Universität Augsburg
Mathematisch-Naturwissenschaftliche Fakultät
Institut für Physik

Modulhandbuch

für den Masterstudiengang

Advanced Functional Materials (AFM)

Stand: 09.01.2012

Content

I. Objectives and Profile of the Program

This international Master of Science (MSc) aims at providing high-level academic and research-oriented education about the synthesis, the characterisation and the processing of all classes of materials with special emphasis on hybrids and ceramics.

The first objective is to promote excellence, innovation, originality, mobility, diversity as well as complementarity between European universities in the domain of functionalised advanced materials. Such a level of scientific education is unique in Europe.

The second objective is to bring highly-motivated third-country graduate students to Europe to allow them benefiting from an education in the technological domain of nanomaterials and materials science.

The final goal is to prepare the students for entering a PhD program in Europe or abroad for instance in one of the FAME network laboratories. Alternatively, students should be able to fill leading positions in industry as scientists or engineers in materials science.

The Master Course ensures an intensive and innovative training for both non-European and European students. The program forms a new generation of students with multidisciplinary and transdisciplinary profile and fosters networking activities within Europe and third countries in the field of research and education.

The 7 institutional partners offer a larger variety of knowledge as well as a broader spectrum on research than a single university could propose. The students benefit from the best practices used in work teams and take part to the management of scientific research-oriented projects. After having passed the first year in one partner university (currently either Univ. Augsburg or INP-Grenoble) the students are obliged to continue in one of the other partner universities in another country. Depending on the rules of the receiving university, they can do the master thesis under supervision of the first or second year university.

They have the opportunity to specialise in 7 different research areas:

* Hybrid Materials and Ceramics
* Materials for Micro- and Nanotechnologies
* Nanomaterials and Hybrids
* Engineering of Materials and Nanostructures
* Nanomaterials and Modelling
* Functional Ceramics
* Materials Interfaces

The Augsburg Institute of Physics comprises one of the largest groups in solid state physics in Germany. The different chairs are not only known for their high- quality basic research but also for their application-oriented research and development activities.
The excellence in basic research as a main pillar of the physics department is reflected for example by participation in several collaborative research centres, covering special topics of fundamental or applied solid state physics and modern materials. Additionally there is a growing cooperation with applied research centers for lightweight construction and application for carbon fiber reinforced materials.

Based on a detailed knowledge of advanced physical and chemical analysis, thin film technology, hard coatings, catalysis, nanoscience, surface science, oxide materials and life cycle analysis, there is - via the centre for Materials- and Environmental Research (AMU) - a close collaboration with industrial and institutional laboratories on a wide variety of topics. Europe-wide, the team of 15 partner organisations of EMMI institute supporting the FAME Master is focusing on smart nano-materials, an emerging field drawing inspiration from nature and the living world.

The FAME Masters program comprises five different module areas as listed below. Credit points (CP) and semester work load (SWS, given in hours per week for one semester) is given in the table, as well.

Module		SWS	CP
1	Fundamentals of Materials Science	15	23
2	Methods in Materials Science	23	33
3	Materials Science Seminar	2	4
4	Specialization in Materials Science	20	30
5	Finals		30

The total of credentials is 120 credit points.

The anticipated learning outcomes in the Masters program go far beyond the ones of the Bachelor's degree program. The following technical and social knowledge, skills and competencies are essential for the professional qualification of the Masters Graduates:

• The graduates have sound working knowledge of scientific fundamentals of materials science, good knowledge of mathematics (in terms of its application to scientific problems), and practical skills in modern materials research. Based on this knowledge, they are able to identify relations between materials science and various economic issues.

• Generally, they are well prepared for demanding tasks, whose processing goes well beyond a schematic application of existing concepts only. They are moreover able to analyze and deliberately modify the tasks according to the respective needs. They have acquired a wide range of material knowledge, scientific methods and techniques and are qualified to use these accordingly and well adaptedto the specific problem.

• The graduates have an understanding of the impact of their activities as material scientists in a company, including resource and environmental issues and are aware of their own scientific and social responsibilities.

• The graduates are able to judge and understand the effects of their actions as materials scientists and to estimate their impact on social, environmental and society issues. They have accquired an awareness for resource management and smart resource handling.

• The program graduates are able to work in a variety of scientific and technical surroundings to organize and carry out projects in several different areas. They are familiar with the learning strategies that lead them and others to professional and social competences and they know how to make this anongoing and deepening process.

• They are able to appropriately present both their own results as well as general questions of modern materials research in front of professional colleagues as well as to the broader public.

• They are prepared for flexible use in various professional fields around and in particular on the work in an occupational or academic field. Successful graduates are well prepared to follow an appropriate PhD program.

Social skills are acquired primarily integrated into the specialized modules, such as team skills in exercises and in internships and project organization during the final thesis work. The Master's degree Materials Science is an international program, the teaching language of the courses is English.

II. Official Documents

The international Masters program‚ Materials Science' was officially opened to students in the winter term 2003/04. The actual examination regulation was enacted on 25. July 2007. It may be downloaded at

http://www.zv.uni-augsburg.de/de/sammlung/download/

or

http://www.physik.uni-augsburg.de/studium/

III. Module summary

The responsible module appointees are named in brackets.

Abbreviations:

SWS = Semester work load, CP = credit points
V = lecture, Ü = exercise, P = Praktikum, S = Seminar

Module Group	Module	Signature	SWS	CP
1 Basics of Materials Science				
	Compulsory Modules: Materials Physics I (Stritzker)	MaMawi-11-01	3 V, 1 Ü	6
	Materials Physics II (Stritzker)	MaMawi-12-01	3 V, 1 Ü	6
	Materials Chemistry (Volkmer)	MaMawi-13-01	3 V, 1 Ü	6
	Physics of Surfaces and Interfaces (Horn)	MaMawi-14-01	3 V, 1 Ü	5
		subtotal	16	23
2 Methods in Materials Science	**Compulsory Modules:** Characterization of materials (Haider)	MaMawi-21-01	4 V	6
	Processing of materials (Haider)	MaMawi-22-01	3 V	5
	Theoretical Concepts and Simulation (Schuster)	MaMawi-23-01	3 V, 1 Ü	6
	Elective Modules:			
	Method Course: Electron Microscopy (Haider)	MaMawi-24-02	4 V, 2 P	8
	Method Course: Electronics for Physicists and Materials Scientists (Wixforth)	MaMawi-24-04	3 V, 3 P	8
	Method Course: Materials Synthesis (Scherer)	MaMawi-24-05	2 V, 4 P	8
	Method Course: Methods in Biophysics (Thalhammer)	MaMawi-24-06	4 V, 1 P	8
	Method Course: Optical Properties of Solids (Loidl)	MaMawi-24-07	2 V, 4 P	8
	Method Course: Spectroscopy on Condensed Matter (Loidl)	MaMawi-24-09	2 V, 4 P	8
	Method Course: Thin Film Analysis with Ion Beams (Karl)	MaMawi-24-11	2 V, 4 P	8
	Method Course: X-ray and Neutron Diffraction Techniques (mit Exkursion) (Scherer)	MaMawi-24-12	2 V, 4 P	8
	Method Course: Solid State Synthesis Lab (Volkmer)	MaMawi-24-13	2 V, 4 P	8
	Method Course: Semiconductor and surface acoustic wave devices (Krener)	MaMawi-24-14	4 V, 1 P	8
	Method Course: Characterization of Porous Materials (Volkmer)	MaMawi-24-15	2 V, 4 P	8
		subtotal	22	33
3 Materials Science Seminar				
	Compulsory Module: Introduction to Materials (Haider)	MaMawi-31-01	2 S	4

	subtotal	2	4

4 Specialization in Materials Scien-ce				
	5 Elective Courses according to postings of examination board			
	Physics and Technology of Semiconduc-tor Devices (Wixforth)	MaMawi-41-01	3 V, 1 Ü	6
	Nanostructures / Nanophysics (Wixforth)	MaMawi-41-02	3 V, 1 Ü	6
	Electronics for Physicists and Materials Scientists (Wixforth)	MaMawi-41-03	3 V, 1 P	6
	Biophysics and Biomaterials (Thalham-mer)	MaMawi-41-04	4	6
	Solid State Spectroscopy with Synchro-tron Radiation (Kuntscher)	MaMawi-41-05	3 V, 1 Ü	6
	Chemische Physik I (Scherer)	MaMawi-41-06	3 V, 1 Ü	6
	Chemische Physik II (Scherer)	MaMawi-41-07	3 V, 1 Ü	6
	Ion-Solid Interaction (Karl)	MaMawi-41-08	3 V, 1 Ü	6
	Physics of Thin Films (Brütting)	MaMawi-41-09	4 V	6
	Organic Semiconductors (Brütting)	MaMawi-41-10	4 V	6
	Magnetism (Krug von Nidda)	MaMawi-41-11	3 V, 1 Ü	6
	Low Temperature Physics (Mannhart)	MaMawi-41-12	3 V, 1 Ü	6
	Spintronics (Mannhart)	MaMawi-41-13	4 V	6
	Materials Synthesis (Scherer)	MaMawi-41-14	3 V, 1 Ü	6
	Oxidation and Corrosion (Haider)	MaMawi-41-15	4 V, 1 Ü	6
	Seminar on Glass Physics (Lunken-heimer)	MaMawi-41-16	2 S	4
	Advanced Solid State Materials (Höppe)	MaMawi-41-17	3 V, 1 Ü	6
	Porous Materials (Volkmer)	MaMawi-41-18	3 V, 1 Ü	6
	Superconductivity (Tidecks)	MaMawi-41,19	3 V, 1 Ü	6
	Sustainable Resource Management (Rathgeber, Reller)	MaMawi-41-20	2 V, 2 Ü	6
	Practical Laboratory Project (Chairman of Examination Board)	MaMawi-42-01	4 V	6
5 Finals				
	Masters Thesis (6 months) (Wixforth)	MaMawi-91-01		26
	Final Colloquium (Wixforth)	MaMawi-91-02		4
		subtotal		30
		Total		**120**

IV. Module descriptions

1. Basics of Materials Science

Modul description	**Material Physics I**
Signature	MaMawi-11-01, MaAFM-11-01
Semester and recurrence	1^{st} Semester/ every winter term
Responsible for module	Prof. Dr. Stritzker
Lecturer	
Language	Englisch
Curriculum inclosures	Master Materials Science, Master Advanced Functional Materials
Lecture type and hours	*Type* / *SWS* / *Group size*: Lecture / 3 / 20 Exercise / 1 / 20
Work load (hours)	*Presence time* / *Self-study* / *Total*: Lecture / 45 / 55 / 100 Exercise / 15 / 35 / 50 written examen / / 30 / 30 / / / 180
Credit points	6
Prerequisites acc.to the regulations of study	None
Recommended prerequisites	None
Acquired skills and knowledge	The students • know the basic terms of solid state and semi-conductor physics like electrical band structure, doping, charge carrier stastics or optical properties. • are capable to apply derived approximations as the effective mass or quasi Fermi-levels to describe the basic characteristics of semiconductive materials. • have the competence to apply these concepts for the description of semiconducting components as diodes, transistors and optical components and to describe their functionality. • know the most important technological procedures for manufacturing of micro- and nanoelectronic components.
Content	**IA Preliminaries** **IB Electrons in solids** IB 1 Free Electron Gas IB 2 Reciprocal Lattice IB 3 Band Structure **IC Phonons** IC 1 Lattice Vibrations **ID General Properties of Materials** ID 1 Electrical Conductivity ID 2 Thermal Properties ID 3 Optical Properties **II Metals** **III Semiconductors** • Pure SC • Intrinsic Conditions • SC in Equilibrium • Doping

	• Heterogeneous Structures • Metal-SC Interfaces, Schottky Contact • pn-junctions • Devices • Diode • Transistor • Solar cell • Technology **IV Dielectric Solids, Optical Properties** • Introduction, Phenomenology • Polarization • Propagation of EM waves in Solids • Ferro electricity • Optically active point defects
Requirements for credits	One written exam, 90 min, and one seminar presentation (20 min)
Media and methods	Lecture: slides/blackboard with help of other media and experiments Tutorial: intensive support in small groups, seminar presentations by students Self-study
Literature	R.E. Hummel: *Electronic Properties of Materials* Springer 2001 (UP1000 H925) G. Burns: *Solid State Physics* Academic Press 1990 (UP1000 B967) N. W. Ashcroft, N.D. Mermin: *Solid State Physics* (UP1000 A 824) C. Kittel: *Introduction to Solid State Physics* (UP1000 K 62)
Further Information	-

