<tr>
<td>written examination</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notenbildung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam result</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grundlage für</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colloids</td>
</tr>
<tr>
<td>Solid State Physics</td>
</tr>
</tbody>
</table>
Introductory Solid State Physics
Modul zugeordnet zu Physics

Code  8822870913

ECTS-Punkte  5

Präsenzzeit  4

Unterrichtssprache  englisch

Dauer  1 Semester

Turnus  jedes Wintersemester

Modulkoordinator  Prof. Dr. Paul Ziemann

Dozent(en)  Prof. Dr. Paul Ziemann

Einordnung in die Studiengänge  Advanced Materials MSc, begin of study WiSe, compulsory modul, 1. semester

Vorkenntnisse  Basic knowledge of Physics including an introduction into Quantum Mechanics and Mathematics according to a BSc degree

Lernergebnisse  This introductory course aims at providing the basic knowledge as well as some fundamental practical tools of Solid State Physics necessary to understand all the forthcoming more advanced Materials Science courses

Inhalt  1. Basic Classification of Solids by Bonds and Structure
        2. Experimental Structure Determination
        3. Lattice Vibrations and Phonons
        4. Electronic properties of Solids, Free electron models

          - Handouts related to specific problems are distributed in the lectures

Lehr- und Lernformen  Introductory Solid State Physics (L), 2 h/week, compulsory
                      Introductory Solid State Physics (E), 1 h/week, compulsory

Arbeitsaufwand  42 h lecture (presence)
                14 h exercises (presence)
                50 h preparation and postprocessing lecture
28 h solution of exercises, postprocessing
16 h exam preparation

**Total: 150h**

<table>
<thead>
<tr>
<th>Bewertungsmethode</th>
<th>written examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notenbildung</td>
<td>Exam result</td>
</tr>
</tbody>
</table>
| Grundlage für     | MSc course of studies Advanced Materials  
|                   | Physics Lab         
|                   | Advanced Physics of Materials |
Physics Lab
Modul zugeordnet zu Physics

Code 8822870915

ECTS-Punkte 4

Präsenzzeit 2

Unterrichtssprache english

Dauer 1 Semester

Turnus jedes Sommersemester

Modulkoordinator Prof. Dr. Paul Ziemann

Dozent(en) Dr. Ulf Wiewald

Einordnung in die Studiengänge
Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester

Vorkenntnisse Introductory Solid State Physics

Lernergebnisse The students will learn the principles of scientific working, of writing a scientific report and how to organize an advanced experiment. The Lab will provide "hands-on" experience how to experimentally determine basic solid state properties introduced in the course Introductory Solid State Physics

Inhalt

I) X-ray diffraction:
Evaporation of Au film at room temperature, short introduction into the problems of Vacuum physics and evaporation techniques, Phi-2Phi-measurements on those films, identification of various reflexes, selection rules for fcc, determination of lattice parameters, second measurement on a pre-prepared epitaxially grown Au film, measurement of a low resolution pole figure.

II) Thermal conductivity:
Temperature dependence (4.2 - 15K, 15K - 77K) of the thermal conductivity of sapphire, quartz, Pb, Cu; this includes the handling of liquid Helium & Nitrogen.

III) Electrical conductivity:
Temperature dependence (4.2 - 77K) of metals (Cu, Au), a doped Semiconductor (p-Si), Constantan and Superconductors (Pb, YBaCuO), this includes the handling of liquid Helium & Nitrogene.

**IV) XPS/UPS:**

XPS/UPS spectra of different metals (Al, Au, AuAl2) as well as non-metals (Si, BN, WO3) are presented. After a short introduction into the applied methods the following properties should be discussed: Fermi energy, various involved electronic transitions, chemical shifts, line shapes, estimate of near surface stoichiometries.

<table>
<thead>
<tr>
<th>Literatur</th>
<th>General literature on Solid State Physics as given for Introductory Solid State Physics, Lab instructions, instrumentation instructions, handouts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lehr- und Lernformen</td>
<td>Physics Lab (L/S/R), 2h/week, compulsory</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>18 h laboratory (presence), 22 h preparation, 80 h home writing report and revision</td>
</tr>
<tr>
<td><strong>Total:</strong> 120 h</td>
<td></td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>Seminar, report, certificate</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>Passed or failed</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>MSc course of studies Advanced Materials</td>
</tr>
</tbody>
</table>
### Applications of Biomaterials

Modul zugeordnet zu Biology - Biomaterials

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870925</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>1</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Sommersemester</td>
</tr>
<tr>
<td>Modulkoodinator</td>
<td>Prof. Dr. Anita Ignatius</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Lecturers of the Institute of Orthopaedic Research and Biomechanics</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 2. semester Advanced Materials (Nanomaterials) MSc, begin of study WiSe, elective modul, 2. semester</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>Introductory Biology and Cell Biology</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>Biomaterials are used in many applications in different tissues and organs. There is a broad field of different applications in e.g. dental medicine, orthopaedic and trauma surgery, cardiovascular surgery, ophthalmology, or plastic surgery. It is a quickly expanding field. The students should - learn the application of biomaterials and implants in various tissues which have to be replaced or supported - learn the positive aspects of materials and implants and the risks in their application</td>
</tr>
</tbody>
</table>
Literatur

Silver F.H.: "Biomaterials, Medical devices and tissue engineering"
Ratner B.D. / Hoffmann A.S. / Schoen F. J. / Lemons J.E. (eds.): "An Introduction to materials in medicine"
Bidanda, Bopaya / Bartolo, Paulo (eds.): "Bio-Materials and Prototyping Applications in Medicine"
Park, Joon B., Bronzino, Joseph D., Park, Park B.: "Biomaterials: Principles and Applications"

Lehr- und Lernformen

Applications of Biomaterials (L), 1 h/week

Arbeitsaufwand

14 h lecture (presence)
30 h preparation and postprocessing lecture
16 h exam preparation

Total: 60 h

Bewertungsmethode

examination of 120 min (together with Biological Tissues and Classes of Biomaterials)

Notenbildung

Exam result

Grundlage für

MSc course of studies Advanced Materials, Biomaterials
## Biological Tissues
Modul zugeordnet zu Biology - Biomaterials

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870923</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>1</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Sommersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td></td>
</tr>
<tr>
<td>Dozent(en)</td>
<td></td>
</tr>
</tbody>
</table>
| Einordnung in die Studiengänge | Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 2. semester  
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, elective modul, 2. semester |

### Vorkenntnisse

### Lernergebnisse

Biomaterials are synthetic or natural materials, which are applied to replace or support tissue or organs. To understand the demands for biomaterial development it is important to know the characteristics of tissues to be replaced. The students should
- learn the composition, structure, properties and function of biological tissues/ organs which are often replaced or supported by biomaterials
- be able to understand of the clinical problems making biomaterials application necessary

### Inhalt

1) Cartilage  
2) Tendon, ligament  
3) Blood vessels, heart  
4) Eyes  
5) Bone  
6) Teeth  
7) Blood  
8) Kidney  
9) Liver/ pancreas  
10) Skin

### Literatur

Hunt, Janie Yungblut L., "Soft and Hard Tissue Repair: Biological and Clinical Aspects"
Silver F.H.: "Biomaterials, Medical devices and tissue engineering"
Ratner B.D. / Hoffmann A.S. / Schoen F. J. / Lemons J.E. (eds.): "An Introduction to materials in medicine"
Wintermantel E.: „Medizintechnik mit biokompatiblen Werkstoffen und Verfahren" 

Handouts

<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
<th>Biological Tissues (L), 1 h/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbeitsaufwand</td>
<td>14 h lecture (presence)</td>
</tr>
<tr>
<td></td>
<td>30 h preparation and postprocessing lecture</td>
</tr>
<tr>
<td></td>
<td>16 h exam preparation</td>
</tr>
<tr>
<td><strong>Total:</strong> 60 h</td>
<td></td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>examination of 120 min (together with Applications of Biomaterials and Classes of Biomaterials)</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>Exam result</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>MSc course of studies Advanced Materials, Biomaterials</td>
</tr>
</tbody>
</table>
Classes of Biomaterials
Modul zugeordnet zu Biology - Biomaterials

Code 8822870924

ECTS-Punkte 2

Präsenzzeit 1

Unterrichtssprache english

Dauer 1 Semester

Turnus jedes Sommersemester

Modulkoordinator Prof. Dr. Anita Ignatius

Dozent(en) Colleagues and coworkers, Lecturers of the Faculties of Medicine and Natural Science

Einordnung in die Studiengänge Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 2. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, elective modul, 2. semester

Vorkenntnisse Introductory Biology and Cell Biology

Lernergebnisse Various synthetic or biological materials are used as biomaterials all of them having specific characteristics and properties. The students should know
- chemical composition and properties of different material classes which are used in biomaterial applications
- processing of biomaterials
- biological and mechanical properties of materials
- advantages and disadvantages of materials

Inhalt 1) Polymers
2) Hydrogels
3) Metals
4) Natural Materials
5) Composites
6) Ceramics (Bone Substitute)