Module description	**Materials Physics II**
Signature	MaMawi-12-01, MaAFM-12-01, MaPhy-42-02
Semester and recurrence	2^{nd} Semester / each summer term
Responsible for module	Prof. Dr. Stritzker
Lecturer	Prof. Dr. Stritzker (SS 2011)
Language	English
Curriculum inclosures	Master Materialwissenschaften, Master Advanced Functional Materials, Master Physik (Wahl)
Lecture type and hours	*Type* / *SWS* / *Group size*: lectures 3, 30-40; tutorial 1, 30-40
Work load (hours)	see table below
Credit points	6
Prerequisites acc. to the regulations of study	None
Recommended prerequisites	None
Acquired skills and knowledge	Die Studierenden ● kennen die grundlegenden physikalischen und chemischen Ursachen für die daraus resultierenden unterschiedlichen Materialeigenschaften, ● sind in der Lage, Materialien hinsichtlich ihrer magnetischen, supraleitenden, thermischen und Transporteigenschaften zu charakterisieren und, im Rahmen einfacher Modelle, entsprechende Berechnungen durchzuführen und ● besitzen die Kompetenz, wissenschaftliche Fragestellungen aus den genannten Bereichen weitgehend selbständig zu bearbeiten.
Content	1. Magnetic materials [4] 1.1. Magnetization 1.2. Atomic origin of magnetic moments 1.3. Paramagnetism 1.4. Ferromagnetism 1.5. Anisotropy 1.6. Ferromagnetic materials, hard and soft magnets 1.7. Magnetooptics 2. Superconductivity [4] 2.1. Basic phenomena 2.2. Meissner effect 2.3. Energy gap 2.4. London equation 2.5. Basic ideas of the BCS theory, Cooper pairs 2.6. Type I/II superconductors 2.7. High T_c superconductors 2.8. Superconducting materials, flux pinning 3. Thermodynamics of materials [7] 3.1. Review of basic terms 3.2. Equilibrium conditions 3.3. Phase diagrams 3.4. Multiphase-multicomponent equilibria 3.5. Thermodynamics of point defects 3.6. Thermodynamics of interfaces 4. Thermal Properties [4] 4.1. Specific Heat 4.2. Thermal Expansion 4.3. Thermal Transport 4.4. Thermal Radiation 4.5. Thermoelectricity

Lecture type and hours:

Type	*SWS*	*Group size*
lectures	3	30-40
tutorial	1	30-40

Work load (hours):

	Presence	*Self-study*	*Total*
Lectures	45	55	100
Tutorial	15	35	50
Homework		30	30
			180

	5. Atomic transport [3] 5.1. Diffusion 5.2. Electro-, thermo-, stress migration
Requirements for credits	1 written examination, 90 min
Media and methods	Beamer presentation, blackboard (occasionally)
Literature	• Charles Kittel: Introduction to Solid State Physics (Wiley & Sons) • Werner Buckel und Reinhold Kleiner: Supraleitung (Wiley-VCH)
Further information	-

Module description	**Materials Chemistry**
Signature	MaMawi-13-01, MaAFM-13-01, MaPhy-41-04, MaPhy-42-06
Semester and recur-rence	1st semester (each winter term)
Responsible for module	Prof. Dr. Volkmer
Lecturer	Prof. Dr. Volkmer
Language	english
Curriculum inclosures	Master Materials Science (compulsory module), Master Physics with minor sub-ject Chemistry (elective module), Master AFM (compulsory module)
Lecture type and hours	*type* / *SWS* / *Group size*: lectures – 3 – 20-30 tutorial – 1 – 20-30
Work load (hours)	see table below
Credit points	6 LP
Prerequisites acc. to the regulations of study	none
Recommended prere-quisites	The lecture course is based on the courses Chemistry I and Chemistry II.
Acquired skills and knowledge	● The students shall acquire knowledge about concepts of chemical bonding in coordination chemistry (main emphasis: d-block transition metal compounds) ● Broaden their capabilities to interpret UV/vis absorption spectra and to predict stability and reactivity of coordination compounds ● learn how to transfer concepts of coordination chemistry onto topics of mate-rials sciences
Content	● Historical development of coordination chemistry [1] ● Structures and nomenclature rules [2] ● Chemical bonds in transition metal coordination compounds [3] ● Stability of transition metal compounds [2] ● Characteristic reactions [4] ● Coordination polymers / metal-organic frameworks [2] ● Cluster compounds [2] ● Functional materials [2] ● Bioinorganic chemistry [2] ● Coordination compounds in medical applications [1]
Requirements for cre-dits	1 written examination, 90 min
Media and methods	Beamer presentation, blackboard (occasionally)
Literature	• *Coordination Chemistry*, Joan Ribas Gispert, Wiley-VCH • Lutz H. Gade, *Koordinationschemie*, Wiley-VCH *As well as selected reviews and journal articles cited on the slides*
Further information	-

Lecture type and hours:

type	*SWS*	*Group size*
lectures	3	20-30
tutorial	1	20-30

Work load (hours):

	Presence time	*Self-study*	*Total*
lectures	45	30	75
tutorial	15	60	75
homework		30	30
			180

Module description	**Physics of Surfaces and Interfaces**
Signature	MaMawi-14-01; MaAFM-14-01; MaPhy-42-03
Semester and recurrence	2^{nd} semester / every year
Responsible for module	Prof. Dr. Horn
Lecturer	Prof. Dr. Haider (SS 2011)
Language	englisch
Curriculum inclosures	Master Materials Science; Master AFM; Master Physics (elective module)
Lecture type and hours	*Type* / *SWS* / *Group size*: lectures / 3 / bis zu 40 tutorial / 1 / bis zu 20
Work load (hours)	*Presence* / *Self-study* / *Total*: lectures: 45 / 45 / 90 tutorial: 15 / 45 / 60 homework: – / 30 / 30 Total: 180
Credit points	5
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	Das Modul Experimentelle Festkörperphysik oder das Modul Theoretische Festkörperphysik sollte zuerst absolviert werden.
Acquired skills and knowledge	Die Studierenden ● haben Kenntnisse der Struktur, der elektronischen Eigenschaften, der Thermodynamik sowie des chemischen Reaktionsverhaltens an Ober- und Grenzflächen, ● haben die Fertigkeit, ihre Kenntnisse auf Problemstellungen der Grundlagenforschung und der angewandten Forschung auf dem Gebiet der Physik von Ober- und Grenzflächen anzuwenden, ● und besitzen die Kompetenz, basierend auf den vermittelten physikalischen Grundlagen eigenständig Lösungsansätze für entsprechende Problemstellungen zu erarbeiten.
Content	I. Introduction [1] 1. The importance of surfaces and interfaces II. Some basic facts from solid state physics [3] 1. Crystal lattice and reciprocal lattice 2. Elektronic structure of solids 3. Lattice dynamics III. Physics at surfaces and interfaces [14] 1. Structure of ideal and real surfaces 2. Relaxation and reconstruction 3. Transport (diffusion, elektronic) on interfaces 4. Thermodynamics of interfaces 5. Elektronic structure of surfaces 6. Chemical reactions on solid state surfaces (catalysis) 7. Interface dominated materials (nano scale materials) IV. Methods to study chemical composition and electronic structure, application examples [4] 1. Scanning electron microscopy 2. Scanning tunneling and scanning force microscopy 3. Auger – electron – spectroscopy 4. Photo electron spectroscopy
Requirements for credits	1 written examination, 90 min

Media and methods	-
Literature	• Ertl, Küppers: Low Energy Electrons and Surface Chemistry (VCH) • Lüth: Surfaces and Interfaces of Solids (Springer) • Zangwill: Physics at Surfaces (Cambridge) • Feldmann, Mayer: Fundamentals of Surface and thin Film Analysis (North Holland) • Henzler, Göpel: Oberflächenphysik des Festkörpers (Teubner) • Briggs, Seah: Practical Surface Analysis I und II (Wiley)
Further information	

2. Methods in Materials Science

<table>
<tr><td>Module description</td><td>Characterization of Materials</td></tr>
<tr><td>Signature</td><td>MaMawi-21-01, MaAFM-21-01</td></tr>
<tr><td>Semester and recur-rence</td><td>1st or 3rd semester / each winter term</td></tr>
<tr><td>Responsible for module</td><td>Prof. Dr. Haider</td></tr>
<tr><td>Lecturer</td><td></td></tr>
<tr><td>Language</td><td>english</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materials Science (compulsory module); Master Advanced Functional Materials</td></tr>
<tr><td>Lecture type and hours</td><td><table>
<tr><td>Type</td><td>SWS</td><td>Group size</td></tr>
<tr><td>lectures</td><td>4</td><td>30</td></tr>
<tr><td>tutorial</td><td>0</td><td>0</td></tr>
</table></td></tr>
<tr><td>Work load
(hours)</td><td><table>
<tr><td></td><td>Presence</td><td>Self-study</td><td>Total</td></tr>
<tr><td>lectures</td><td>60</td><td>60</td><td>120</td></tr>
<tr><td>tutorial</td><td></td><td></td><td></td></tr>
<tr><td>exam</td><td></td><td>60</td><td>60</td></tr>
<tr><td></td><td></td><td></td><td>180</td></tr>
</table></td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td>none</td></tr>
<tr><td>Recommended prere-quisites</td><td>Grundkenntnisse der Materialwissenschaften</td></tr>
<tr><td>Acquired skills and knowledge</td><td>Den Studierenden wird im Rahmen einer Ringvorlesung in jeweils 4 SWS grund-legende Charakterisierungsmethoden vorgestellt.
Die Studierenden
● kennen die grundlegenden Charakterisierungsmethoden der Materialwissen-schaften,
● verfügen über Kenntnisse der Einsatzmöglichkeiten dieser Methoden,
● besitzen Kompetenzen, diese Techniken zur Untersuchung der strukturellen, chemischen, elektronischen, magnetischen und optischen Eigenschaften von Materialen einzusetzen.</td></tr>
<tr><td>Content</td><td>• X-ray diffraction [2]
• Mechanical characterisation [2]
• Optical methods [2]
• Elektrical mearsurements and characterisation [2]
• NMR spectroscopy [2]
• Spectroscopy using synchrotron radiation[2]
• Thermal analysis [2]
• Ion beam methods [2]
• Charakterisation of organic systems [2]
• Elektron microscopy [2]
• (Stand: Wintersemester 2009/2010)</td></tr>
<tr><td>Requirements for cre-dits</td><td>1 written examination, 90 min</td></tr>
<tr><td>Media and methods</td><td>Vorlesung: Folien/Tafelvortrag mit Medienunterstützung
Selbststudium</td></tr>
<tr><td>Literature</td><td>Wird von den einzelnen Dozenten themenspezifisch genannt</td></tr>
<tr><td>Further information</td><td></td></tr>
</table>

<table>
<tr><td>Module description</td><td colspan="5">Processing of Materials</td></tr>
<tr><td>Signature</td><td colspan="5">MaMawi-22-01; MaAFM-22-01, MaPhy-42-05</td></tr>
<tr><td>Semester and recurren-ce</td><td colspan="5">2nd / summer term</td></tr>
<tr><td>Responsible for module</td><td colspan="5">Prof. Dr. Haider</td></tr>
<tr><td>Lecturer</td><td colspan="5">Prof. Dr. Haider
Prof. Dr. Horn
Prof. Dr. Ruhland
Prof. Dr. Stritzker
Prof. Dr. Wixforth (SS 2011)</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Curriculum inclosures</td><td colspan="5">Master of Materials Science (compulsory module), Master Advanced Functional Materials, Master Physics</td></tr>
<tr><td rowspan="2">Lecture type and hours</td><td rowspan="2"></td><td>Type</td><td colspan="2">SWS</td><td>Group size</td></tr>
<tr><td>Vorlesung</td><td colspan="2">3</td><td></td></tr>
<tr><td rowspan="5"></td><td rowspan="5"></td><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr>
<tr><td>Vorlesung</td><td>56</td><td>56</td><td>112</td></tr>
<tr><td>Klausur</td><td>2</td><td>40</td><td>42</td></tr>
<tr><td></td><td></td><td></td><td>154</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">5</td></tr>
<tr><td>Work load
(hours)</td><td colspan="5">none</td></tr>
<tr><td></td><td colspan="5">Grundkenntnisse der Materialwissenschaften</td></tr>
<tr><td>Acquired skills and knowledge</td><td colspan="5">Die Studierenden
kennen die wichtigsten Methoden der Materialbe- und -verarbeitung für die unterschiedlichen Klassen von Materialien – Halbleiter, Dünnschichtmaterialien, Polymere, Metalle, Verbundmaterialien,
beherrschen neben industriellen Verfahren auch Methoden, die bis-lang eher im Labormassstab realisisert sind und
besitzen die Kompetenz, aktuelle Problemstellungen aus dem obengenannten Themenbereich selbständig zu bearbeiten.</td></tr>
<tr><td>Content</td><td colspan="5">1. Processing of Polymers
1.1. Introduction to Polymers
1.2. Mechanical Behavior of Polymers
1.3. Rheology of Polymer Melts
1.4. Extrusion
1.5. Mixing
1.6. Injection Molding
1.7. Secondary Shaping (Fibers, Films)
1.8. Other Important Polymer Processes
1.9. (Calendering, Coating, Foaming…)
2. Processing of Composite materials
2.1. Production and properties of
2.1.1. glass fibers
2.1.2. ceramic fibers
2.1.3. carbon fibers
2.2. Production and properties of fiber reinforced materials
2.2.1. carbon reinforced polymers
2.2.2. glass fiber reinforced polymers
2.2.3. carbon fiber reinforced ceramics
2.2.4. ceramic fiber reinforced ceramics
2.3. Fields of aplications
3. Processing of Thin Films
3.1. Thin Film Deposition:
3.1.1. Laserablation
3.1.2. Ionimplantation
3.1.3. Plasma Immersion-Ionimplantation
3.1.4. Microwave Plasma CVD</td></tr>
</table>