Literatur Silver F.H.: Biomaterials, Medical devices and tissue engineering
Ratner B.D. / Hoffmann A.S. / Schoen F. J. / Lemons J.E. (eds.): An Introduction to materials in medicine
<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
<th>Classes of Biomaterials (L), 1 h/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbeitsaufwand</td>
<td>14 h lecture (presence)</td>
</tr>
<tr>
<td></td>
<td>30 h preparation and postprocessing lecture</td>
</tr>
<tr>
<td></td>
<td>16 h exam preparation</td>
</tr>
<tr>
<td><strong>Total: 60 h</strong></td>
<td></td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>examination of 120 min (together with Biological Tissues and Applications of Biomaterials)</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>Exam result</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>MSc course of studies Advanced Materials, Biomaterials</td>
</tr>
</tbody>
</table>
Degradation of Biomaterials
Modul zugeordnet zu Biology - Biomaterials

Code 8822870926

ECTS-Punkte 2

Präsenzzeit 1

Unterrichtssprache english

Dauer 1 Semester

Turnus jedes Wintersemester

Modulkoordinator Prof. Dr. Anita Ignatius

Dozent(en) Lecturers of the Faculties of Medicine and Natural Science

Einordnung in die Studiengänge Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 3. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, elective modul, 3. semester

Vorkenntnisse Applications of Biomaterials, Biological Tissues and Classes of Biomaterials, Introductory Biology and Cell Biology

Lernergebnisse Biomaterials are not stable but degrade or corrode in the body. This could lead to changes in the chemical composition and in the biological and mechanical properties. The students should
- learn the desired or undesired degradation of biomaterials in a biological environment with special focus of the chemical and biological degradation of polymers and corrosion of metals as well as the mechanical breakdown
- understand the problems connected with materials degradation. Degradation is analyzed in detail, from both negative and positive aspects.

Inhalt Corrosions of metals
Degradation of Polymers

Handouts
<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
<th>Degradation of Biomaterials (L), 1 h/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbeitsaufwand</td>
<td>14 h lecture (presence)</td>
</tr>
<tr>
<td></td>
<td>30 h preparation and postprocessing lecture</td>
</tr>
<tr>
<td></td>
<td>16 h exam preparation</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>60 h</strong></td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>examination of 120 min (together with Host Reactions to Biomaterials and Testing of Biomaterials)</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>Exam result</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>MSc course of studies Advanced Materials, Biomaterials</td>
</tr>
</tbody>
</table>
Host Reactions to Biomaterials
Modul zugeordnet zu Biology - Biomaterials

Code 8822870928

ECTS-Punkte 2

Präsenzzeit 1

Unterrichtssprache english

Dauer 1 Semester

Turnus jedes Wintersemester

Modulkoordinator

Dozent(en) Lecturers of the Faculties of Medicine and Natural Science

Einordnung in die Studiengänge Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 3. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, elective modul, 3. semester

Vorkenntnisse Introductory Biology and Cell Biology, Applications of Biomaterials, Biological Tissues and Classes of Biomaterials

Lernergebnisse Biomaterials interact with the biological environment leading to at best to integration or to inflammation and foreign body reactions. Students should
- understand the host reactions and the relationships between synthetic biomaterials and the biological environment
- learn the positive interactions leading to the integration of materials into the tissue
- understand the negative interactions leading to inflammatory reactions, foreign body reactions and implant loosening

Inhalt 1) Blood reactions to biomaterials
2) In vitro cell biomaterials reactions
3) In vivo tissue reactions to biomaterials
4) Systematic effects of biomaterials

Literatur Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen
Handouts
<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
<th>Host reactions to Biomaterials (L), 1 h/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbeitsaufwand</td>
<td>14 h lecture (presence)</td>
</tr>
<tr>
<td></td>
<td>30 h preparation and postprocessing lecture</td>
</tr>
<tr>
<td></td>
<td>16 h exam preparation</td>
</tr>
<tr>
<td><strong>Total:</strong> 60 h</td>
<td></td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>examination of 120 min (together with Degradation of Biomaterials and testing of Biomaterials)</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>Exam result</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>MSc course of studies Advanced Materials</td>
</tr>
</tbody>
</table>
**Introductory Biology and Cell Biology**  
Modul zugeordnet zu Biology - Biomaterials

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870922</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>5</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>4</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Dr. Bernhard Koch</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Prof. Dr. Bernhard Koch, Prof. Dr. Paul Walther, PD Dr. Andreas Ziegler</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester</td>
</tr>
<tr>
<td></td>
<td>Advanced Materials (Nanomaterials) MSc, begin of study WiSe, elective modul, 1. semester</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>BSc degree</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>The students should</td>
</tr>
<tr>
<td></td>
<td>• be able to understand central problems of Biology and Cell Biology.</td>
</tr>
<tr>
<td></td>
<td>• be well prepared to for lectures in Biomaterials in 2nd and 3rd semester</td>
</tr>
<tr>
<td>Inhalt</td>
<td><strong>BASICS AND ECOSYSTEMS</strong></td>
</tr>
<tr>
<td></td>
<td>• Secondary production in ecosystems The cycling of chemical elements in ecosystems</td>
</tr>
<tr>
<td></td>
<td><strong>BIOMOLECULES</strong></td>
</tr>
<tr>
<td></td>
<td>• Water and the fitness of the environment Carbon and the molecular diversity of life Structure and function of macromolecules Introduction to metabolism, Enzymes</td>
</tr>
<tr>
<td></td>
<td><strong>CELLULAR RESPIRATION</strong></td>
</tr>
<tr>
<td></td>
<td>• Harvesting chemical energy</td>
</tr>
<tr>
<td></td>
<td><strong>CELL MORPHOLOGY AND GENEXPRESSION</strong></td>
</tr>
<tr>
<td></td>
<td>• A tour of the cell Membrane structure and function The cell cycle The molecular basis of inheritance From gene to protein</td>
</tr>
</tbody>
</table>
ORGANISMIC AND ANIMAL DIVERSITY

- The major lineages of life: Prokaryotes and the origins of metabolic diversity. The origin and early diversification of eukaryote details from animal evolution and groups of invertebrates.

DEVELOPMENT

- Animal development

FUNCTIONAL ANATOMY

- An introduction to animal structure and function: muscle function, nervous system.

ENDOCRINOLOGY

- Chemical signals in animals: Blood glucose and adrenal gland.

CIRCULATION AND GAS EXCHANGE

- Circulation and gas exchange: Gas exchange in animals.
- Intracellular Compartments and Protein Sorting: Vesicular Transport.
- Cytoskeleton and Mitosis.
- Structure and function of cellular membranes.
- Cell-cell contacts and cell adhesion.
- Structure and function of the extracellular matrix.

CELLULAR CIRCULATION AND GAS EXCHANGE

- Circulation and gas exchange: Gas exchange in animals.
- Intracellular Compartments and Protein Sorting: Vesicular Transport.
- Cytoskeleton and Mitosis.
- Structure and function of cellular membranes.
- Cell-cell contacts and cell adhesion.
- Structure and function of the extracellular matrix.

CELLULAR RESPIRATION

- Harvesting chemical energy.

CELL MORPHOLOGY AND GENEXPRESSION

- A tour of the cell.
- Membrane structure and function.
- The cell cycle.
- The molecular basis of inheritance.
- From gene to protein.

ORGANISMIC AND ANIMAL DIVERSITY

- The major lineages of life.
- Prokaryotes and the origins of metabolic diversity.
- The origin and early diversification of eukaryote details from animal evolution and groups of invertebrates.

DEVELOPMENT

- Animal development.

FUNCTIONAL ANATOMY

- An introduction to animal structure and function.
• muscle function
• Nervous system

ENDOCRINOLOGY

• Chemical signals in animals Blood glucose and adrenal gland

CIRCULATION AND GAS EXCHANGE

• Circulation and gas exchange Gas exchange in animals
• Intracellular Compartments and Protein Sorting Vesicular Transport
• Cytoskeleton and Mitosis
• Structure and function of cellular membranes
• Cell-cell contacts and cell adhesion
• Structure and function of the extracellular matrix

Intracellular Compartments and Protein Sorting
Vesicular Transport
Cytoskeleton and Mitosis
Structure and function of cellular membranes
Cell-cell contacts and cell adhesion
Structure and function of the extracellular matrix

Literatur

Thomas D. Pollard, William C. Earnshaw , Jennifer Lippincott-Schwartz, Cell Biology
Handouts related to specific problems are distributed in the lectures

Lehr- und Lernformen

Introductory Biology and Cell Biology (L), 4 h/week, compulsory
Introductory Biology and Cell Biology (L), 4 h/week, elective

Arbeitsaufwand

55 h lecture (presence)
79 h preparation and revision lecture
16 h exam preparation
Total: 150 h

Bewertungsmethode

examination of 120 min

Notenbildung

Exam result

Grundlage für

MSc course of studies Advanced Materials, Biomaterials
# Production of Biomaterials

Modul zugeordnet zu Biology - Biomaterials

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870929</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>1</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Dr. Anita Ignatius</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Lecturers of the visited Institutes</td>
</tr>
</tbody>
</table>

**Einordnung in die Studiengänge**

- Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 3. semester
- Advanced Materials (Nanomaterials) MSc, begin of study WiSe, elective modul, 3. semester

**Vorkenntnisse**

**Lernergebnisse**
The students should gain a knowledge of properties, processing and usage of biocompatible materials

**Inhalt**

Commercial production of Biomaterials
- Excursions to different companies Whole day excursions to different companies, where different labs, processing halls and plants are visited. Often combination with an additional lecture.