	3.2. Thin Film Characterization: 3.2.1. Ion Beam Techniques 3.2.2. Electron Microscopy 3.2.3. X-ray Diffraction 3.2.4. Scanning Microscopy 3.2.5. Magnetooptics 3.2.6. Optical, electrical, mechanical Properties 4. Processing of Semiconductors 4.1. crystal growth and epitaxy 4.1.1. crystal growth techniques,molecular beam-, liquid phase- and gas phase epitaxy, surface preparation 4.2. oxidation and lithography 4.2.1. thermal and pyrolithic oxidation 4.2.2. optical lithography, fabrication of photo masks 4.3. etching processes 4.4. doping and contacting 4.4.1. diffusion doping, masking with oxide layers, ion implantation, fabrication of ohmic contacts 4.5. complete processes 4.5.1. process steps for fabrication of planar devices and integrated circuits 4.6. cleanrooms 4.6.1. concepts, cleanroom classes, requirements for cleanrooms 5. Processing of Metals and Alloys 5.1. Basics 5.1.1. characteristics of metals 5.1.2. plastic deformation 5.1.3. thermodynamics 5.1.4. diffusion 5.2. thermal processing: 5.2.1. solidification 5.2.2. rapid solidification 5.2.3. casting techniques 5.2.4. soldering, welding 5.3. forming processes 5.3.1. cold forming 5.3.2. hot forming, forging 5.3.3. thixoforming 5.3.4. cutting, milling 5.3.5. ECAP, SPD 5.4. Thermal processes 5.4.1. annealing, age hardening 5.4.2. recovery and recrytallization 5.4.3. sintering 5.5. Miscellanous 5.5.1. Nanocrystals 5.5.2. metallic foams 5.5.3. metal matrix composites
Requirements for credits	1 written examination, 90 min
Media and methods	Vorlesung: Powerpointpräsentationen
Literature	M. Ohring, Materials science of thin films (Academic Press) H. E. H. Meijer (ed.), Processing of polymers (Wiley-VCH) K. A. Jackson, Processing of semiconductors (VCH) M. Stuke, Materials surface processing (Elsevier) R. W. Cahn, Processing of metals and alloys (VCH)
Further information	-

<table>
<tr><td>Module description</td><td>Theoretical Concepts and Simulation</td></tr>
<tr><td>Signature</td><td>MaMawi-23-01; MaAFM-23-01</td></tr>
<tr><td>Semester and recur-rence</td><td>2nd semester / each summer term</td></tr>
<tr><td>Responsible for module</td><td>Dr. Schuster</td></tr>
<tr><td>Lecturer</td><td>Prof. Dr. Chioncel (SS 2011)</td></tr>
<tr><td>Language</td><td>english</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materials Science (compulsory module), Master Advanced Functional Materials (compulsory module)</td></tr>
<tr><td>Lecture type and hours</td><td><table><tr><td>Type</td><td>SWS</td><td>Group size</td></tr><tr><td>Lecture</td><td>3</td><td>40</td></tr><tr><td>Project</td><td>1</td><td>20</td></tr></table></td></tr>
<tr><td>Work load
(hours)</td><td><table><tr><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr><tr><td>Lecture</td><td>45</td><td>30</td><td>75</td></tr><tr><td>Project</td><td>15</td><td>60</td><td>75</td></tr><tr><td>Presentation</td><td></td><td>30</td><td>30</td></tr><tr><td></td><td></td><td></td><td>180</td></tr></table></td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td>none</td></tr>
<tr><td>Recommended prere-quisites</td><td>Basic knowledge of quantum mechanics, thermodynamics, and numerical me-thods as well as of a programming language</td></tr>
<tr><td>Acquired skills and knowledge</td><td>● The students know the principal concepts of thermodynamics and statistical physics as well as the numerical methods relevant in material science.
● The students are able to solve simple problems numerically. They are able to write the codes and to present the results.
● They have the expertise to find the numercal method approriate for the given problem and to judge the quality and validity of the numerical results.
● Integrated acquirement of soft skills: independent handling of hard- and soft-ware while using English documentations, ability to investigate abstract cir-cumstances with the help of a computer and present the results in written and oral form, capacity for teamwork</td></tr>
<tr><td>Content</td><td>1. Introduction: operating systems, programming languages, data visualization tools
2. Basic numerical methods: interpolation, integration
3. Ordinary and Partial Differential Equations (e.g., diffusion equation, Schrödinger equation)
4. Molecular Dynamics
5. Monte Carlo Simulations</td></tr>
<tr><td>Requirements for cre-dits</td><td>Project work in small groups, including a written summary of the results (ca. 10-20 pages) as well as an oral presentation</td></tr>
<tr><td>Media and methods</td><td>Blackboard presentation, occasionally supplemented by beamer or overhead presentations; in the project work with a computer in order to numerically imple-ment a given concrete problem.</td></tr>
<tr><td>Literature</td><td>1. Tao Pang, An Introduction to Computational Physics (Cambridge University Press)
2. J. M. Thijssen, Computational Physics (Cambridge University Press)
3. Koonin, Meredith, Computational Physics (Addison-Weseley)
4. D. C. Rapaport, The Art of Molecular Dynamics Simulation, (Cambridge University Press)
5. W. H. Press et al, Numerical Recipes (Cambridge University Press)</td></tr>
<tr><td>Further information</td><td>Links to software related to the course:

- http://www.bloodshed.net/</td></tr>
</table>

	- http://www.cplusplus.com/doc/tutorial/ - http://www.cygwin.com/ - http://xmd.sourceforge.net/download.html - http://www.rasmol.org/ - http://felt.sourceforge.net/

Module description	**Method Course: Electron Microscopy**
Signature	MaMawi-24-02, MaAFM-24-02
Semester and recurrence	2^{nd} / summer term
Responsible for module	Prof. Dr. Haider
Lecturer	Prof. Dr. Haider
Language	english
Curriculum inclosures	Master of Science Materials Science; Master Advanced Functional Materials
Lecture type and hours	*Type*: Methodenkurs; *SWS*: 6; *Group size*: 3-4
Credit points	8
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	Kenntnisse der Festkörperphysik, reziproker Raum
Acquired skills and knowledge	In diesem Kurs werden die wichtigsten Grundlagen und Verfahren der Rasterelektronenmikroskopie und Transmissionselektronenmikroskopie vermittelt. Hierzu werden in je zweiständigen Vorlesungen die theoretischen Grundlagen behandelt, die anschließend in praktischen Übungen an den Geräten vertieft werden. Die Studierenden werden in die Lage versetzt, Materialien mittels verschiedener elektronenmikroskopischer Techniken zu charakterisieren bzw. zu entscheiden, ob der Einsatz dieser Techniken für bestimmte Fragestellungen sinnvoll ist.

Work load (hours):

	Presence time	*Self-study*	*Total*
Vorlesung	24	48	72
Praktikum	48	48	96
Protokoll	-	50	50
			218

Content:

SEM:

Lectures

1. Layout of Electron Microscopes and Electron Optical Components
2. Electron Solid Interactions
3. Contrast Formation in Scanning Electron Microscopy (SEM)
4. SE/BSE contrast
5. Electron Back Scattering Diffraction (EBSD)
6. Analytical techniques
7. Special Applications of SEM

Exercises

8. Sample preparation: cutting, polishing and etching
9. Introduction to the SEM instrument
10. Modes of imaging
11. Energy Dispersive X-ray Spectroscopy (EDX)

TEM:

Lectures

1. TEM specimen preparation techniques
2. Components of a TEM, principle lens design, lens aberrations
3. Electron diffraction: fundamentals
4. Contrast formation at bright field, dark field, weak beam dark field, and many beam conditions, „chemical“ imaging
5. Bright field, dark field, weak beam dark field imaging of dislocations
6. Kinematical theory of electron wave propagation in crystals,
7. Howie Whelan equations, contrast of defects
8. High resolution TEM, lattice imaging of crystals
9. Advanced diffraction techniques: Kikuchi patterns, HOLZ lines and Convergent Beam Diffraction (CBED)
10. Image simulation
11. Analytical TEM: Electron energy loss spectroscopy & energy filtered TEM

	Exercises 12. Visit to TEM Labs, 13. preparation of Al samples, 14. preparation of Si plan view samples 15. TEM inspection of Al samples at TEM, 16. fundamental alignements 17. Recording of single crystalline diffraction patterns, indexing of diffraction spots, calibration of camera length & image rotation 18. Observation of stacking faults, thickness fringes, strain contrast in crystalline samples 19. Lattice imaging of a compound semiconductor 20. Observation of Kikuchi patterns 21. Recording of elemental maps
Requirements for credits	Bericht (jeweils ein Bericht pro Gruppe)
Media and methods	
Literature	1. D.B.Williams and C.B.Carter Transmission Electron Microscopy Plenum Press, New York/London, 1996 2. M.A. Hirsch, A. Howie, R. Nicholson, D.W. Pashley, M.J. Whelan Electron microscopy of thin crystals Krieger Publishing Company, Malabar (Florida), 1977 3. L. Reimer Transmission electron microscopy Springer Verlag, Berlin/Heidelberg/New York, 1984 4. P.J. Goodhew Thin foil preparation for electron microscopy Elsevier, Amsterdam, 1985 5. P.R. Buseck, J.M. Cowley, L. Eyring High-resolution transmission electron microscopy Oxford University Press, 1988 6. E. Hornbogen, B. Skrotzki Werkstoff-Mikroskopie Springer Verlag, Berlin/Heidelberg/New York, 1995 7. In situ scanning electron microscopy in materials research Klaus Wetzig, Akad.-Verl., 1995 8. Scanning electron microscopy and x-ray microanalysis Joseph I. Goldstein, Plenum Press, 1992 9. Scanning electron microscopy Ludwig Reimer, Springer Verlag, 1985 10. Elektronenmikroskopie Stanley L. Flegler ; John W. Heckman ; Karen L. Klomparens Spektrum, Akad. Verl., 1995
Further information	-

Modul description	**Method Course: Electronics for Physicists and Materials Scientists**
Signature	MaMawi-24-04; MaAFM-24-04
Semester and recur-rence	1st semester / each term
Responsible for module	Prof. Dr. Wixforth
Lecturer	Dr. Hörner (SS 2012)
language	english
Curriculum inclosures	Master Material Science; Master Advanced Functional Materials
Lecture type and hours	*type* / *SWS* / *Group size* lectures / 3 / 20 tutorial / 1 / 20 Practical course / 2,5 / 20
Work load (hours)	/ *Presence time* / *Self-study* / *Total* lectures / 45 / 40 / 85 tutorial / 15 / 40 / 55 homework / / 50 / 50 Practical course / 40 / 10 / 50 / / / 240
Credit points	8
Prerequisites acc. to the regulations of study	none
Recommended prere-quisites	none
Acquired skills and knowledge	The students ● know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the Lab, ● have skills in easy circuit design, measuring and control technology, analog and digital electronics ● have expertise in independent working on circuit problems. They can calcu-late and develop easy circuits.
Content	1. Basics in electronic and electrical engineering [4] 2. Quadrupole theory [2] 3. Analog technique, transistor and opamp circuits [5] 4. Boolean algebra und logic [4] 5. Digital electronics and calculation circuits [6] 6. Microprocessors and Networks [4] 7. Basics in Electronic [8] 8. Implementation of transistors [8] 9. Operational amplifiers [8] 10. Digital electronics [8] 11. Practical circuit arrangement [8]
Requirements for cre-dits	Oral examination (max. 15 min.)
Media and methods	lectures: slides/blackboard talk with help of other media and experiments tutorial: pratical circuit design self-study
Literature	● Paul Horowitz: The Art of Electronics (Cambridge University Press) ● National Instruments: MultiSim software package (erhältlich in der Vorlesung)
Further information	● The lecture **Electronics for Physicists and Materials Scientists** TOGETH-ER with the lab course will be awarded by credit points for the **Method Course Electronics for Physicists and Materials Scientists**

Module description	**Method Course: Materials Synthesis**
Signature	MaMawi-24-05; MaAFM-24-05
Semester and recurrence	1st or 3rd Semester / winter term
Responsible for module	Prof. Dr. Scherer
Lecturer	Prof. Dr. Scherer, Co-workers
language	english
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials
Lecture type and hours	*Type* / *SWS* / *Group size*: Practical course – 4 – 4 Lecture – 2 – 8
Work load (hours)	*Presence time* / *Self-study* / *Total*: Practical course – 60 – 90 – 150 Lecture – 30 – 30 – 60 Exam – – 30 – 30 Total: 240
Credit points	8
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	The practical course is based on the modules Chemistry I, Chemistry II, Chemistry III and the practical course in physical chemistry
Acquired skills and knowledge	The student • Gains basic practical knowledge about chemical materials synthesis and analytical methods (e.g. ICP/EA/REM-EDX). This includes the characterization via X-ray diffraction and spectroscopic techniques (e.g. IR/NMR) as well as physical methods (e.g. thermoelectric properties, magnetism). • Possesses the ability to perform materials syntheses under instruction • is able to choose the appropriate characterization method for the materials.
Content	Content of the practical course and the lecture are the theoretical basics, the synthesis and characterisation of the following functional materials: • Organic Polymers [4+2] • Zeolites and mesoporous Materials [4+2] • Porous Coordination polymers [4+2] • Ionic liquids [4+2] • Bio materials [4+2] • Oxides „Sol-Gel Processing and ceramic Methods" [4+2] • Lower dimensional structure materials [4+2] • Ferrofluides [2+1]
Requirements for credits	1 written examination, 90 min.
Media and methods	Black board presentation, Beamer presentation, Handouts
Literature	1. U. Schubert, N. Hüsing, Synthesis of Inorganic Materials (Wiley-VCH) 2. D. W. Bruce, D. O'Hare, Inorganic Materials (John Wiley & Sons) 3. J.-P. Jolivet, Metal Oxide Chemistry and Synthesis – From Solution to Solid State (John Wiley & Sons) 4. W. Jones, C.N.R. Rao, Supramolecular Organization and Materials Design (Cambridge University Press) 5. L.V. Interrante, M.J. Hampden Smith, Chemistry of Advanced Materials – An Overview (Wiley) 7. A. R. West, Basic Solid State Chemistry (John Wiley & Sons)
Further information	-