**Literatur**

- 

**Lehr- und Lernformen**

Excursion: Production of Biomaterials (S), 1h/week

**Arbeitsaufwand**

30 h Excursions and presence
30 h revision at home

Total: 60h
<table>
<thead>
<tr>
<th>Bewertungsmethode</th>
<th>Attendance of all excursions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notenbildung</td>
<td>Certificate</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>MSc course of studies Advanced Materials, Biomaterials</td>
</tr>
</tbody>
</table>
## Testing of Biomaterials

**Modul zugeordnet zu Biology - Biomaterials**

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870927</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>1</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Dr. Anita Ignatius</td>
</tr>
</tbody>
</table>

### Dozent(en)

### Einordnung in die Studiengänge

- Advanced Materials (Biomaterials) MSc, begin of study WiSe, compulsory modul, 3. semester
- Advanced Materials (Nanomaterials) MSc, begin of study WiSe, elective modul, 3. semester

### Vorkenntnisse

Biomaterials used for medical devices must be thoroughly tested before their introduction so that any negative effects on the body are known and can be prevented. By using in vitro laboratory tests, dangers for patients and unnecessary animal experiments can be avoided.

Students should
- learn appropriate test methods used in vitro and in vivo
- learn the regulatory standards for approval of biomaterials

### Inhalt

- Biomechanical testing of biomaterials
- In vivo testing of biomaterials
- In vitro testing of biomaterials

### Literatur

- Handouts

### Lehr- und Lernformen

- Testing of Biomaterials (L), 1h/week
<table>
<thead>
<tr>
<th>Arbeitsaufwand</th>
<th>14 h lecture (presence)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 h preparation and postprocessing lecture</td>
</tr>
<tr>
<td></td>
<td>16 h exam preparation</td>
</tr>
<tr>
<td></td>
<td>Total: 60 h</td>
</tr>
</tbody>
</table>

| Bewertungsmethode    | examination of 120 min (together with Host Reactions to Biomaterials and Degradation of Biomaterials) |

| Notenbildung         | Exam result             |

| Grundlage für        | MSc course of studies Advanced Material, Biomaterials |
Biosensors
Modul zugeordnet zu Elective Courses

**Code**  
8822870903

**ECTS-Punkte**  
3

**Präsenzzeit**  
2

**Unterrichtssprache**  
Englisch

**Dauer**  
1 Semester

**Turnus**  
jedes Semester

**Modulkoordinator**  
Prof. Dr.-Ing. Hermann Schumacher  
Dr. Alberto Pasquarelli

**Dozent(en)**  
Dr. Alberto Pasquarelli

**Einordnung in die Studiengänge**  
Electrical Engineering, M.Sc., Elective Module  
Electrical Engineering, M.Sc., Optional Module, General Electrical Engineering  
Electrical Engineering, M.Sc., Optional Module, Communication and System Technology  
Electrical Engineering, M.Sc., Optional Module, Automation and Energy Technology  
Electrical Engineering, M.Sc., Optional Module, Microelectronics  
Communications Technology, M.Sc., Elective Module, Microelectronics

**Vorkenntnisse**  
Basic knowledge of chemistry and biochemistry help understanding the biological part of biosensors.

**Lernergebnisse**  
The world-wide needs for chemical detection and analysis rise steadily. Several reasons lead to this trend, for instance the rapid increase in the prevalence of diabetes, the increasing need for environmental and health monitoring, new legislative standards for food and drugs quality control or even the early detection of biological and chemical terror attacks. Thanks to higher sensitivity and specificity, short response times and reduction of overall costs, biosensors can be very competitive in addressing these needs when compared to traditional methods. Students can describe basic principles, mechanisms of action and applications of biosensors in different scenarios. After taking this module, participants can analyze biosensors, break-down in the elementary components and identify and illustrate every individual function in the information flow, from recognition to transduction and transmission. Students illustrate the clinical and industrial applications differentiate biosensor market sectors, e.g. commodities for everyday consumer needs or professional equipments for research. Furthermore, they are able to understand and critically analyze research in biosensors. Finally students
are able to develop appropriate concepts and independently propose solutions for

given problems.

Inhalt
- Introduction to biosensors
- Applications overview
- Biological detection methods: catalytic, immunologic, etc
- Physical transduction methods: electrochemical, optical, gravimetric, etc.
- Immobilization techniques: adsorption, entrapment, cross-linking, covalent
  bonds
- Biochip technologies: DNA and protein chips, Ion-channel devices, MEA and
  MTA
- Extras: invited talk(s), experimental exercise, excursion

Literatur

Lecture Notes

For in-depth study, following books are recommended:
Springer e-Books (full pdf download at https://ulm.ibs-bw.de):
Hierlemann: Integr. Chem. Microsensor Syst. in CMOS Techn., ISBN:
  9783540273721
Jay: Modern Food Microbiology, ISBN: 9780387234137

Lehr- und
Lernformen
Lecture “Biosensors”, lecture with demonstrations and seminars, 1,75 SWS
Seminar “Biosensors”, 0,25 SWS
Laboratory “Biosensors”, 2 x 2 h

Arbeitsaufwand
Active Time: 28 h
Preparation and Evaluation: 50 h
Self-Study: 12 h
Sum: 90 h

Bewertungsmethode
Die Vergabe der Leistungspunkte erfolgt aufgrund des Bestehens einer

schriftlichen Prüfung. Die Anmeldung zu dieser Prüfung setzt keinen

Leistungsnachweis voraus.

Notenbildung
Die Modulnote entspricht dem Ergebnis der Modulprüfung.

Grundlage für
Masters Thesis in the area of biosensors.
**Cell Interaction with Biomaterials and Imaging Techniques**
Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870945</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>1</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Semester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Dr. Ralf Kemkemer</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Dr. Ralf Kemkemer</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>Master degree in Advanced Materials, elective, 2. semester</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>Introductory biology and Cell Biology</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>This lecture introduces some basic features and physical models of cell adhesion and interaction with physically and chemically micro- and nano-structured materials</td>
</tr>
<tr>
<td>Inhalt</td>
<td>Special emphasis is on recent developments in that rapidly growing field: I. Introduction to the cell and cytoskeleton and adhesion elements II. Interaction of cells with topographical features of surfaces and response to physical and chemical structures of materials III. Design and application of nanostructured materials for cellular biotechnology IV. Imaging techniques for cell studies (fusion proteins, FRET)</td>
</tr>
<tr>
<td>Literatur</td>
<td>Roland Glaser, Biophysics, Springer handouts</td>
</tr>
<tr>
<td>Lehr- und Lernformen</td>
<td>Cell Interaction with Biomaterials and Imaging Techniques (L) 1 h/week</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>14 h lecture (presence)</td>
</tr>
</tbody>
</table>
30 h preparation and revision lecture
16 h exam preparation

**Total: 60 h**

**Bewertungsmethode**  Please switch to English version.

**Notenbildung**  Please switch to English version.

**Grundlage für**  MSc course of studies Advanced materials
Cell Mechanics and Interactions with Biomaterials
Modul zugeordnet zu Elective Courses

Code  8822870624

ECTS-Punkte  2

Präsenzzeit  1

Unterrichtssprache  english

Dauer  1 Semester

Turnus  jedes Semester

Modulkoordinator  Dr. Ralf Kemkemer

Dozent(en)  Dr. Ralf Kemkemer

Einordnung in die Studiengänge  Master degree in Advanced Materials, elective, 3. semester

Vorkenntnisse  Introductory Biology and Cell Biology, General Chemistry

Lernergebnisse  Cells are very adaptive Systems and respond to various external Signals. Besides chemical Stimuli, cells react to mechanical manipulations as well as to physical properties of the materials they interact with. Studies of the mechanics of Single cells, subcellular components and biological molecules have rapidly evolved during the past decade with significant implications for biotechnology, tissue engineering, and human health. This lecture introduces some basic features of the deformation of Single cells and the interaction of cells with physically and chemically micro- and nano-structured materials. Special emphasis is on recent developments in that rapidly growing field.