<table>
<tr><td>Module description</td><td>Method Course: Methods in Biophysics</td></tr>
<tr><td>Signature</td><td>MaMawi-24-06; MaAFM-24-06</td></tr>
<tr><td>Semester and recurrence</td><td>every term (upon agreement)</td></tr>
<tr><td>Responsible for module</td><td>Priv.-Doz. Thalhammer</td></tr>
<tr><td>Docent</td><td>Priv.-Doz. Thalhammer, Dr. Franke, Dr. Schmid (SS 2011)</td></tr>
<tr><td>language</td><td>german/english</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materials Science; Master Advanced Functional Materials, Master Physics</td></tr>
<tr><td>Lecture type and hours</td><td><table><tr><td>Type</td><td>SWS</td><td>Group size</td></tr><tr><td>lecture
laboratory course</td><td>4
1</td><td>20-30
3</td></tr></table></td></tr>
<tr><td>Work load
(hours)</td><td><table><tr><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr><tr><td>lecture</td><td>45</td><td>40</td><td>85</td></tr><tr><td>lab. course</td><td>40</td><td>15</td><td>55</td></tr><tr><td>exam</td><td></td><td>40</td><td>40</td></tr><tr><td></td><td></td><td></td><td>180</td></tr></table></td></tr>
<tr><td>Credit points</td><td>8</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td>attendence of the lecture Biophysics and Biomaterials</td></tr>
<tr><td>Recommended prerequisites</td><td>none</td></tr>
<tr><td>Acquired skills and knowledge</td><td>the students
• know basic terms, concepts and phenomena in radiation biophysics
• aquire basic knowledge of fluidic and biophysical phenomena on small length scales and applications and technologies of microfluidic analystical systems
• learn skills in tissue culture and immun-histochemical staining procedures
• learn skills in fluorescence and confocal scanning microsopy
• learn skills to calculate fluidic problems on small length scales
• learn skills to handle microfluidic channel systems</td></tr>
<tr><td>Content</td><td>practical laboratory course and experiments:
1. unit radiation biophysics
a. concepts in radiation protection
b. low-dose irradiation biophysics
c. DNA repair dynamics of living cells after ionizing radiation
d. confocal scanning laser microscopy
2. unit microfluidic
a. microfluidic systems
b. accoustic driven microfluidics
c. calculation of microfluidic problems
3. unit analysis</td></tr>
<tr><td>Requirements for credits</td><td>work (lab) report</td></tr>
<tr><td>Media and methods</td><td>lecture: transparencies/chalkboard with additional media and experiments
exercise: intensive mentoring in small groups
private study</td></tr>
<tr><td>Literature</td><td>T. Herrmann, Klinische Strahlenbiologie – kurz und bündig, Elsevier Verlag, ISBN-13: 978-3-437-23960-1
J. Freyschmidt, Handbuch diagnostische Radiologie – Strahlenphysik, Strahlenbiologie, Strahlenschutz, Springer Verlag, ISBN: 3-540-41419-3
S. Haeberle und R. Zengerle, Microfluidic platforms for lab-on-a-chip applications, Lab-on-a-chip, 2007, 7, 1094-1110
J. Berthier, Microdrops and digital microfluidics, William Andrew Verlag, ISBN:978-0-8155-1544-9
lecture notes</td></tr>
<tr><td>Further information</td><td>the course will partly take place at the Helmholtz Center Munich. Lab course requires attendance of the Biophysics Lecture!</td></tr>
</table>

Modul description	**Method Course: Optical Properties of Solids**
Signature	MaMawi-24-07, MaAFM-24-07
Semester and recurrence	1st -3rd semester / each term
Responsible for module	Prof. Dr. Loidl
Lecturer	Dr. Deisenhofer, Dipl.-Phys. Schmidt, M.Sc. Wang (SS 2011)
language	English
Curriculum inclosures	Master Material Science; Master Advanced Functional Materials
Lecture type and hours	*type* / *SWS* / *Group size*: lectures / 2 / Max. 9 tutorial / / practical course / 4 / 2 to 5
Work load (hours)	*Presence time* / *Self-study* / *Total*: lectures: 30 / 35 / 65 home work: / 30 / 30 practical course: 60 / 35 / 95 protocol: / 50 / 50 Total: 240
Credit points	8
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	Basic knowledge in solid state physics, basic knowledge in electrodynamics and optics
Acquired skills and knowledge	The students ● get to know the basic principles of Far-Infrared Spectroscopy, Terahertz Time-Domain-Spectroscopy and submillimeter-wave spectroscopy with coherent sources ● learn about fundamental physical excitations in condensed matter that can be studied by these methods ● learn to plan and carry out complex experiments. They learn how to critically analyze the data. ● specifically learn to analyze the experimental results in the light of models and modern theories of condensed matter physics.
Content (approximated duration in hours)	1. Electrodynamics of solids (24) a. Maxwell equations b. Electromagnetic waves c. Refraction and Interference, Fresnel equations 2. FTIR spectroscopy (30) a. Fourier transformation b. Michelson-Morley and Genzel interferometer c. Sources and detectors 3. Submillimeter spectroscopy (12) a. Mach-Zehnder interferometer b. Backward-wave oscillators and detectors 4. Terahertz Time Domain spectroscopy (12) a. Generation of pulsed THz radiation b. Gated detection, Austin switches 5. Elementary excitations in solids (12) a. Infrared-active phonons b. Magnetic-dipole excitations c. Crystal-field excitations
Requirements for credits	Written homework, written report on the experiments (editing time 3 weeks, max. 30 pages), short presentation (20 min)

Media and methods	Media: Projector, slides, blackboard, web resources Methods: Lecture, exercises, teamwork, students' presentations
Literature	• J.D. Jackson, Classical Electrodynamics (de Gruyter) • N.W. Ashcroft, N.D. Mermin, Solid state physics (Saunders) • Ch. Kittel, Introduction to solid state physics (Wiley) • E. Hecht, Optics (Addison-Wesley Longman)
Further information	-

Modul description	**Method Course: Spectroscopy on Condensed Matter**
Signature	MaMawi-24-09, MaAFM-24-09
Semester and recurrence	1st - 3rd semester / each term
Responsible for module	Prof. Dr. Loidl
Lecturer	Dr. Krohns, M.Sc. Schrettle, Dipl.-Phys. Wolf (SS 2011)
language	English
Curriculum inclosures	Master Material Science; Master Advanced Functional Materials

Lecture type and hours

type	*SWS*	*Group size*
lectures	2	9
tutorial		
Practical course	4	3 x 3

Work load (hours)

	Presence time	*Self-study*	*Total*
lectures	30	30	60
tutorial			
Practical course	60	60	120
examination	2	24	26
			236

Credit points	8
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	Basic knowledge in solid state physics, basic knowledge in physics of glasses and supercooled liquids

Acquired skills and knowledge

The students
- learn about the basic concepts of dielectric spectroscopy and the phenomena examined with it. Therefore they are instructed in experimental methods for the investigation of the dielectric properties of condensed matter.
- are trained in planning and performing complex experiments. They learn to evaluate and analyze the collected data.
- are taught to work on problems in experimental solid state physics. This includes analysis of measurement results and their interpretation in the framework of models and theories.

Content

6. Dielectric Spectroscopy [8]
   - Methods
   - Cryo-techniques
   - Measurement quantities
   - Relaxation processes
   - Dielectric phenomena
7. Ferroelectric Materials [7]
   - Mechanism of ferroelectric polarization
   - Hysteresis loop measurements
   - Dielectric spectroscopy
8. Glassy Matter [8]
   - Introduction
   - Glassy Phenomena
   - Dielectric Spectroscopy
9. Multiferroic Materials [7]
   - Introduction
   - Microscopic origins of multiferroicity
   - Pyrocurrent measurements
   - Dielectric Spectroscopy

Requirements for credits	1 examination (120 min); written report on the experiments, editing time 2 weeks
Media and methods	lectures: slides/blackboard talk with help of other media and experiments self-study

Literature

- N.W. Ashcroft, N.D. Mermin, Festkörperphysik (Oldenbourg)
- Ch. Kittel, Einführung in die Festkörperphysik (Oldenbourg)

	• C.J.F. Böttcher, P. Bordewijk, Theory of Electric Polarization (Elsevier) • J. R. Macdonald, Impedance Spectroscopy (Wiley) • H. Scholze, Glas (Springer) • S.R. Elliott, Physics of Amorphous Materials (Longman) • R. Zallen, The Physics of Amorphous Solids (Wiley)
Further information	-

Modul description	**Method Course: Thin Film Analysis with Ion Beams**
Signature	MaMawi-24-11, MaAFM-24-11
Semester and recur-rence	3rd or 4th semester / once a year
Responsible for module	Priv.-Doz. Karl
Docent	
language	English
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials
Lecture type and hours	*type* / *SWS* / *Group size*: lectures: 2 / 12 tutorial: N/A / N/A Practical course: 4 / 2-5
Work load (hours)	*Presence time* / *Self-study* / *Total*: lectures: 30 / 30 / 60 tutorial: – / – / – practical course: 60 / 80 / 140 report: – / 40 / 40 Total: 240
Credit points	8
Prerequisites acc. to the regulations of study	
Recommended prere-quisites	Solid knowledge in solid state and experimental physics
Acquired skills and knowledge	The students ● Know basic terms, skills and concepts to plan and perform analysis of thin films by ion beams ● Prepare themselves for successful research during their Master thesis
Content	• Introduction to ion beam analysis techniques and concepts • Rutherford backscattering spectroscopy • Theory of particle scattering and cross-section • Experimental setup • Dynamic secondary ion mass spectroscopy (SIMS) • Simulation and data evaluation of Rutherford backscattering spectrometry (RBS) experiments Experimental work in the laboratory in the Institute of Physics. Has to be conduc-ted within 3 months.
Requirements for cre-dits	1 written report and seminar talk
Media and methods	
Literature	● Will be provided by supervisor.
Further information	-

<table>
<tr><td>Module description</td><td colspan="4">Method Course: X-ray and Neutron Diffraction Techniques</td></tr>
<tr><td>Signature</td><td colspan="4">MaMawi-24-12, MaAFM-24-12</td></tr>
<tr><td>Semester and recur-rence</td><td colspan="4">2nd semester / summer semester</td></tr>
<tr><td>Responsible for module</td><td colspan="4">Prof. Dr. Scherer</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. Scherer, Dr. Eickerling (SS 2011)</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Curriculum inclosures</td><td colspan="4">Master Materials Science; Master Advanced Functional Materials</td></tr>
<tr><td rowspan="3">Lecture type and hours</td><td></td><td>Type</td><td>SWS</td><td>Group size</td></tr>
<tr><td></td><td>practical course</td><td>4</td><td>4</td></tr>
<tr><td></td><td>lecture</td><td>2</td><td>8</td></tr>
<tr><td rowspan="5">Work load
(hours)</td><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr>
<tr><td>practical course</td><td>60</td><td>90</td><td>150</td></tr>
<tr><td>lecture</td><td>30</td><td>30</td><td>60</td></tr>
<tr><td>examination</td><td></td><td>30</td><td>30</td></tr>
<tr><td></td><td></td><td></td><td>240</td></tr>
<tr><td>Credit points</td><td colspan="4">8</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td colspan="4">none</td></tr>
<tr><td>Recommended prere-quisites</td><td colspan="4">The practical course is based on the module „Chemisch-Physikalisches Prakti-kum“</td></tr>
<tr><td>Acquired skills and knowledge</td><td colspan="4">The students

• gain basic practical knowledge on structural characterisation methods for sin-gle-crystalline and powder samples employing X-ray and neutron diffraction techniques
• have the skill to, under guidance, perform phase-analyses and structure de-terminations
• are competent to analyze the structure-property relationships of new mate-rials.</td></tr>
<tr><td>Content</td><td colspan="4">Subjects of the practical training and the accompanying lecture are the theoreti-cal basics and the practical application of X-ray and neutron diffraction tech-niques:
• Basic introduction to X-ray and neutron crystallography [4+2]
• X-ray/neutron scattering [4+2]
• Data collection and reduction techniques [4+2]
• Symmetry and space group determination [4+2]
• Structural refinements: (a) The Rietveld method (b) Difference Fourier syn-thesis [4+2]
• Structure determination: (a) Patterson Method (b) Direct Methods [4+2]
• Interpretation of structural refinement results [4+2]
• Electronic structure determination and analysis [2+1]</td></tr>
<tr><td>Requirements for cre-dits</td><td colspan="4">1 written examination, approx. 90 min.</td></tr>
<tr><td>Media and methods</td><td colspan="4">blackboard and beamer presentations, handouts</td></tr>
<tr><td>Literature</td><td colspan="4">1. C. Hammond, The Basis of Crystallography and Diffraction, Oxford University Press Inc., New York, 2001.
2. W. Clegg, A. J. Blake, R. O. Gould, P. Main, Crystal Structure Analysis, Prin-ciple and Practice, Oxford University Press Inc., New York, 2001.
3. G. Giacovazzo, Fundamentals of Crystallography, Oxford University Press Inc., New York, 1994.
4. R. A. Young, The Rietveld Method, Oxford University Press Inc., New York, 2002.
5. W. Massa, Crystal Structure Determination, Springer, Berlin, 2004.</td></tr>
<tr><td>Further information</td><td colspan="4">-</td></tr>
</table>