Inhalt  1. Introduction to the cell and cytoskeleton elements  
2. Basics mechanical properties of filaments and networks  
3. Experiments for mechanical probing and manipulation of single cells,  
   - measuring the elastic properties of cells  
   - mechanical manipulation of cells  
   - how does it sense mechanical forces  
   - what force can a cell apply during cell movement
4. Interaction of cells with topographical features of surfaces sensing and response to physical and chemical structures of materials

5. Design and application of nanostructured materials for cellular biotechnology

<table>
<thead>
<tr>
<th>Literatur</th>
<th>Roland Glaser, Biophysics, Springer handouts</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
<th>Cell Interaction with Biomaterials and Imaging Techniques (L) 1 h/week</th>
</tr>
</thead>
</table>

| Arbeitsaufwand       | 14 h lecture (presence)  
|                      | 30 h preparation and postprocessing lecture  
|                      | 16 h exam preparation  
|                      | **Total: 60 h** |

|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th>Notenbildung</th>
<th>Die Modulnote entspricht dem Ergebnis der Modulprüfung.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Grundlage für</th>
<th>MSc course of studies Advanced Materials</th>
</tr>
</thead>
</table>
# Chemistry Lab
Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822871086</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>2</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordiater</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Inhalt</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Literatur</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Lehr- und Lernformen</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>keine Angabe</td>
</tr>
</tbody>
</table>
**Compound Semiconductors (Verbindungshalbleiter)**
Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th><strong>Code</strong></th>
<th>8822870461</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECTS-Punkte</strong></td>
<td>6</td>
</tr>
<tr>
<td><strong>Präsenzzeit</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Unterrichtssprache</strong></td>
<td>Englisch</td>
</tr>
<tr>
<td><strong>Dauer</strong></td>
<td>1 Semester</td>
</tr>
<tr>
<td><strong>Turnus</strong></td>
<td>jedes Semester</td>
</tr>
<tr>
<td><strong>Modulkoordinator</strong></td>
<td>Prof. Dr. Ferdinand Scholz</td>
</tr>
<tr>
<td><strong>Dozent(en)</strong></td>
<td>Prof. Dr. Ferdinand Scholz</td>
</tr>
</tbody>
</table>

**Einordnung in die Studiengänge**
- Electrical Engineering, M.Sc., Elective Module, Advanced Materials, M.Sc., Optional Module
- Electrical Engineering, M.Sc., Optional Module, Microelectronics
- Electrical Engineering, M.Sc., Optional Module, Automation and Energy Technology
- Electrical Engineering, M.Sc., Optional Module, General Electrical Engineering
- Communications Technology, M.Sc., Optional Technical Module, Microelectronics

**Vorkenntnisse**
Kenntnisse und Kompetenzen der Module: Grundlagen der Halbleiterphysik

**Lernergebnisse**
After successfully having finished the module, the students are able to describe the basic physics of compound semiconductors and contrast them to those of elemental semiconductors. They are able to describe important characteristics like band gap, lattice constant or refractive index and identify their systematic trends. They are able to derive from those basics the application possibilities of compound semiconductors and discuss their advantages and disadvantages. They are able to describe and compare the most important fabrication and characterization methods. They are able to describe the constitution of the most important basic hetero structures and explain their mode of operation. Based on that, they are able to develop the structure of important representative devices like light emitting diodes or laser diodes and to describe in detail the function of the respective structural details.

**Inhalt**
- Basics of Semiconductors, Compound Semiconductors
- Bulk crystal growth, liquid phase epitaxy, vapor phase epitaxy, molecular beam epitaxy
- Optical processes, spectroscopic methods
- Electrical characterisation methods
- x-ray diffraction, microscopy methods, other characterisation methods
- Strain in semiconductor structures
- Low-dimensional structures: quantum wells, wires, dots
- Semiconductor Light emitters and Laser Diodes
- Short Wavelength materials: Group III nitrides
- Electronic devices: HEMTs, HBTs
- Solar Cells

Literatur
- skript to lecture
- O. Madelung, Grundlagen der Halbleiterphysik, Springer
- S.M. Sze, Physics of Semiconductor Devices, John Wiley
- R.K. Willardson, A.C. Beer, Semiconductors and Semi-metals, Book Series Academic
- E. Rosencher, B. Vinter, Optoelectronics, Cambridge University Press 2002
- K.J. Ebeling; Integrated optoelectronics : waveguide optics, photonics, semiconductors
  Berlin ; Heidelberg [u.a.] : Springer, 1993

Lehr- und Lernformen
- Lecture “Compound Semiconductors”, 3 SWS
- Exercise “Compound Semiconductors”, 1 SWS

Arbeitsaufwand
- Preparation and Evaluation: 56 h
- Active Time: 74 h
- Self-Study: 50 h
- Sum: 180 h

Bewertungsmethode
- Participation in lectures and exercises, own seminar talk, typically oral examination, otherwise written exam with duration of 120 minutes

Notenbildung
- Die Modulnote entspricht dem Ergebnis der Modulprüfung.

Grundlage für -
# Exploring the Nanoworld with X-Rays and High-Energy Electrons

Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870904</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>3</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>2</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
</tbody>
</table>

**Dauer** 1 Semester

**Turnus** jedes Semester

**Modulkoordinator** Prof. Dr. Ute Kaiser

**Dozent(en)** Prof. Dr. Ute Kaiser, Prof. Ph. D. Carl Emil Krill, Prof. Dr.-Ing. Ulrich Herr

**Einordnung in die Studiengänge** Master degree in Advanced Materials, elective, 3. semester

**Vorkenntnisse** Materials Science I, Materials Science II

**Lernergebnisse** Selected topics of research and methods in Nanophysics and Nanoengineering

**Inhalt**

- Scattering of x-rays and electrons
  - elastic scattering
  - background info: biographies of Röntgen, Bragg/Bragg, Ruska
  - application: Ewald sphere-x-ray diffraction vs. TEM
- Inelastic scattering of x-rays and electrons
  - theory of absorption, applications: EBSD
- Diffraction from crystals-Bragg peak intensities
  - structure factor
  - intensity analysis (Rietveld)
- indexing complex powder diffraction patterns
  - application: macromolecular crystallography
- Diffraction from crystals-Bragg peak shapes
  - peak shape analysis (Fourier methods)
  - size/strain separation (Warren-Averbach)
- application: characterization of nanocrystalline materials
- X-ray reflectometry
  - Fresnel equation
  - effect of interface roughness
  - methods for simulation
- application: analysis of thin-film thickness, multilayers
Magnetic lenses and lens aberrations
- magnetic focusing of electrons
- sources of lens aberrations
- application: CS-corrector
High-resolution TEM
- phase and amplitude contrast
- contrast transfer function
- application: multislice simulation,
  Atomic-resolution Z-contrast
- Z-contrast, STEM, TEM
- application: atomic-resolution imaging, EELS, energy-filtered TE

Holography
- amplitude vs. phase information
- light holography
- electron holography
- application: magnetic microstructure of bacteria

Lorentz microscopy
- magnetic contrast
- imaging conditions
- application: magnetic "ripple" in thin films, Abrikosov lattice

Electron tomography (Bright-field, Z-contrast)
- imaging (Z-contrast, Amplitude Contrast)
- principles of image reconstruction, visualization
- application: materials science
- application life science

X-ray tomography
- sources of contrast (absorption, phase, diffraction, fluorescence)
- reconstruction artefacts
- applications: CT of human bone under mechanical loading, metallic foams

X-ray microscopy
- x-ray lenses (Fresnel, refraction)
- concepts for 3-D resolution
- application: growth of individual grains during recrystallization

Focused ion beam
- ion irradiation
- imaging with ion beam
- single vs. dual-beam units
- application: sample preparation, lithography, electron tomography

Small-angle x-ray scattering (SAXS)
- theory
- measurement apparatus
- application: nanoparticle growth, ferrofluid characterization

**Literatur**
Selected literature for preparing the presentations, handouts

**Lehr- und Lernformen**
Exploring the Nanoworld (S), 1 h/week
<table>
<thead>
<tr>
<th>Arbeitsaufwand</th>
<th>28 h lecture (presence)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52 h preparation of presentation and revision seminar</td>
</tr>
<tr>
<td></td>
<td>10 h seminar (presence) an presentation</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>90 h</strong></td>
</tr>
</tbody>
</table>

**Bewertungsmethode** keine Angaben

**Notenbildung** keine Angaben

**Grundlage für** MSc course of studies Advanced Materials
Innovation Management for Nanotechnology
Modul zugeordnet zu Elective Courses

Inhalt
Nanotechnology, based on groundbreaking Nanoscience, is quickly becoming one of the key technological developments in the 21st century. It is a young and fascinatingly interdisciplinary field of research, ranging from engineering via the natural to the medical sciences and beyond. With increasing speed, small companies as well as big industry, particularly those active in the material and life sciences are picking up on these novel developments and are transferring them to daily applications. These developments are opening new markets with potentials, which must be evaluated systematically, before the focusing of R&D or new business development preparing the launch of a radical technology are acted on prematurely. I am continuously developing this lecture (now in its sixth year) to pay tribute to this ongoing development, allowing my students to get a broad overview of all relevant fields, from science to technology to markets. The lecture is structured as follows:
Content of course:
1) Introduction
   Definition and Relevancy
   The Enabling Technology
   Class Work: Nanoscience-fundamental new laws
2) Tools of Nanotechnology
   Chromatographies
   Spectroscopies
   Microscopies
   Nanomanipulation
   Case: From Tool to Technology
3) Nanoscience
   Nanochemistry
   Nanophysics
   Nanobiology
   Nanomedicine
   Case: from Nanoscience to Nanotechnology
4) Innovation management
   Why Innovation Management?
   Principles of IMfN
   Project Management for Nanotechnology
   New Business Development
   Business Development
5) Nanotechnology as Enabler for Industries
   Transportation
   Construction
   Optics
   Electronics
   Pharma and Medicine
   Case: from Nanotechnology to Nanomarkets
6) Nanomarkets
   Technology Push from Nanotech - solutions needed
   Market Pull for Nanotech - where it comes from
   Opportunities Created by Nanoscience
   Markets Today
   Class Work: Markets and Society
7) Nanofinance
   Financing R&D
   Financial Tools for Start-Ups
   Portfolio Management
8) Nanofinance
   Societal Concerns
   Real and Apparent Dangers
   Ensuring Sustainable Business Success

Literatur
Meeting the Challenge of Sustainable Mobility, by Harry Geerlings, Springer, Berlin (1999)

<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
<th>Innovation Management for Nanotechnology from Science to Technology Markets (L, S) 2 h/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arbeitsaufwand</td>
<td>28 h lecture (presence)</td>
</tr>
<tr>
<td></td>
<td>16 h preparation and revision lecture</td>
</tr>
<tr>
<td></td>
<td>8 h seminar (presence)</td>
</tr>
<tr>
<td></td>
<td>30 h seminar, presentation, report</td>
</tr>
<tr>
<td></td>
<td>8 h excursion (BASF)</td>
</tr>
<tr>
<td></td>
<td><strong>Total: 90 h</strong></td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>MSc course of studies Advanced Materials</td>
</tr>
</tbody>
</table>
# Introductory Engineering

Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870916</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>5</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>4</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Dr. Ferdinand Scholz</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Prof. Dr. Ferdinand Scholz</td>
</tr>
</tbody>
</table>

## Einordnung in die Studiengänge
- Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 1. semester
- Advanced Materials (Biomaterials) MSc, begin of study WiSe, elective modul, 1. semester

## Vorkenntnisse
- BSc degree

## Lernergebnisse
**Electrical Engineering:**
Students should be able to
- perform circuit analysis of linear DC and AC (RLC) circuits
- analyze transient problems of RLC circuits
- understand the basics of crystal and semiconductor physics
- understand how basic semiconductor devices work
- understand basic treatment/evaluation of measured data

## Inhalt

**Measurement units, SI units**

**Basic Electrical Engineering:**

- Charge, voltage, current, power, energy, Kirchhoff's laws, Circuit analysis: Resistive circuits, resistances in series and parallel; network analysis by using series and parallel equivalents, voltage and current dividers, duality, nodevoltage analysis, mesh current analysis, Thevenin and Norton equivalent circuits, superposition principle, linearity, Wheatstone bridge; Capacitor, inductor: capacitance, modelling of real elements, inductance, magnetic fields, magnetic circuits, magnetic materials, ideal and real transformers, Maxwell's equations

**Analysis of transients:**

- First and second order transient circuits, steadystate sinusoidal analysis: phasors, complex numbers, complex impedances, power in AC circuits,
average power etc., Thevenin and Norton equivalent, maximum power transfer, Frequency analysis, filters etc.: Frequency response, logarithmic scale, Bode diagram, low pass, high pass, 2nd order low pass etc.

**Fourier and Laplace transformation:**
- Transfer function, step, pulse response, convolution

**Semiconductors:**
- Basics of crystallography: Miller's indices, reciprocal lattice, Brillouin zone, Basics of band structure: Naïve band diagram, dispersion relation, Schrödinger equation, effective mass, concept of hole, direct/indirect band structure, interaction with light, carrier statistics, density of states, Fermi statistics, impurity conduction, mobility, diffusion, Hall-effect

**Diodes:**
- pn junction, ideality factor, load line analysis, fabrication, special diodes, pn as capacitance, hetero junction, Schottky diode, compound semiconductors

**Transistors:**
- Bipolar transistor, band structure, common base, common emitter, amplification, Field Effect Transistor: Structure, operation, enhancement and depletion; load line analysis

**Devices for measurement:**
- Operational amplifier: Basics, adder, subtractor, integrator, differentiator, logarithmiser, instrumentation amplifier

**Basics of measurement, errors, statistics:**
- Random and systematic errors, mean value, standard deviation, probability distributions: Binomial, Poisson, Gauss, error propagation, regression

**Signal filtering, Noise :**
- Thermal, shot, 1/f, distribution, generation-recombination, noise figure of 4-port, Signal filtering: passive, active, Lock-In, Boxcar, signal transmission

**Digital Signal Processing:**
- Binary signals, Binary numbers, Gray code, basic logic operations, adders, flip-flop, Digitization: Basics, sampling theorem, DA and AD converters, Digital filters, z-transformation, Microcomputers, microcontrollers: Building blocks, data storage, data transmission

---

**Literatur**

- Electrical Engineering:
| Lehr- und Lernformen | Introductory Engineering (L), 3 h/week  
| Introductory Engineering (E), 1 h/week |
|---------------------|----------------------------------------------------------------------------------|
| Arbeitsaufwand      | 42 h lecture (presence)  
|                     | 14 h exercises, practical training (presence)  
|                     | 50 h preparation and postprocessing lecture  
|                     | 28 h solution of exercises, postprocessing  
|                     | 16 h exam preparation  
|                     | Total: **150 h** |
| Bewertungsmethode   | written examination |
| Notenbildung        | Exam result |
| Grundlage für       | MSc course of studies Advanced Materials |
Laser, Laser-Matter Interactions
Modul zugeordnet zu Elective Courses

Code 8822870455

ECTS-Punkte 3

Präsenzzeit 2

Unterrichtssprache englisch

Dauer 1 Semester

Turnus jedes Wintersemester

Modulkoordinator Prof. Dr. Alwin Kienle

Dozent(en) Prof. Dr. Alwin Kienle

Einordnung in die Studiengänge Advanced Materials M.Sc., Wahlmodul, 3. Semester
Physik M.Sc., Wahlmodul, 1. oder 2. Semester
Elektrotechnik, M.Sc., Wahlmodul Ingenieurwissenschaften
Elektrotechnik, M.Sc., Wahlpflichtmodul Mikroelektronik

Vorkenntnisse Formale Voraussetzungen: Keine
Empfohlene Vorkenntnisse: Keine

Lernergebnisse Studierende, die dieses Modul erfolgreich absolviert haben,
• verstehen die Physik und Technik von Lasern
• haben einen breiten Überblick für die verschiedenen Arten von Lasern und deren Anwendungsmöglichkeiten.
• verstehen die Wechselwirkungsmechanismen der Laserstrahlung mit Materie.
• sind in der Lage, Laser in der Praxis einzusetzen.
• können geeignete Laser und Laserparameter für vorgegebene Aufgaben auswählen.
• haben ihre Präsentationsfähigkeiten geübt.

Inhalt In diesem Modul werden folgende fachliche Inhalte vermittelt:
• physikalischer Hintergrund der Erzeugung von Laserstrahlung
• Aufbau von Lasern
• Charakterisierung der Laserstrahlung
• physikalische und technische Eigenschaften von verschiedenen Lasertypen
• optische Eigenschaften von Dielektrika, Halbleitern und Metallen
• Modellbildung zur Reflexion, Absorption und Streuung
• photochemische Effekte
• Laserablation
• Anwendungen von Lasern

Literatur
Handouts:
- printout of lecture material
- book chapter copies
Reference texts:
a) General
b) Laser physics
- dtv-Atlas zur Atomphysik, dtv, 1980
c) Optical properties of matter and light propagation
- Bergmann, Schaefer: Lehrbuch der Experimentalphysik, Band 3, Optik, de Gruyter, 1993
- Bergmann, Schaefer: Lehrbuch der Experimentalphysik, Band 6, Festkörper, de Gruyter, 1992
- Handbook of Chemistry and Physics, CRC, 1986
d) Laser material interactions

Lehr- und Lernformen
Vorlesung (1 SWS)
Seminar (1 SWS)

Arbeitsaufwand
15 h Vorlesung (Anwesenheit)
15 h Seminar und Praktikum (Anwesenheit)
60 h Selbstdstudium und Prüfungsvorbereitung
Summe: 90 h

Bewertungsmethode
Schriftliche Prüfung. Prüfungsvoraussetzung ist die erfolgreiche Teilnahme am Seminar.

Notenbildung
Die Modulnote entspricht der Prüfungsnote.
Grundlage für -
**Materials in Cell and Tissue Engineering**
Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822871139</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>1</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Inhalt</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Literatur</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Lehr- und Lernformen</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>keine Angabe</td>
</tr>
</tbody>
</table>
Mechanics of Materials
Modul zugeordnet zu Elective Courses

Code 8822870947

ECTS-Punkte 3

Präsenzzeit 2

Unterrichtssprache English

Dauer 1 Semester

Turnus jedes Semester

Modulkoordinator Prof. Carl Krill, Ph.D.

Dozent(en) Dr. J.-H. You
Prof. Carl Krill, Ph.D.