Modul description	**Method Course: Solid State Synthesis Lab**
Signature	MaMawi-24-13, MaAFM-24-13
Semester and recurrence	1st semester, 2nd semester
Responsible for module	Prof. Dr. Volkmer
Lecturer	Prof. Dr. Volkmer, Prof. Dr. Höppe, Dr. Bredenkötter, Dr. Hanss (SS 2011)
language	English / German
Curriculum inclosures	Master Materials Science (elective module); Master Advanced Functional Materials (elective module)
Lecture type and hours	*type*: Method course; *SWS*: 6; *Group size*: 1-2
Work load (hours)	see table below
Credit points	8
Prerequisites acc. to the regulations of study	None
Recommended prerequisites	None
Acquired skills and knowledge	The students will learn how to ● develop functional materials based on organic/inorganic hybrid materials ● use modern preparation techniques (e.g. microwave synthesis) ● acquire competence to work under inert conditions (Schlenk technique) ● employ dedicated structure analytical methods
Content	Synthesis and characterization of functional materials according to following topics: ● porous functional materials (e.g. Metal-Organic Frameworks, Zeolites) ● metal-organic precursor compounds ● ceramics, luminescent compounds ● characterization methods (e.g. thermal analysis, spectroscopy (MS, FT-IR, UV/VIS), XRD, sorption methods)
Requirements for credits	Seminar talk, protocols
Media and methods	Presentation, publications, self-study
Literature	● Chemical databases ● Primary literature (scientific articles and reviews)
Further information	upon request

Work load (hours):

	Presence time	*Self-study*	*Total*
Seminar	20	40	60
Practical course	100	20	120
Homework	-	60	60
			240

Module description	**Method Course: Semiconductor and surface acoustic wave devices**
Signature	MaMawi-24-14, MaAFM-24-14
Semester and recur-rence	1st or 3rd Semester / winter term
Responsible for module	Dr. H. Krenner
Docent	Dr. H. Krenner
Language	english
Curriculum inclosures	Master Material Science; Master Advanced Functional Materials
Lecture type and hours	*Type* / *SWS* / *Group size*: Lecture / 4 / 20-30 Lab Course / 1 / 1
Work load (hours)	*Presence time* / *Self-study* / *Total*: Lecture / 45 / 40 / 85 Lab course / 40 / 15 / 55 Exam / / 40 / 40 Total: 180
Credit points	8
Prerequisites acc. to the regulations of study	Attendence of lecture „Physics and Technology of Semiconductor Devices“
Recommended prere-quisites	Basic knowledge in solid-state physics and quantum mechanics
Acquired skills and knowledge	Acquired skills: ● Basic knowledge of solid-state and semiconductor physics such as electronic bandstructure, doping, carrier excitations and carrier transport ● Application of developed concepts (effective mass, quasi-Fermi levels) to decribe the basic properties of semiconductors ● Application of these concepts to describe and understand the operation prin-ciples of semiconductor devices such as diodes, transistors and optically ac-tive elements (LEDs, detectors and lasers) ● Knowledge of the technologically relevant methods and tools in semiconduc-tor micro- and nanofabrication ● Pratical application clean room fabrication techniques: sample preparation, optical lithography, deposition methods, lift-off techniques, sample inspection ● Electrical and optcial characterization of fabricated devices
Content	1. Basic properties of semiconductors (electronic bandstructure, doping, carrier excitations and carrier transport) [10] 2. Semiconductor diodes and transitors [8] 3. Semiconductor technology [4] 4. Optoelectronics [4] 5. Surface acoustic wave (SAW) devices
Requirements for cre-dits	1 Written lab report plus 1 written exam
Media and methods	Lecture: slides/blackboard supported by other media and experiments Lab class: intensive support in small groups Self-study
Literature	● Yu und Cardona: Fundamentals of Semiconductors (Springer) ● Sze: Physics of Semiconductor Devices (Wiley) ● Sze: Semiconductor Devices (Wiley) ● Madelung: Halbleiterphysik (Springer) ● Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press)
Further information	Requires attendence of „Physics and Technology of Semiconductor Devices“

Modul description	**Method Course: Characterization of Porous Materials**
Signature	MaMawi-24-15, MaAFM-24-15
Semester and recurrence	2nd semester
Responsible for module	Prof. Dr. Volkmer
Lecturer	Prof. Dr. Volkmer, co-workers
language	English / German
Curriculum inclosures	Master Materials Science (elective module); Master Advanced Functional Materials (elective module)
Lecture type and hours	*type*: Method course; *SWS*: 6; *Group size*: 1-2
Work load (hours)	see table below
Credit points	8
Prerequisites acc. to the regulations of study	None
Recommended prerequisites	Lecture Porous Materials (MaMawi-41-18, MaAFM-41-18)
Acquired skills and knowledge	The students will learn how to ● use modern solid state preparation techniques (e.g. microwave synthesis) ● employ analytical methods dedicated to porous materials
Content	● Synthesis of porous functional materials (e.g. Metal-Organic Frameworks, Zeolites) ● Characterization methods - Thermal Analysis (TGA; EGA) - Structure Determination (XRD, VTXRPD) - Absorption and Diffusion (BET, BET isotherms) - Catalytic Properties (UV/VIS, thermal programmed oxidation and reduction (TPO and TPR) - Computational Modeling (calculation and predictions of framework structures)
Requirements for credits	Written examination (45 min) and written report (editing time 1 week)
Media and methods	Slices/blackboard, face to face tutorial, self-study
Literature	● Various. Will be provided by supervisor
Further information	upon request

Work load (hours):

	Presence time	*Self-study*	*Total*
Seminar	20	40	60
Practical course	100	20	120
Homework	-	60	60
			240

3. Materials Science Seminar

Module description	**Introduction to Materials**
Signature	MaMawi-31-01, MaAFM-31-01
Semester and recurrence	1st semester / Winter term
Responsible for module	Prof. Dr. Haider
Lecturer	
Language	English
Curriculum inclosures	Master of Science Materials Science; Master Advanced Functional Materials
Lecture type and hours	*Type*: Seminar; *SWS*: 2; *Group size*: 20
Work load (hours)	Seminar: *Presence time* 28; *Self-study* 80; *Total* 108
Credit points	4
Prerequisites acc. to the regulations of study	None
Recommended prerequisites	Knowledge of basic materials science
Acquired skills and knowledge	the students ● know the major principles, applications and processes of modern materials ● auqire the competence to compile knowledge for examples of material specific topics and to present this knowledge in given time to an audience
Content	Varying topics for each year, giving an aoverview into scope, application, requirements and preparation of all types of modern materials
Requirements for credits	presentation with term paper of 30-45 min
Media and methods	Powerpoint presentation
Literature	specific for each topic, to be gathered by the students
Further information	

4. Specialization in Materials Science

Module description	**Physics and Technology of Semiconductor Devices**
Signature	MaMawi-41-01, MaAFM-41-01, BaMawi-64-01, MaPhy-24-01
Semester and recur-rence	1st or 3rd Semester / every winter term
Responsible for module	Prof. Dr. Wixforth
Lecturer	
Language	english
Curriculum inclosures	Master Material Science; Master Advanced Functional Materials; Master Physics (elective module)
Lecture type and hours	*Type* / *SWS* / *Group size* Lecture / 3 / 20 Tutorial / 1 / 20
Work load (hours)	*Presence time* / *Self-study* / *Total* Lecture: 45 / 40 / 85 Tutorial: 15 / 40 / 55 Exam: – / 40 / 40 Total: 180
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prere-quisites	Basic knowledge in solid-state physics and quantum mechanics
Acquired skills and knowledge	Acquired skills: ● Basic knowledge of soid-state and semiconductor physics such as electronic bandstructure, doping, carrier excitations and carrier transport ● Application of developed concepts (effective mass, quasi-Fermi levels) to decribe the basic properties of semiconductors ● Application of these concepts to describe and understand the operation prin-ciples of semiconductor devices such as diodes, transistors and optically ac-tive elements (LEDs, detectors and lasers) ● Knowledge of the technologically relevant methods and tools in semiconduc-tor micro- and nanofabrication
Content	6. Basic properties of semiconductors (electronic bandstructure, doping, carrier excitations and carrier transport) [10] 7. Semiconductor diodes and transitors [8] 8. Semiconductor technology [4] 9. Optoelectronics [4]
Requirements for cre-dits	1 Written exam (90 min)
Media and methods	Lecture: slides/blackboard supported by other media and experiments Tutorial: intensive support in small groups Self-study
Literature	● Yu und Cardona: Fundamentals of Semiconductors (Springer) ● Sze: Physics of Semiconductor Devices (Wiley) ● Sze: Semiconductor Devices (Wiley) ● Madelung: Halbleiterphysik (Springer) ● Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press)
Further information	

<table>
<tr><td>Module description</td><td>Nanostructures / Nanophysics</td></tr>
<tr><td>Signature</td><td>MaMawi-41-02, MaAFM-41-02, MaPhy-24-02</td></tr>
<tr><td>Semester and recur-
rence</td><td>2nd Semester / every summer term</td></tr>
<tr><td>Responsible for module</td><td>Prof. Dr. Wixforth</td></tr>
<tr><td>Lecturer</td><td>Dr. Krenner, Prof. Dr. Wixforth (SS 2011)</td></tr>
<tr><td>Language</td><td>english</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materialwissenschaften; Master Advanced Functional Materials; Master Physics (elective module)</td></tr>
<tr><td>Lecture type and hours</td><td>
<table>
<tr><td>Type</td><td>SWS</td><td>Group size</td></tr>
<tr><td>Lecture</td><td>3</td><td>20</td></tr>
<tr><td>Tutorial</td><td>1</td><td>20</td></tr>
</table>
</td></tr>
<tr><td>Work load
(hours)</td><td>
<table>
<tr><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr>
<tr><td>Lecture</td><td>45</td><td>40</td><td>85</td></tr>
<tr><td>Tutorial</td><td>15</td><td>40</td><td>55</td></tr>
<tr><td>Exam</td><td></td><td>40</td><td>40</td></tr>
<tr><td></td><td></td><td></td><td>180</td></tr>
</table>
</td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td>none</td></tr>
<tr><td>Recommended prere-
quisites</td><td>Knowledge of quantum mechanics and semiconductor physics</td></tr>
<tr><td>Acquired skills and knowledge</td><td>Acquired skills:
● Basic knowledge oft he fundamental concepts in modern nanoscale science
● Profound knowledge of low-dimensinal semiconductor structures and how these systems can be applied for novel functional devices for high-frequency electroncis and optoelectronics
● Konwledge of different fabrication approaches using bottom-up and top-down techiques
● Application of these concepts to tackle present problems in nanophysics</td></tr>
<tr><td>Content</td><td>● Semiconductor quantum wells, wires and dots, low dimensional electron sys-tems [5]
● Magnetotransport in low-dimensional systems, Quanten-Hall-Effect, Quan-tized conductance [5]
● Optical properties of quantum wells and quantum dots and their application in modern optoelectonic devices [5]
● Nanowires, Carbon Nanotubes, Graphen [3]
● Nanophotonics, photonic band gap materials, photonic crystals
● Emerging concepts such as Quantum Computing und Quantum Information Processing [4]</td></tr>
<tr><td>Requirements for cre-
dits</td><td>1 written exam, 90 min</td></tr>
<tr><td>Media and methods</td><td>Lecture: slides/blackboard supported by other media and experiments
Tutorial: intensive support in small groups
Self-study</td></tr>
<tr><td>Literature</td><td>● Yu und Cardona: Fundamentals of Semiconductors
● Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press)
● Davies: The Physics of low-dimensional Semiconductors (Cambridge Univer-sity Press)
● V. V. Mitin et al.: Quantum Mechanics for Nanostructures (Cambridge Uni-versity Press)
● Yariv: Quantum Electronics (Wiley)
● Journal and review articles on current topics in nanoscience</td></tr>
<tr><td>Further information</td><td></td></tr>
</table>

Module description	**Electronics for Physicists and Material Scientists**
Signature	MaMawi-41-03, MaAFM-41-03, MaPhy-24-03, BaMawi-64-02
Semester and recurrence	1st semester / each semester
Responsible for module	Prof. Dr. Wixforth
Lecturer	Dr. Hörner (SS 2012)
Language	English
Curriculum inclosures	Master Material Science (elective module); Master Advanced Functional Materials
Lecture type and hours	*Type* / *SWS* / *Group size*: lectures / 3 / 20 tutorial / 1 / 20
Work load (hours)	*Presence time* / *Self-study* / *complete*: lectures: 45 / 40 / 85 tutorial: 15 / 40 / 55 homework: – / 50 / 50 total: 190
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	none
Acquired skills and knowledge	The students ● know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the Lab, ● have skills in easy circuit design, measuring and control technology, analog and digital electronics ● have expertise in independent working on circuit problems. They can calculate and develop easy circuits.
Content	1. Basics in electronic and electrical engineering [4] 2. Quadrupole theory [2] 3. Analog technique, transistor and opamp circuits [5] 4. Boolean algebra und logic [4] 5. Digital electronics and calculation circuits [6] 6. Microprocessors and Networks [4] 7. Basics in Electronic [8] 8. Implementation of transistors [8] 9. Operational amplifiers [8] 10. Digital electronics [8]
Requirements for credits	Oral examination (max. 15 min.)
Media and methods	lectures: slides/blackboard talk with help of other media and experiments tutorial: pratical circuit design self-study
Literature	● Paul Horowitz: The Art of Electronics (Cambridge University Press) ● National Instruments: MultiSim software package (erhältlich in der Vorlesung)
Further information	Attendance in the **Method Course Electronics for Physicists and Materials Scientists (combined lab course AND lecture)** excludes credit points for the lecture **Electronics for Physicists and Materials Scientists SEPERATELY**