Einordnung in die Studiengänge Elektrotechnik, M.Sc., Wahlmodul Ingenieurwissenschaften

Vorkenntnisse Materials Science I

Lernergebnisse At the completion of this course, students will be able to calculate support reactions and internal loadings by the method of sections, applying equations of static equilibrium to free-body diagrams. For a given object of known composition and dimensions, participants will quantify the stresses induced by internal and external loads and compute the resulting deformation for the cases of uniaxial loading, bending and torsion. In light of the maximum stresses and strains determined in this manner, the students will be able to perform a proper dimensioning of load-bearing structures for applications in MEMS and nanotechnology.

Inhalt Topics
1. Introduction
   i. Equilibrium conditions, internal forces
   ii. Stress
   iii. Strain
   iv. Generalized Hooke's law
2. Axial loading
   i. Deformations
   ii. Thin-walled pressure vessels
3. Flexural loading
   i. Stresses
a. introduction
b. elastic flexure formula
c. shear forces and bending moments
d. shear stress
   ii. Deflections
   a. introduction
   b. deflections by integration
c. singularity functions
d. deflections by superposition
e. deflections due to shearing stress
   iii. Statically indeterminate systems
4. Torsional loading
   i. Stress
   ii. Displacements
   iii. Thin-walled tubes-shear flow
   iv. General stress state
5. Stress and strain transformation
   i. Stress transformation equations for plane stress
   ii. Principle stresses
   iii. Mohr’s circle for plane stress
6. Combined loading
   i. Special cases
   ii. Theories of failure

Literatur

Lehr- und Lernformen
Lecture (2 SWS)

Arbeitsaufwand
28 h lecture (presence)
46 h preparation and revision lecture
16 h exam preparation
Total: 90 h

Bewertungsmethode

Notenbildung
Die Modulnote entspricht dem Ergebnis der Modulprüfung.

Grundlage für
keine Angaben
## Micro- and Nanostructured Optics

Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870626</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>1</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Semester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Dr. Robert Brunner</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Prof. Dr. Robert Brunner</td>
</tr>
</tbody>
</table>

### Einordnung in die Studiengänge
Master degree in Advanced Materials, elective, 3. semester

### Vorkenntnisse
Introductory Solid State Physics, Materials Science I and II

### Lernergebnisse
The shrinking of optical dimensions down to the micro- and nanometer scale is opening new approaches to design and to realize optical devices and systems with divers and fascinating opportunities. The application spectrum ranges from consumer optics, e.g. micro-mirror devices for projection displays, up to sophisticated, high performance systems in deep-UV lithography or in space science.

Learned lessons from nature and also the introduction of new bottom-up structuring techniques is meanwhile shifting optical features sizes down to the nanometer range.

The goal of the course is to present a selection of topics of micro- and nanooptics and to develop and to expand an intuitive understanding of the application potentials in this field and the technological challenges.

### Inhalt
- refractive and diffractive microoptics
- fabrication techniques:
  - e.g. e-beam-, laser-, interference lithography
- replication processes
- microoptical mechanical systems (MOEMS)
- hybrid optics
• nanostructured optics
• moth-eye effect
• near field optics

**Literatur**
Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge
Handouts

**Lehr- und Lernformen**
Micro- and nanostructured Optics(L), 1 h/week

**Arbeitsaufwand**
14 h lecture (presence)
30 h preparation and revision lecture
16 h exam preparation
*Total: 60 h*

**Bewertungsmethode**
keine Angaben

**Notenbildung**
keine Angaben

**Grundlage für**
## Micro- and Nanotechnologie

Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870918</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>4</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>3</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Prof. Dr. Peter Unger</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Prof. Dr. Peter Unger</td>
</tr>
</tbody>
</table>

### Einordnung in die Studiengänge

- Advanced Materials (Biomaterials) MSc, begin of study WiSe, elective modul, 3. semester
- Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 3. semester

### Vorkenntnisse

Introductory Engineering

### Lernergebnisse

This course on the Micro- and Nanotechnology provides an advanced understanding of the technology for fabricating structures with micron- and nanometer-scale dimensions.

### Inhalt

At the beginning of the course, the basic technological processes for lithography and pattern transferttechniques are discussed. As applications of these technologies, fabrication processes are presented like CMOS and III-V technology, micromechanics, magneticthin-film heads, flat-panel displays, micro optics, x-ray optics and quantum-effect electronic devices. The lectures are accompanied by exercises, where important original publications will be discussed and hands-on experiments in the clean room will be performed.
Literatur


Lehr- und Lernformen

- Micro- and Nanotechnology (L), 2 h/week
- Micro- and Nanotechnology (E), 1 h/week

Arbeitsaufwand

- 28 h lecture (presence)
- 14 h exercises, practical training (presence)
- 34 h preparation and postprocessing lecture
- 28 h solution of exercises, postprocessing
- 16 h exam preparation

Total: 120 h

Bewertungsmethode

examination of 120 min., precondition: successful participation in exercises

Notenbildung

Exam result

Grundlage für

MSc course of studies Advanced Materials
### Nearfield Optics and Plasmonics

Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822871422</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>3</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>2</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Inhalt</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Literatur</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Lehr- und Lernformen</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>keine Angabe</td>
</tr>
</tbody>
</table>
Polymers in Medicine
Modul zugeordnet zu Elective Courses

Code 8822870948

ECTS-Punkte 2

Präsenzzeit 1

Unterrichtssprache Please switch to English version.

Dauer 1 Semester

Turnus jedes Semester

Modulkoordinator Please switch to English version.

Dozent(en) Please switch to English version.

Einordnung in die Studiengänge Please switch to English version.

Vorkenntnisse Please switch to English version.

Lernergebnisse Please switch to English version.

Inhalt Please switch to English version.

Literatur Please switch to English version.

Lehr- und Lernformen Please switch to English version.

Arbeitsaufwand Please switch to English version.

Bewertungsmethode Please switch to English version.

Notenbildung Please switch to English version.
Grundlage für

Please switch to English version.
Principles of Structure Formation in Nanomaterials
Modul zugeordnet zu Elective Courses

Code 8822870920

ECTS-Punkte 5

Präsenzzeit 4

Unterrichtssprache english

Dauer 1 Semester

Turnus jedes Wintersemester

Modulkoordinator Prof.Dr. Katharina Landfester

Dozent(en) Prof. Dr. Katharina Landfester, PD. Dr. Elena Mena-Osteritz, Prof. Dr. T. Bernhardt, Prof. Dr. J. Behm

Einordnung in die Studiengänge Advanced Materials (Biomaterials) MSc, begin of study WiSe, elective modul, 3. semester
Advanced Materials (Nanomaterials) MSc, begin of study WiSe, compulsory modul, 3. semester

Vorkenntnisse

Lernergebnisse Students should gain an insight into
a) the basics and production of some functional nanomaterials
b) the structure-function relationship at the nanoscale which enables new routes to the knowledge based design of functional nanomaterials

Inhalt

Polymeric Materials:
1) Block copolymers
2) Liquid-crystalline polymers
3) Semiconducting and conducting polymers
4) Nanolithography with Polymers
5) Molecular Imprinting

Surface Structuring and Nanoparticles:
1) classes of chemical reactions/processes
2) growth modes in growth processes
3) elementary surface processes during film growth
4) applications of nanoparticles is their use in Heterogeneous Catalysis, as part of supported catalysts
5) basic types of bimolecular catalytic reactions
Van der Waals interaction:
1) Interaction forces
2) Electrostatic interaction between systems

Cluster Based Materials:
1) Chemisorption (dissociative or molecular) and molecular physisorption.
2) Clusterstructure calculations based on the Lennard-Jones (LJ) interaction potential
3) Cluster mass spectra
4) Carbon cluster structures
5) One-dimensional metal structures

Literatur
- Geoffrey A Ozin (Author), André C Arsenault (Author), Ludovico Cademartiri (Author) m, Nanochemistry ISBN: 978-1-84755-895-4
- Handouts related to specific problems are distributed in the lectures

Lehr- und Lernformen
Principles of structure formation in nanomaterials (L), 4 h/week

Arbeitsaufwand
42 h lecture (presence)
92 h preparation and postprocessing lecture
16 h exam preparation
Total: 150 h

Bewertungsmethode
written examination

Notenbildung
Exam result

Grundlage für
MSc course of studies Advanced Materials
Semiconductor Sensors - Halbleitersensoren
Modul zugeordnet zu Elective Courses

Code 8822870450
ECTS-Punkte 5
Präsenzzeit 3
Unterrichtssprache englisch
Dauer 1 Semester
Turnus jedes Sommersemester
Modulkoordinator Prof. Dr.-Ing. Hermann Schumacher
Dozent(en) Dr. Alberto Pasquarelli
Einordnung in die Studiengänge Electrical Engineering, M.Sc., Elective Module
Electrical Engineering, M.Sc., Compulsory Subject Module, Microelectronics
Electrical Engineering, M.Sc., Optional Module, Automation and Energy Technology
Communications Technology, M.Sc., Optional Technical Module, Microelectronics
Embedded Systems, M.Sc., Application Subject, Mixed Signal Systems

Vorkenntnisse Halbleiterbauelemente

Lernergebnisse The advances in microelectronics and micro electro-mechanical systems (MEMS) have revolutionized the scenario of sensor technology. Thanks to new materials and processes, traditional bulky, slow and expensive sensor systems could be replaced by miniaturized and integrated smart sensors based on semiconductors. With the help of semiconductor sensors various application areas have been developed. In everyday life we encounter them, for example in the form of navigation and control systems in vehicles or as microphones, accelerometers, compass and cameras in mobile phones and tablets. In addition to the automotive industry and the mobile communications, semiconductor sensors are used in many other areas, for example in health care to record the blood pressure or body temperature in real time.

The students describe and classify principles of operation, technological implementations and application areas of different sensors. They recognize and discuss the various physical phenomena in semiconductors, which are used for the detection of physical quantities and their conversion to electrical signals.

They know various semiconductor materials suitable for the production of sensors, analyze the peculiarities of each one, explain and predict their response under different conditions and can calculate sensor examples for different measurement needs. The students can design a semiconductor sensor choosing the right material among several semiconductors. They are able to analyze a measurement
problem, compare appropriate sensing techniques and develop their own solution. Doing this they can properly dimension the sensor unit to meet the design specifications.

<table>
<thead>
<tr>
<th>Inhalt</th>
<th>Semiconductor-based detection methods for:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- radiation (ionizing and non-ionizing)</td>
</tr>
<tr>
<td></td>
<td>- magnetic fields</td>
</tr>
<tr>
<td></td>
<td>- mechanical forces</td>
</tr>
<tr>
<td></td>
<td>- temperature</td>
</tr>
<tr>
<td></td>
<td>Basics on operational amplifiers</td>
</tr>
<tr>
<td></td>
<td>Basics on MST (micro system technology)</td>
</tr>
<tr>
<td></td>
<td>Basics on MEMS (micro electro-mechanical systems)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Literatur</th>
<th>Lecture Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For in-depth study, following books (University library) are recommended:</td>
</tr>
<tr>
<td></td>
<td>Pierret: Field effect devices - TK 7871.95/1990 P</td>
</tr>
<tr>
<td></td>
<td>Michalski: Temperature measurement - I: QC 291/1991 M</td>
</tr>
<tr>
<td></td>
<td>Glück: MEMS in der Mikrosystemtechnik - T99: TK 7875/2005 G</td>
</tr>
<tr>
<td></td>
<td>Hilleringmann: Mikrosystemtechnik - T99: TK 7875/2006 H</td>
</tr>
<tr>
<td></td>
<td>Middelhoek: Silicon sensors - I: T 50/1989 M</td>
</tr>
<tr>
<td></td>
<td>Sze: Semiconductor sensors - T99: T 50/1994 Sc</td>
</tr>
<tr>
<td></td>
<td>Fraden, Jacob - Handbook of modern sensors – I: T 50/1993 F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lehr- und Lernformen</th>
<th>Lecture “Semiconductor Sensors”, 3 SWS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exercise “Semiconductor Sensors”, 1 SWS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arbeitsaufwand</th>
<th>Active Time: 45 h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preparation and Evaluation: 105 h</td>
</tr>
<tr>
<td></td>
<td>Sum: 150 h</td>
</tr>
</tbody>
</table>


| Notenbildung | Die Modulnote entspricht dem Ergebnis der Modulprüfung. |

| Grundlage für | Master thesis in the area of semiconductor sensors. |
Solid State Chemistry
Modul zugeordnet zu Elective Courses

Code 8822870949

ECTS-Punkte 2

Präsenzzeit 1

Unterrichtssprache english

Dauer Semester

Turnus keine Angaben

Modulkoordinator Prof. Dr. Nicola Hüsing

Dozent(en) Prof. Dr. Nicola Hüsing

Einordnung in die Studiengänge Master degree in Advanced Materials, elective, 2. semester

Vorkenntnisse General Chemistry, Synthesis of Inorganic and Organic Materials, Physical Chemistry

Lernergebnisse The lecture covers the most fundamental principles of modern solid state chemistry, i.e. structures, properties, syntheses and applications of solid materials. Besides minerals and bulk materials, today's advanced materials serve to illustrate these basics.

Inhalt
1. Structure of solids: Close packing, basic structure types, complex structures, structure of nanomaterials
2. Basic crystallography: unit cells, symmetry elements, spacegroups, "International Tables for Crystallography"
3. Characterization of solids I: diffraction techniques
4. Characterization of solids II: electron microscopy, spectroscopy, thermal analysis
5. Bonding in solids: Ionic bonding, metallic bonding, band structure, concepts to predict structures
6. Real structure of crystals: defects, solid solutions, extended defects and nanostructures
7. Electrical, magnetic and optical properties: semiconductivity, superconductivity, ionic conductivity, ferromagnetism, luminescence
8. Synthesis of solids: solid state reaction, sol-gel method, hydrothermal synthesis, vapor phase transport, methods for crystal growth
9. Structure-property relations I: zeolites
10. Structure-property relations II: nanomaterials

Literatur
A.R. West, Solid State Chemistry and its Applications, Wiley
L. Smart, Moore Elaine A, Solid State Chemistry, An Introduction, CRC
http://www.chemistry.ohio-state.edu/~woodward/ch754...
Handouts

Lehr- und Lernformen
Solid State Chemistry(L), 1 h/week

Arbeitsaufwand
14 h lecture (presence),
30 h preparation and revision lecture
16 h exam preparation
Total: 60 h

Bewertungsmethode
keine Angaben

Notenbildung
keine Angaben

Grundlage für
keine Angaben
Surface Plasmon Photonics
Modul zugeordnet zu Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>8822871088</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>2</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Dr. Manuel Rodrigues Gonçalves</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Dr. Manuel Rodrigues Gonçalves</td>
</tr>
</tbody>
</table>

Einordnung in die Studiengänge
Master degree in Advanced Materials, elective module, 3. semester

Vorkenntnisse
Introductory Solid State Physics, Advanced Physics of Materials

Lernergebnisse
Basic knowledge of physical phenomena related to surface plasmons polaritons. Detailed understanding of excitation mechanisms and their measurement. Basic knowledge of simulation methods and experimental applications.

Inhalt
Several physical phenomena related to surface plasmons polaritons (SPPs) are known since the Roman Empire, namely the light scattering on a glass cup (Lycurgus cup). However, the first satisfactory explanation was only presented by the beginning of the XX century (Mie scattering).
In the last decades the study of fundamental phenomena related to SPPs increased drastically. More recently, several applications in sensing and photonics have been proposed. Moreover, SPPs provide many advantages on photonics because they allow light focusing beyond the diffraction limit and couple light with electronic oscillations at the nanoscale.
In this course the basic physical concepts of the surface plasmons will be presented. The excitation mechanisms and their measurement will be discussed. Several simulations methods and experimental applications will be analysed.

Topics:
1. Fundamental concepts of classical electrodynamics
   1.1 Electromagnetic waves; Boundary conditions
2. Near-fields and far-fields
3. Fields and field-modes at metal-dielectric boundaries: Surface plasmon-polaritons (SPPs)
4. SPPs at small particles: Mie theory, scattering
5. Field enhancements
6. Surface enhanced Raman scattering (SERS), enhanced fluorescence, spontaneous emission enhancement
7. Imaging of near-fields and SPPs
7.1 SNOM, confocal Raman microscopy, EELS, PEEM
8. Simulation methods: DDA, FDTD, FEM, MMP, etc.
9. Applications: SPPs propagation in waveguides, plasmonic metamaterials, SERS, SEIRA, QED

<table>
<thead>
<tr>
<th>Literatur</th>
<th>Roland Glaser, Biophysics, Springer handouts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lehr- und Lernformen</td>
<td>Surface Plasmon Photonics (L) 2 h/week</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>28 h lecture (presence)</td>
</tr>
<tr>
<td></td>
<td>46 h preparation and revision</td>
</tr>
<tr>
<td></td>
<td>16 h exam preparation</td>
</tr>
<tr>
<td></td>
<td><strong>Total: 90 h</strong></td>
</tr>
<tr>
<td>Notenbildung</td>
<td>Die Modulnote entspricht dem Ergebnis der Modulprüfung.</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>-</td>
</tr>
</tbody>
</table>
Theory in Materials Science
Modul zugeordnet zu Elective Courses

Code 8822870628

ECTS-Punkte 2

Präsenzzeit 1

Unterrichtssprache english

Dauer 1 Semester

Turnus jedes Semester

Modulkoordinator Dr. Igor Potemkin

Dozent(en) Dr. Igor Potemkin

Einordnung in die Studiengänge Master degree in Advanced Materials, elective module, 3. semester

Vorkenntnisse Materials Science I and II, General Chemistry, Physical Chemistry

Lernergebnisse The course is called to show the basic physical properties of various polymeric systems