<table>
<tr><td>Module description</td><td colspan="5">Biophysics and Biomaterials</td></tr>
<tr><td>Signature</td><td colspan="5">MaMawi-41-04, MaAFM-41-04, MaPhy-24-04</td></tr>
<tr><td>Semester and recur-
rence</td><td colspan="5">2nd Semester / every term</td></tr>
<tr><td>Responsible for module</td><td colspan="5">Priv.-Doz. Thalhammer</td></tr>
<tr><td>Docent</td><td colspan="5">Priv.-Doz. Thalhammer, Dr. Franke, Dr. Schmid (SS 2011)</td></tr>
<tr><td>Language</td><td colspan="5">english</td></tr>
<tr><td>Curriculum inclosures</td><td colspan="5">Master Materials Science (elective module); Master Advanced Functional Mate-
rials; Master Physics</td></tr>
<tr><td rowspan="3">Lecture type and hours</td><td></td><td>Type</td><td>SWS</td><td>Group size</td><td></td></tr>
<tr><td></td><td>lecture</td><td>4</td><td>20-30</td><td></td></tr>
<tr><td></td><td>lab. course</td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Work load
(hours)</td><td></td><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr>
<tr><td></td><td>lecture</td><td>45</td><td>40</td><td>85</td></tr>
<tr><td></td><td>lab. course</td><td></td><td></td><td></td></tr>
<tr><td></td><td>exam</td><td></td><td>40</td><td>40</td></tr>
<tr><td></td><td></td><td></td><td></td><td>125</td></tr>
<tr><td>Credit points</td><td colspan="5">6</td></tr>
<tr><td>Prerequisites acc. to
the regulations of study</td><td colspan="5">none</td></tr>
<tr><td>Recommended prere-
quisites</td><td colspan="5">mechanics, thermo dynamics, statistical physics</td></tr>
<tr><td>Acquired skills and
knowledge</td><td colspan="5">the students
● learn basic terms, concepts and phenomena of biological physics
● learn models of the (bio)polymer-theory, microfluidic, radiation biophysics, nanobiotechnology, membranes and neuronal networks
● adapt skills in the independent processing of problems and deal with current literature. They will be able to translate a biological oberservation into a physical question.</td></tr>
<tr><td>Content</td><td colspan="5">1. radiation biophysics
1.1 natural radiation
1.2 radiation in the low-dose regime
1.3 radiation protection
1.4 energy transfer in biological systems
1.5 biophysical concepts and biological response to ionizing radiation
2. microfluidics
2.1 Navier-Stokes equation
2.2 life at low Reynolds numbers
2.3 microfluidic phenomena
2.4 Lab-on-a-Chip systems
3. dynamic properties of polymers
3.1 the Rousse model
3.2 the Zimm model
3.3 reptation
3.4 viscoelastic networks
4. membranes
5.1 thermodynamics and fluctuation
5.2 thermodynamics of interfaces
5.3 phase transition – 2 state model
5.4 membrane elasticity
5. neuronal networks
7.1 ion channels
7.2 ion transport
7.3 electro physiology
7.4 dynamic neuronal processes
7.5 diffusion and random walk</td></tr>
<tr><td>Requirements for cre-
dits</td><td colspan="5">1 written examination, 90 min</td></tr>
</table>

Media and methods	lecture: transparencies/chalkboard with additional media exercise: talks to current problems in biophysics
Literature	• P.-G. De Gennes, Scaling Concepts in Polymer Physics (Cornell University Press) • L.D. Landau and E.M. Lifschitz, Vol. 5 and 7 (Harri Deutsch) • P. Nelson, Biological Physics (W. H. Freeman) • T. Heimburg, Thermal Biophysics of Membranes (Wiley-VCH) • D. Boal, The Mechanics of the Cell (Cambridge University Press)
Further information	This lecture is part and requirement for the methodical course Methods in Biophysics. Lecture alone will be awarded 6 CP, Method Course 8 CP

<table>
<tr><td>Module description</td><td>Solid State Spectroscopy with Synchrotron Radiation</td></tr>
<tr><td>Signature</td><td>MaMawi-41-05, MaAFM-41-05, BaMawi-64-03, MaPhy-24-05</td></tr>
<tr><td>Semester and recur-
rence</td><td>2nd Semester / every year</td></tr>
<tr><td>Responsible for module</td><td>Prof. Dr. Kuntscher</td></tr>
<tr><td>Lecturer</td><td>Prof. Dr. Kuntscher</td></tr>
<tr><td>Language</td><td>english</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materials Science (elective module); Master Advanced Functional Mate-
rials; Master Physics; Bachelor Materials Science</td></tr>
<tr><td>Lecture type and hours</td><td><table>
<tr><td>Type</td><td>SWS</td><td>Group size</td></tr>
<tr><td>Vorlesung</td><td>3</td><td>8-10</td></tr>
<tr><td>Übungen</td><td>1</td><td>8-10</td></tr>
</table></td></tr>
<tr><td>Work load
(hours)</td><td><table>
<tr><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr>
<tr><td>Vorlesung</td><td>45</td><td>45</td><td>90</td></tr>
<tr><td>Übung</td><td>15</td><td>45</td><td>60</td></tr>
<tr><td>Prüfung</td><td></td><td>30</td><td>30</td></tr>
<tr><td></td><td></td><td></td><td>180</td></tr>
</table></td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc. to
the regulations of study</td><td>none</td></tr>
<tr><td>Recommended prere-
quisites</td><td>Basic knowledge in solid state physics</td></tr>
<tr><td>Acquired skills and
knowledge</td><td>The students
● know the basics of spectroscopy and important instrumentation and methods.
● have acquired the skills of formulating a mathematical-physical ansatz in spectroscopy and can apply these in the field of solid state spectroscopy,
● and have the competence to deal with current problems in solid state spectroscopy autonomously, and are able to judge proper measurement methods for application.</td></tr>
<tr><td>Content</td><td>1. Electromagnetic radiation: description, generation, detection [5]
2. Spectral analysis of electromagnetic radiation: monochromators, spektrometer, interferometer [2]
3. Excitations in the solid state: Dielectric function [2]
4. Infrared spectroscopy [3]
5. Ellipsometry [2]
6. Photoemission spectroscopy [2]
7. X-ray absorption spectroscopy [1]
8. Neutrons: Sources, detectors [2]
9. Neutron scattering [2]</td></tr>
<tr><td>Requirements for cre-
dits</td><td>Oral examination, 30 min.</td></tr>
<tr><td>Media and methods</td><td>Beamer presentation</td></tr>
<tr><td>Literature</td><td>● H. Kuzmany, Solid State Spectroscopy (Springer)
● N. W. Ashcroft, N. D. Mermin, Solid State Physics (Holt, Rinehart and Winston)
● J. M. Hollas, Modern Spectroscopy</td></tr>
<tr><td>Further information</td><td>-</td></tr>
</table>

Module description	**Chemische Physik I**
Signature	MaMawi-41-06, MaAFM-41-06, MaPhy-24-06, MaPhy-41-02, BaMawi-64-04
Semester and recurrence	jedes Wintersemester
Responsible for module	Prof. Dr. Scherer
Lecturer	Prof. Dr. Scherer, Dr. Eickerling
Language	Deutsch
Curriculum inclosures	Master Materialwissenschaften (Wahlpflichtmodul); Master AFM; Master Physik; Bachelor Materialwissenschaften
Lecture type and hours	*Lehrform* / *SWS* / *Gruppengröße*: Vorlesung: 3, 10-30 Übungen: 1, 10-30
Work load (hours)	*Präsenzzeit* / *Eigenstudium* / *Gesamt*: Vorlesung: 45, 45, 90 Übung: 15, 45, 60 Klausur: –, 30, 30 Gesamt: 180
Credit points	6
Prerequisites acc. to the regulations of study	keine
Recommended prerequisites	Es wird empfohlen, im Rahmen des Moduls „Physikalisches Fortgeschrittenenpraktikum“ die Versuche FP11 (IR-Spektroskopie) und FP17 (Raman-Spektroskopie) zu absolvieren.
Acquired skills and knowledge	Die Studierenden • kennen die Grundlagen der Extended Hückel Methode und der Dichtefunktional Theorie. • verfügen über ein grundlegendes Verständnis der Gruppentheorie, können die aus Symmetrieüberlegungen gewonnenen Erkenntnisse im Rahmen der Schwingungs-, NMR- und UV/VIS-Spektroskopie anwenden, • und sind in der Lage, die grundlegenden geometrischen, elektronischen und magnetischen Eigenschaften von Übergangsmetallkomplexen zu interpretieren und vorherzusagen.
Content	1. Grundlagen Quantenchemischer Methoden [8] - Die Extended Hückel Methode (EHM) - Moderne quantenchemische Methoden der Chemischen Physik - Anwendung: Beispielrechnungen und Interpretation einfacher elektronischer Strukturen 2. Molekülsymmetrie und Gruppentheorie [7] - Symmetrieoperationen und Matrixdarstellungen - Punktgruppen - Reduzible und Irreduzible Darstellungen - Charaktertafeln - Anwendung: Infrarot- und Raman-Spektroskopie, NMR-Spektroskopie 3. Die Elektronische Struktur von Übergangsmetallkomplexen [7] - Ligandfeldtheorie und Angular-Overlap Modell (AOM) - Die physikalische Basis der Spektrochemischen Reihe - Molekülorbitaltheorie von Übergangsmetallkomplexen - Anwendung: UV/VIS-Spektroskopie, molekularer Magnetismus
Requirements for credits	Klausur, etwa 90 min
Media and methods	Tafelvortrag und Beamer-Präsentation
Literature	• J. Reinhold, Quantentheorie der Moleküle (Teubner) • H.-H. Schmidtke, Quantenchemie (VCH) • D. C. Harris und M. D. Bertolucci, Symmetry and Spectroscopy (Dover Publications) • D. M. Bishop, Group Theory and Chemistry (Dover Publications) • J. K. Burdett, Chemical Bonds: A Dialog (Wiley) • F. A. Kettle, Physical Inorganic Chemistry (Oxford University Press) • A. Frisch, Exploring Chemistry with Electronic Structure Methods (Gaussian Inc. Pittsburg, PA)
Further information	Die Studenten erhalten die Möglichkeit im Rahmen der Übungen selbständig einfache EH, HF und DFT Rechnungen und Analysen elektronischer Strukturen

	von Molekülen auf einem Computer-cluster durchzuführen. The lecture „Chemische Physik I“ is one of the regular lectures of the physics masters program and is therefore only offered in German language.

<table>
<tr><td>Module description</td><td>Chemische Physik II</td></tr>
<tr><td>Signature</td><td>MaMawi-41-07, MaAFM-41-07, MaPhy-24-06, MaPhy-41-02, BaMawi-64-04</td></tr>
<tr><td>Semester and recur-rence</td><td>jedes Sommersemester</td></tr>
<tr><td>Responsible for module</td><td>Prof. Dr. Scherer</td></tr>
<tr><td>Lecturer</td><td>Prof. Dr. Scherer, Dr. Eickerling</td></tr>
<tr><td>Language</td><td>Deutsch</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materialwissenschaften (Wahlpflichtmodul); Master AFM; Master Physik; Bachelor Materialwissenschaften</td></tr>
<tr><td>Lecture type and hours</td><td>
<table>
<tr><td>Type</td><td>SWS</td><td>Group size</td></tr>
<tr><td>Vorlesung</td><td>3</td><td>10-30</td></tr>
<tr><td>Übungen</td><td>1</td><td>10-30</td></tr>
</table>
</td></tr>
<tr><td>Work load
(hours)</td><td>
<table>
<tr><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr>
<tr><td>Vorlesung</td><td>45</td><td>45</td><td>90</td></tr>
<tr><td>Übung</td><td>15</td><td>45</td><td>60</td></tr>
<tr><td>Klausur</td><td></td><td>30</td><td>30</td></tr>
<tr><td></td><td></td><td></td><td>180</td></tr>
</table>
</td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td>keine</td></tr>
<tr><td>Recommended prere-quisites</td><td>Es wird dringend empfohlen, das Modul Chemical Physics I zuerst zu absolvie-ren.</td></tr>
<tr><td>Acquired skills and knowledge</td><td>Die Studierenden
• kennen grundlegende quantenchemische Methoden der Chemischen Physik zur Interpretation elektronischer Strukturen in Molekülen und Festkörpern.
• besitzen somit die Fertigkeit u.a. die Quantum Theorie der Atome in Molekü-len (QTAIM) und gängige Elektronenlokalisierungsfunktionen (z. B. ELF) zur Analyse von Ladungsdungs- und Spindichteverteilungen anzuwenden.
• sind kompetent selbstständig einfache quantenchemische Rechnungen unter Verwendung der Dichtefunktionaltheorie (DFT) durchzuführen und die elekt-ronischen Strukturen funktioneller Moleküle und Materialien im Hinblick auf chemische und physikalische Eigenschaften zu interpretieren.</td></tr>
<tr><td>Content</td><td>1. Ladungsdichteverteilungen aus Experiment und Theorie [3]
2. Analyse der Topologie von Spin- und Ladungsdichteverteilungen [6]
- Die Quantentheorie der „Atome in Molekülen“ (QTAIM)
- Elektronenlokalisierungsfunktionen (ELF) und –Indikatoren (ELI)
3. Die Natur der chemischen Bindung [5]
4. Analyse von Wellenfunktionen mittels lokalisierter Orbitale [4]
5. Moderne quantenchemische Methoden: Konfigurationswechselwirkung [4]</td></tr>
<tr><td>Requirements for cre-dits</td><td>Klausur, etwa 90 min</td></tr>
<tr><td>Media and methods</td><td>Tafelvortrag und Beamer-Präsentation</td></tr>
<tr><td>Literature</td><td>• J. Reinhold, Quantentheorie der Moleküle (Teubner)
• H.-H. Schmidtke, Quantenchemie (VCH)
• J. K. Burdett, Chemical Bonds: A Dialog (Wiley)
• F. A. Kettle, Physical Inorganic Chemistry (Oxford University Press)
• R. F. W. Bader, Atoms in Molecules: A Quantum Theory (Oxford University Press)
• P. Popelier, Atoms in Molecules: An Introduction (Pearson Education Limited)
• F. Weinhold, C. R. Landis, Valency and Bonding: A Natural Bond Orbital Do-nor-Acceptor Perspective (Cambridge University Press)
• A. Frisch, Exploring Chemistry with Electronic Structure Methods (Gaussian Inc. Pittsburg, PA)</td></tr>
<tr><td>Further information</td><td>Die Studenten erhalten die Möglichkeit selbständig quantenchemische Rech-nungen und Analysen elektronischer Strukturen von Molekülen und Festkörpern auf einem Computercluster im Rahmen der Übungen durchzuführen. The lecture „Chemische Physik II“ is one of the regular lectures of the physics masters pro-gram and is therefore only offered in German language.</td></tr>
</table>

<table>
<tr><td>Module description</td><td>Ion-Solid Interaction</td></tr>
<tr><td>Signature</td><td>MaMawi-41-08, MaAFM-41-08, MaPhy-24-09</td></tr>
<tr><td>Semester and recurrence</td><td>2nd Semester / every year</td></tr>
<tr><td>Responsible for module</td><td>Priv.-Doz. Dr. Karl</td></tr>
<tr><td>Lecturer</td><td></td></tr>
<tr><td>Language</td><td>English</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materialwissenschaften (elective module); Master FAME; Master Physik (Wahl)</td></tr>
<tr><td>Lecture type and hours</td><td><table><tr><td>Type</td><td>SWS</td><td>Group size</td></tr><tr><td>Vorlesung</td><td>3</td><td>10-15</td></tr><tr><td>Übung</td><td>1</td><td>10-15</td></tr></table></td></tr>
<tr><td>Work load
(hours)</td><td><table><tr><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr><tr><td>Vorlesung</td><td>45</td><td>45</td><td>90</td></tr><tr><td>Übung</td><td>15</td><td>45</td><td>60</td></tr><tr><td>Klausur</td><td></td><td>30</td><td>30</td></tr><tr><td></td><td></td><td></td><td>180</td></tr></table></td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td>keine</td></tr>
<tr><td>Recommended prerequisites</td><td>Grundkenntnisse aus Physik I – IV, Festkörperphysik, Kernphysik</td></tr>
<tr><td>Acquired skills and knowledge</td><td>Die Studierenden
● kennen die physikalischen Prinzipien und die grundlegenden Mechanismen der Wechselwirkung von Teilchen und Festkörpern im Energiebereich von eV bis MeV,
● sind in der Lage, geeignete physikalische Modelle für spezifische technologische und wissenschaftliche Anwendungen auszuwählen, und
● sind kompetent, Probleme aus dem Bereich der Wechselwirkung zwischen Ionen und Festkörpern weitgehend selbständig zu bearbeiten.</td></tr>
<tr><td>Content</td><td>Folgende Themen bzw. Themenkreise werden behandelt:

● Introduction (areas of scientific and technological application, principles) [2]
● Fundamentals of atomic collision processes (scattering, cross-sections, energy loss models, potentials in binary collision models) [6]
● Ion-induced modification of solids (integrated circuit fabrication with emphasis on ion induced phenomena, ion implantation, radiation damage, ion milling and etching (RIE), sputtering , erosion, deposition) [8]
● Transport phenomena [2]
● Analysis with ion beams [4]</td></tr>
<tr><td>Requirements for credits</td><td>1 written examination, 90 min</td></tr>
<tr><td>Media and methods</td><td>Tafelvortrag, ggf. mit Folienunterstützung, Beamer-Präsentation</td></tr>
<tr><td>Literature</td><td>● R. Smith, Atomic and ion collisions in solids and at surfaces (Cambridge University Press, 1997)
● E. Rimini, Ion implantation: Basics to device fabrication (Kluwer, 1995)
● W. Eckstein: Computer Simulation of Ion-Solid Interactions (Springer, 1991)
● H. Ryssel, I. Ruge: Ionenimplantation (Teubner, 1978)
● Y. H. Ohtsuki: Charged Beam Interaction with Solids (Taylor & Francis, 1983)
● J. F. Ziegler (Hrsg.): The Stopping and Range of Ions in Solids (Pergamon)
● R. Behrisch (Hrsg.): Sputtering by Particle Bombardment (Springer)
● M. Nastasi, J. K. Hirvonen, J. W. Mayer: Ion-Solid Interactions: Fundamentals and Applications (Cambridge University Press, 1996)
● http://www.SRIM.org</td></tr>
<tr><td>Further information</td><td>-</td></tr>
</table>

Module description	**Physics of Thin Films**
Signature	MaMawi-41-09, MaAFM-41-09, MaPhy-24-10, BaMawi-64-07
Semester and recurrence	2nd or 3rd Semester / every 2nd year
Responsible for module	Prof. Dr. Brütting
Lecturer	Dr. Schmehl, Prof. Dr. Mannhart (SS 2011)
Language	English
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials, Master Physics (elective module); Bachelor Materials Science
Lecture type and hours	*Type* / *SWS* / *Group size* Vorlesung / 4 / 10-15
Work load (hours)	*Presence time* / *Self-study* / *Total* Vorlesung: 60 / 60 / 120 Klausur: – / 60 / 60 Total: 180
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	none
Acquired skills and knowledge	The students ● know methods of thin film technology and material properties and applications of thin films, ● have acquired skills of grouping the various technologies for producing thin layers with respect to their properties and applications, ● and have the competence to deal with current problems in the field of thin film technology largely autonomous.
Content	● Layer growth [2] ● Thin film technology [10] ● Analysis of thin films [8] ● Properties and applications of thin films [10]
Requirements for credits	1 written examination, 90 min
Media and methods	Blackboard and/or beamer presentation
Literature	● H. Frey, G. Kienel, Dünnschichttechnologie (VDI Verlag, 1987) ● H. Lüth, Solid Surfaces, Interfaces and Thin Films (Springer Verlag, 2001) ● A. Wagendristel, Y. Wang, An Introduction to Physics and Technology of Thin Films (World Scientific Publishing, 1994) ● M. Ohring, The Materials Science of Thin Films (Academic Press, 1992)
Further information	-

Module description	**Organic Semiconductors**
Signature	MaMawi-41-10, MaAFM-41-10, MaPhy-24-11
Semester and recur-rence	2nd or 3rd Semester / every 2nd year
Responsible for module	Prof. Dr. Brütting
Lecturer	
Language	English
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials; Master Phys-ics (elective module)
Lecture type and hours	*Type*: Lecture; *SWS*: 4; *Group size*: 10-15
Work load (hours)	*Presence time* / *Self-study* / *Total*: Lecture: 60 / 60 / 120 Written exam: – / 60 / 60 Total: 180
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prere-quisites	It is strongly recommended to complete the module solid-state physics first. In addition, knowledge of molecular physics is desired.
Acquired skills and knowledge	The students ● know the basic structural and electronic properties of organic semiconductors as well as the essential function of organic semiconductor devices, ● have acquired skills for the classification of the materials taking into account their specific features in the functioning of components, ● and have the competence to comprehend and attend to current problems in the field of organic electronics.
Content	1. Introduction [15] 1.1. Materials and preparation 1.2. Structural properties 1.3. Electronic structure 1.4. Optical and electrical properties 2. Devices and Applications [15] 2.1. Organic metals 2.2. Light-emitting diodes 2.3. Field-effect transistors 2.4. Solar cells and laser
Requirements for cre-dits	1 written examination, 90 min
Media and methods	Blackboard and/or beamer presentation
Literature	● M. Schwoerer, H. C. Wolf, Organische Molekulare Festkörper (Wiley-VCH, 2005) ● M. Schwoerer, H. C. Wolf, Organic Molecular Solids (Wiley-VCH, 2007) ● M. Pope, C. E. Swenberg, Electronic Processes in Organic Crystals and Polymers (Oxford University Press 1999) ● W. Brütting, Physics of Organic Semiconductors (lecture script)
Further information	-

Module description	**Magnetism**
Signature	MaMawi-41-11, MaAFM-41-11, MaPhy-24-12, BaMawi-64-10
Semester and recurrence	ab dem 1. Semester / annual
Responsible for module	Priv.-Doz. Dr. Krug von Nidda
Lecturer	Priv.-Doz. Dr. Krug von Nidda
Language	english or german, dependent on participants
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials; Master Physics (elective module); Bachelor Materials Science
Lecture type and hours	*Type* / *SWS* / *Group size*: Lecture / 3 / 5-10 Exercices / 1 / 5-10
Work load (hours)	*Presence time* / *Self-study* / *Total*: Lecture: 45 / 30 / 75 Exercices: 15 / 60 / 75 Exam: – / 30 / 30 Total: 180
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	Basics of solid-state physics and quantum mechanics
Acquired skills and knowledge	The students ● know the basic properties and phenomena of magnetic materials and the most important methods and concepts for their description, like mean-field theory, exchange interactions and micro magnetic models ● have the ability to classify different magnetic phenomena and to apply the corresponding models for their interpretation ● have the competence independently to treat fundamental and typical topics and problems of magnetism.
Content	1. History, basics [1] 2. Magnetic moments, classical and quantum phenomenology [4] 3. Exchange interaction and mean-field theory [3] 4. Magnetic anisotropy and magnetoelastic effects [3] 5. Thermodynamics of magnetic systems and applications [2] 6. Magnetic domains und domain walls [2] 7. Magnetization processes und micro magnetic treatment [2] 8. AC susceptibility and ESR [2] 9. Spintransport / spintronics [2] 10. Recent problems of magnetism [2]
Requirements for credits	Oral examination, 30 min.
Media and methods	Black board, overhead, and beamer presentation
Literature	● D. H. Martin, Magnetism in Solids (London Iliffe Books Ltd.) ● J. B. Goodenough, Magnetism and the Chemical Bond (Wiley) ● P. A. Cox, Transition Metal Oxides (Oxford University Press) ● C. Kittel, Solid State Phyics (Wiley) ● D. C. Mattis, The Theory of Magnetism (Wiley) ● G. L. Squires, Thermal Neutron Scattering (Dover Publications Inc.)
Further information	-

Module description	**Low Temperature Physics**
Signature	MaMawi-41-12, MaAFM-41-12, MaPhy-24-14
Semester and recurrence	2nd or 3rd Semester / every 2nd year
Responsible for module	Prof. Dr. Mannhart
Lecturer	
Language	English
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials; Master Physics (elective module)
Lecture type and hours	*Type* / *SWS* / *Group size*: Lecture / 3 / 8-10 Exercices / 1 / 8-10
Work load (hours)	*Presence time* / *Self-study* / *Total*: Lecture / 45 / 45 / 90 Exercices / 15 / 45 / 60 Exam / / 30 / 30 / / / 180
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	Physik IV – Solid-state physics
Acquired skills and knowledge	The students ● know the basic properties of matter at low temperatures and the corresponding experimental techniques, ● have acquired the theoretical knowledge to perform low-temperature measurements, ● and know how to experimentally investigate current problems in low-temperature physics.
Content	● Introduction [1] ● Quantum Fluids [6] ○ Helium 4 ○ Helium 3 ● Quantum Solids [1] ● Bose-Einstein Condensate [2] ● Material Properties at Low Temperatures [6] ○ Heat capacity ○ Thermal conductivity ○ Electric conductivity ● Low temperature techniques [5] ○ Cooling ○ Temperature measurement ○ Design of cryogenic equipment ● Overview on state of current research [1]
Requirements for credits	Oral examination, 30 min.
Media and methods	Lecture at blackboard, using transparencies and computer projection
Literature	● C. Enss, S. Hunklinger, Tieftemperaturphysik (Springer) ● F. Pobell, Matter and Methods at Low Temperatures (Springer)
Further information	-

Module description	**Spintronics**
Signature	MaMawi-41-13, MaAFM-41-13
Semester and recur-rence	2nd or 3rd Semester / every 2nd year
Responsible for module	Prof. Dr. Brütting
Docent	Dr. Schmehl, Prof. Dr. Mannhart (WS 2011/12)
Language	English
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials
Lecture type and hours	*Type*: Vorlesung; *SWS*: 4; *Group size*: 15-25
Work load (hours)	Vorlesung: *Presence time* 60, *Self-study* 60, *Total* 120 Klausur: *Self-study* 60, *Total* 60 *Total*: 180
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prereq-uisites	none
Acquired skills and knowledge	The students ● know the fundamental properties of magnetic materials, the basic spintronic effects, and the related device structures ● have acquired skills in identifying materials with respect to their applicability for spintronic devices ● and have the competence to deal with current problems in the field of semi-conductor and metal based spintronics largely autonomous.
Content	● Introduction into magnetism [4] ● Basic spintronic effects and devices [4] ● Novel materials for spintronic applications [4] ● Spin-sensitive experimental methods [4] ● Semiconductor based spintronics [4]
Requirements for cred-its	1 written examination, 90 min
Media and methods	Blackboard and/or beamer presentation
Literature	● S. Bandyopadhyay, M. Cahay: *Introduction to Spintronics* (CRC Press, 2008)
Further information	-