Inhalt
1 Introduction to Polymer Physics
2 Flexibility of a polymer chain. Flexibility mechanisms
   2.1 Flexibility mechanisms
   2.2 Portrait of a polymer coil
   2.3 Ideal Polymer Chain
   2.4 Kuhn segment length of a polymer chain
   2.5 Persistent length of a polymer chain
   2.6 Stiff and flexible chains
   2.7 Polymer volume fraction inside ideal coil
   2.8 Radius of gyration of ideal chain
   2.9 Gaussian distribution for the end-to-end vector for ideal chain
3 High Elasticity of Polymer Networks
   3.1 The property of high elasticity
   3.2 Elasticity of a Single Ideal Chains
   3.3 Elasticity of a polymer network (rubber)
4 Viscoelasticity of Entangled Polymer Fluids
   4.1 Main properties of entangled polymer fluids
   4.2 Viscosity of fluids
4.3 The property of viscoelasticity
4.4 Theory of reptations
4.5 The method of gel-electrophoresis in application to DNA molecules
4.6 Gel permeation chromatography

5 Swelling and Collapse of Single Polymer Molecules and Gels
5.1 Basic physical effects
5.2 Simplified polymer chain models for the consideration of polymer chains with interacting monomer units
5.2.1 Model of beads on a Gaussian filament
5.2.2 Lattice model
5.3 Concept of # -temperature
5.4 The excluded volume problem
5.5 Swelling of polymer gels
5.6 Superabsorbing properties of polyelectrolyte gels
5.7 Coil-Globule Transition.
5.8 Collapse of polyelectrolyte gels

6 Concentrated polymer solutions
6.1 Possible concentration regimes of polymer solution
6.2 Screening of excluded volume in semidilute and concentrated polymer solutions
6.3 Polymer coil dimensions in semidilute solutions: example of scaling arguments
6.4 Behavior of polymer solutions in poor solvent
6.4.1 Free energy of polymer solution in the Flory-Huggins theory
6.4.2 Conditions for macroscopic phase separation
6.4.3 Phase diagram for polymer solutions

7 Other polymer systems
7.1 Polymer mixtures
7.2 Microphase separation in block-copolymers
7.3 Liquid-crystalline ordering in polymer solutions
7.4 Basic properties of polyelectrolytes

Literatur

Lehr- und Lernformen
Theory in Materials Science, (L) 1 h/week

Arbeitsaufwand
14 h lecture (presence)
30 h preparation and revision lecture
16 h exam preparation
Total: 60 h

Bewertungsmethode
keine Angaben

Notenbildung
keine Angaben

Grundlage für
keine Angaben
<table>
<thead>
<tr>
<th>Code</th>
<th>8822871421</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>2</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>1</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Wintersemester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Inhalt</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Literatur</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Lehr- und Lernformen</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>keine Angabe</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>keine Angabe</td>
</tr>
</tbody>
</table>
Thin Films
Modul zugeordnet zu Elective Courses

Code 8822870625

ECTS-Punkte 4

Präsenzzeit 2

Unterrichtssprache english

Dauer 1 Semester

Turnus jedes Semester

Modulkoordinator Prof. Dr. Ulrich Herr

Dozent(en) Prof. Dr. Ulrich Herr

Einordnung in die Studiengänge Master degree in Advanced Materials, elective, 3. semester

Vorkenntnisse Materials Science I, Materials Science II

Lernergebnisse Understanding of thin film technology and processing techniques. Critical assessment of property changes in thin films with respect to bulk materials. Understand microstructure/property relationships in thin films.

Inhalt
1. Vacuum science and technology
   - Kinetic gas theory, application
   - Vacuum pumps and measurement
2. Thin film growth techniques
   - Evaporation
   - Sputtering
3. Substrate surface and nucleation
   - Thermodynamics and kinetics of nucleation and growth
4. Epitaxy
   - Lattice misfit and defects
   - Mechanisms and characterization
5. Film structure
   - Structural morphology
   - Grain growth, texture, microstructure control
   - Amorphous thin films
6. Mechanical properties of thin films  
- Internal stresses: origin and analysis  
- Mechanical relaxation effects  
7. Magnetic properties of thin films  
- Micromagnetism  
- Magnetic structures in thin films  
8. Applications  
- Magnetic recording media  
- Magneto-electronics

**Literatur**  

**Lehr- und Lernformen**  
Thin Films (L) 2 h/week, (E) 1 h/week

**Arbeitsaufwand**  
28 h lecture (presence)  
32 h preparation and revision lecture  
14 h exercises (presence)  
16 h exam preparation  
**Total: 90 h**

**Bewertungsmethode**  
keine Angaben

**Notenbildung**  
keine Angaben

**Grundlage für**  
MSc course of studies Advanced Materials
<table>
<thead>
<tr>
<th>Additive Key Qualifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modul zugeordnet zu ASQ und Masterarbeit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>8822886000</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>6</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>4</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Semester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Inhalt</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Literatur</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Lehr- und Lernformen</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>keine Angaben</td>
</tr>
</tbody>
</table>
Grundlage für keine Angaben
<table>
<thead>
<tr>
<th><strong>Additive Key Qualifications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Modul zugeordnet zu Additive Key Qualifications</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Code</strong></th>
<th>8822870973</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECTS-Punkte</strong></td>
<td>8</td>
</tr>
<tr>
<td><strong>Präsenzzeit</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Unterrichtssprache</strong></td>
<td>Master program &quot;Energy Science and Technology&quot; is taught in English. Module descriptions are only available in English. Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Dauer</strong></td>
<td>1 Semester</td>
</tr>
<tr>
<td><strong>Turnus</strong></td>
<td>jedes Semester</td>
</tr>
<tr>
<td><strong>Modulkoordinator</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Dozent(en)</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Einordnung in die Studiengänge</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Vorkenntnisse</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Lernergebnisse</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Inhalt</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Literatur</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Lehr- und Lernformen</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Arbeitsaufwand</strong></td>
<td>Please switch to English version of HIS Online-Portal.</td>
</tr>
<tr>
<td><strong>Bewertungsmethode</strong></td>
<td>Inhalte werden vom Studiengang eingetragen.</td>
</tr>
<tr>
<td><strong>Notenbildung</strong></td>
<td>Inhalte werden vom Studiengang eingetragen.</td>
</tr>
</tbody>
</table>
Please switch to English version of HIS Online-Portal.
## German Language

Modul zugeordnet zu Additive Key Qualifications

<table>
<thead>
<tr>
<th>Code</th>
<th>8822870974</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>8</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>10</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>deutsch</td>
</tr>
<tr>
<td>Dauer</td>
<td>3 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Semester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Dr. Timm, Ms Husemann</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Ms Kathrin Husemann, Lecturers of the Center of Languages</td>
</tr>
</tbody>
</table>

### Einordnung in die Studiengänge

- Master degree in Advanced Materials (compulsory)
- Master degree in Energy Science and Technology (compulsory)
- Master degree in Finance (elective)

### Vorkenntnisse

- BSc degree

### Lernergebnisse

- The students should be able to talk and understand German

### Inhalt

- **Course / Kurs I**
  - Words and phrases
  - People, travelling
  - Supermarket
  - Rent a room, buying furnitures
  - Talks, discussion
  - Grammar

- **Course / Kurs II**
  - Grammar
  - Talks, discussion,
  - Writing

- **Course / Kurs III**
  - Grammar
  - Talks, discussion
  - Writing
| **Literatur** | - H. Aufderstraße, J. Müller, T. Starz, Delfin: Lehrbuch und Arbeitsbuch Max Hueber Verlag  
- Handouts |
| **Lehr- und Lernformen** | Seminars, 4 h/week (1st and 2nd semester), 2h/week (3rd semester) |
| **Arbeitsaufwand** | 140 h seminars (presence)  
76 h preparation and revision seminars  
24 h exam preparation  
**Total: 240 h** |
| **Bewertungsmethode** | keine Angaben |
| **Notenbildung** | keine Angaben |
| **Grundlage für** | MSc course of studies Advanced Materials  
MSc course of studies Energy Science and Technology |
**Master Thesis**  
Modul zugeordnet zu ASQ und Masterarbeit

<table>
<thead>
<tr>
<th>Code</th>
<th>8822880000</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECTS-Punkte</td>
<td>30</td>
</tr>
<tr>
<td>Präsenzzeit</td>
<td>30</td>
</tr>
<tr>
<td>Unterrichtssprache</td>
<td>english</td>
</tr>
<tr>
<td>Dauer</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Turnus</td>
<td>jedes Semester</td>
</tr>
<tr>
<td>Modulkoordinator</td>
<td>Head of examination committee, Prof. Dr. Paul Ziemann</td>
</tr>
<tr>
<td>Dozent(en)</td>
<td>Lecturers of Advanced Materials</td>
</tr>
<tr>
<td>Einordnung in die Studiengänge</td>
<td>Advanced Materials MSc, compulsory module, 4. semester</td>
</tr>
<tr>
<td>Vorkenntnisse</td>
<td>At least 83 credit points in modules of the first three semesters, 2 referees, application form for Master Thesis signed by student, signed by head of examination committee and signed by student secretary</td>
</tr>
<tr>
<td>Lernergebnisse</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Inhalt</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Literatur</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Lehr- und Lernformen</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Arbeitsaufwand</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Bewertungsmethode</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Notenbildung</td>
<td>keine Angaben</td>
</tr>
<tr>
<td>Grundlage für</td>
<td>keine Angaben</td>
</tr>
</tbody>
</table>