Module description	**Materials Synthesis**
Signature	MaMawi-41-14, MaAFM-41-14, MaPhy41-05, MaPhy-42-07, BaMawi-64-09
Semester and recurrence	winter term / each year
Responsible for module	Prof. Dr. Scherer
Lecturer	
Language	English
Curriculum enclosures	Master Materials Science; Master Advanced Functional Materials; Master Physics; Bachelor Materials Science
Lecture type and hours	Lecture type and hours Lecture type and hours
Work load (hours)	Work load (hours) Work load (hours) Work load (hours)
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	none
Acquired skills and knowledge	The students • know the basic approaches to synthesize functional materials and obey a fundamental knowledge of the respective microscopic reaction mechanisms involved. • obey the capability to classify materials with respect to their individual synthetic routes. • obey the competence to adopt established synthesis approaches for the design of new materials
Content	1. Introduction: examples of materials syntheses 2. Solid-solid reactions (ceramic methods) 3. Decomposition – and dehydratisation reactions 4. Intercalation reactions 5. Chemical transport 6. Chemical vapor deposition (CVD) 7. Aerosol processes 8. materials from solution and melts 9. Solvo-thermal synthesis 10. Sol-Gel processes 11. excursion: bio-inspired materials 12. excursion: combinatorical materials synthesis 13. excursion: ultrasonic synthesis
Requirements for credits	1 written examination, 90 min
Media and methods	Blackboard presentation, eventually with beamer projection techniques
Literature	1. U. Schubert, N. Hüsing, Synthesis of Inorganic Materials (Wiley-VCH) 2. D. W. Bruce, D. O'Hare, Inorganic Materials (John Wiley & Sons) 3. J.-P. Jolivet, Metal Oxide Chemistry and Synthesis – From Solution to Solid State (John Wiley & Sons) 4. W. Jones, C.N.R. Rao, Supramolecular Organization and Materials Design (Cambridge University Press) 5. L.V. Interrante, M.J. Hampden Smith, Chemistry of Advanced Materials – An Overview (Wiley) 6. G.A. Ozin, A.C. Arsenault, Nanochemistry – A Chemical Approach to Nanomaterials, (RSC Publishing) 7. A. R. West, Basic Solid State Chemistry (John Wiley & Sons)
Further information	-

<table>
<tr><td>Module description</td><td>Oxidation and Corrosion</td></tr>
<tr><td>Signature</td><td>MaMawi-41-15, MaAFM-41-15</td></tr>
<tr><td>Semester and recurren-ce</td><td>3rd semester / winter term</td></tr>
<tr><td>Responsible for module</td><td>Prof. Dr. Haider</td></tr>
<tr><td>Lecturer</td><td></td></tr>
<tr><td>Language</td><td>English</td></tr>
<tr><td>Curriculum inclosures</td><td>Master of Science Materials Science, Master Advanced Functional Materials</td></tr>
<tr><td>Lecture type and hours</td><td>
<table>
<tr><th>Type</th><th>SWS</th><th>Group size</th></tr>
<tr><td>Vorlesung</td><td>4</td><td>20-40</td></tr>
<tr><td>Practical Exer-cises</td><td>1</td><td>3</td></tr>
</table>
</td></tr>
<tr><td>Work load
(hours)</td><td>
<table>
<tr><th></th><th>Presence time</th><th>Self-study</th><th>Total</th></tr>
<tr><td>Vorlesung</td><td>60</td><td>60</td><td>120</td></tr>
<tr><td>Practic.</td><td>8</td><td>40</td><td>48</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>168</td></tr>
</table>
</td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td>none</td></tr>
<tr><td>Recommended prerequi-sites</td><td>Gute Kenntnisse der Materialwissenschaften, Grundkenntnisse der physik. Chemie</td></tr>
<tr><td>Acquired skills and knowledge</td><td>Die Studierenden

lernen die elementaren Grundlagen, Vorgänge und Erscheinungs-formen von Korrosionsprozessen kennen
erarbeiten sich speziellere praktische Kenntnisse für ein Beispiel ei-ner Korrosionsform
</td></tr>
<tr><td>Content</td><td>Introduction
Review of thermodynamics
Chemical equilibria
Electrochemistry
Electrode kinetics
High temperature oxidation
Localized corrosion

Shallow pit corrosino
Pitting corrosion
Crevice corrosion
Intercrystalline corrosion
Stress corrosion cracking
Fatigue corrosion
Erosion corrosion
Galvanic corrosion

Water and seawater corrosion
Corrosion monitoring
Corrosion properties of specific materials
Specific corrosion problems in certain branches

Oil and Gas industry
Automobile industry
Food industry

corrosion protection

Passive layers
Reaction layers (Diffusion layers …)
Coatings (organic, inorganic)
Cathodic, anodic protection
Inhibitors
</td></tr>
<tr><td>Requirements for credits</td><td>Prakt. Übung, Vortrag und Ausarbeitung 30-45 min</td></tr>
<tr><td>Media and methods</td><td>Powerpoint presentation</td></tr>
</table>

Literature	6. Schütze: Corrosion and Environmental Degradation
Further information	

Module description	**Seminar on Glass Physics**
Signature	MaMawi-41-16, MaAFM-41-16, MaPhy-31-09
Semester and recurrence	2nd semester / each summer semester
Responsible for module	PD Dr. Lunkenheimer
Lecturer	PD Dr. Lunkenheimer (SS 2011)
Language	English
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials; Master Physics
Lecture type and hours	*Type*: Seminar; *SWS*: 2; *Group size*: 10-12
Work load (hours)	Seminar: *Presence time* 30; *Self-study* 90; *Total* 120
Credit points	4
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	Basic knowledge of solid-state physics
Acquired skills and knowledge	• The students know the phenomenology of the glass state and the glass transition, the material properties of glasses, their technical applications and the most important models of glassy matter. They have acquired knowledge concerning the preparation of scientific presentations. • They are able to independently acquaint themselves with a physical or material-science topic using various sources of information. They are capable of preparing a graphically attractive scientific talk using modern, computer-based presentation techniques. They are able to present a talk in a clear and informative way, adhering to a fixed time limit. • The students have the competence to distinguish between important and less important contents when preparing a scientific talk and to edit and restructure the chosen contents in order to provide a didactically sound presentation.
Content	The following topics are treated: - Technical glasses - Polymers - Metallic glasses - Relaxation phenomena - Models of the glass transition - Aging phenomena in glasses - Non-structural glasses - Ionic conductivity - Electrons in glasses
Requirements for credits	Talk with discussion, about 60 min
Media and methods	Beamer presentation
Literature	• H. Scholze, Glas (Vieweg) • S.R. Elliott, Physics of Amorphous Materials (Longman) • R. Zallen, The Physics of Amorphous Solids (Wiley) • J. Zarzycki (ed.), Material Science and Technology, Vol. 9: Glasses and Amorphous Materials (VCH) • J. Zarzycki, Glasses and the Vitreous State (Cambridge University Press)
Further information	-

Modul description	**Advanced Solid State Materials**
Signature	MaMawi-41-17, MaAFM-41-17, MaPhy-41-07
Semester and recurrence	2nd semester / each summer term
Responsible for module	Prof. Dr. Höppe
Lecturer	Prof. Dr. Höppe
Language	English
Curriculum inclosures	Master Materials Science (elective module); Master Advanced Functional Materials (elective module); Master Physics (elective module);
Lecture type and hours	*type* / *SWS* / *Group size*: lectures: 3 / 24 tutorial: 1 / 24
Work load (hours)	see table below
Credit points	6
Prerequisites acc. to the regulations of study	none
Recommended prerequisites	Contents of modules Chemistry I and Solid State Chemistry (Bachelor)
Acquired skills and knowledge	The students ● are aware of correlations between composition, structures and properties of functional materials ● acquire skills to predict the properties of chemical compounds, based on their composition and structures ● gain competence to evaluate the potential of functional materials for future technological developments ● will know how to measure the properties of these materials.
Content	● luminescent materials [5] ● pigments [3] ● ion conductors [3] ● magnetic/data storage materials [3] ● thermoelectric materials [2] ● catalysts [4] ● hard materials [2]
Requirements for credits	1 written examination, 90 min.
Media and methods	blackboard, beamer presentation occasionally
Literature	● A. West, Solid State Chemistry and Its Applications ● L. Smart, E. Moore, Solid State Chemistry ● Scripts Solid State Chemistry and Chemistry I and II
Further information	-

Lecture type and hours:

type	*SWS*	*Group size*
lectures	3	24
tutorial	1	24

Work load (hours):

	Presence time	*Self-study*	*Total*
lectures	45	40	85
tutorial	15	30	45
homework		50	50
			180

<table>
<tr><td>Module description</td><td>Porous Materials</td></tr>
<tr><td>Signature</td><td>MaMawi-41-18, MaPhy-41-08, MaPhy-42-08, MaAFM-41-18</td></tr>
<tr><td>Semester and recurrence</td><td>2nd semester (each summer term)</td></tr>
<tr><td>Responsible for module</td><td>Prof. Dr. Volkmer</td></tr>
<tr><td>Lecturer</td><td>Prof. Dr. Volkmer</td></tr>
<tr><td>Language</td><td>English</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materials Science (elective module); Master Advanced Functional Materials (elective module); Master Physics with minor subject Chemistry (elective module)</td></tr>
<tr><td>Lecture type and hours</td><td><table>
<tr><td>Type</td><td>SWS</td><td>Group size</td></tr>
<tr><td>lectures</td><td>3</td><td>20-30</td></tr>
<tr><td>tutorial</td><td>1</td><td>20-30</td></tr>
</table></td></tr>
<tr><td>Work load
(hours)</td><td><table>
<tr><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr>
<tr><td>lectures</td><td>45</td><td>30</td><td>75</td></tr>
<tr><td>tutorial</td><td>15</td><td>60</td><td>75</td></tr>
<tr><td>homework</td><td></td><td>30</td><td>30</td></tr>
<tr><td></td><td></td><td></td><td>180</td></tr>
</table></td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc. to the regulations of study</td><td>none</td></tr>
<tr><td>Recommended prerequisites</td><td>Participation in the Course Materials Chemistry: MaPhy-41-04, MaPhy-42-06, MaMawi-13-01, MaAFM-13-01.</td></tr>
<tr><td>Acquired skills and knowledge</td><td>● The students shall acquire knowledge about design principles and synthesis of porous functional materials
● Broaden their capabilities to characterize porous solid state materials with special emphasis laid upon sorption and thermal analysis
● become introduced into typical technical applications of porous solids</td></tr>
<tr><td>Content</td><td>[double hours]

1. Overview and historical developments [1]
2. Structural families of porous frameworks [2]
3. Structure Determination and Computer Modelling [3]
4. Synthesis strategies [2]
5. Adsorption and diffusion [3]
6. Thermal analysis methods [3]
7. Catalytic properties [3]
8. Advanced applications and current trends [1]</td></tr>
<tr><td>Requirements for credits</td><td>1 written examination, 90 min</td></tr>
<tr><td>Media and methods</td><td>Beamer presentation, blackboard (occasionally)</td></tr>
<tr><td>Literature</td><td>• Paul A. Wright, Microporous Framework Solids
(RSC Materials Monographs, 2008)

As well as selected reviews and journal articles cited on the slides</td></tr>
<tr><td>Further information</td><td>Subsequent to the lecture course, the students can take part in a hands-on method course („Solid State Synthesis”, MaMawi-24-09, MaAFM-24-09) to practice their knowledge</td></tr>
</table>

Module description	**Superconductivity**
Signature	MaMawi-41-19, MaAFM-41-19, MaPhy-24-18
Semester and recurrence	2nd or 3rd Semester / every 2nd year
Responsible for module	Priv.- Doz. Dr. R. Tidecks
Lecturer	Priv.- Doz. Dr. R. Tidecks
Language	English
Curriculum inclosures	Master Materials Science (elective module), Master AFM (elective module), Master Physics (elective module)
Lecture type and hours	*Type* / *SWS* / *Group size* Lecture / 4 / 40-50 Exercises / none / -
Work load (hours)	*Presence time* / *Self-study* / *Total* Lecture: 60 / 75 / 135 Exercises: - / - / - Exam: / 45 / 45 Total: 180
Credit points	6
Prerequisites acc. to the regulations of study	None
Recommended prerequisites	Physik IV – Solid-state physics, Theoretical physics I-III
Acquired skills and knowledge	● The students will get an introduction to superconductivity. ● By a presentation of experimental results they will learn the fundamental properties of the superconducting state. ● Special attention will be drawn to the basic concepts of the main phenomenological and microscopic theories of the superconducting state, to explain the experimental observations. ● The students are informed about the most important technical applications of superconductivity. ● For self-studies a comprehensive list of further reading will be supplied.
Content	0. Introductory Remarks and Literature[1] 1. History and Main Properties of the Superconducting State, an Overview [1] 2. Phenomenological Thermodynamics and Electrodynamics of the SC [4] 3. Ginzburg-Landau Theory [4] 4. Microscopic Theories[4] 5. Fundamental Experiments on the Nature of the Superconducting State [3] 6. Josephson-Effects [4] 7. High Temperature Superconductors [5] 8. Application of Superconductivity [4]
Requirements for credits	Oral examination, 20-30 min.
Media and methods	Handwritten lecture at the overhead projector, occasional use of transparencies
Literature	7. W. Buckel, Supraleitung, 5. Auflage (VCH, Weinheim, 1994) 8. W. Buckel und R. Kleiner, Superconductivity, 2nd edition (WILEY-VCH, Berlin, 2004) 9. M. Tinkham, Introduction to Superconductivity, 2nd edition (McGraw-Hill, Inc., New York, 1996, Reprint by Dover Publications Inc. Miniola , 2004) 10. A list of further literature will be given in the lecture.
Further information	-

<table>
<tr><td>Modul description</td><td>Sustainable Resource Management</td></tr>
<tr><td>Signature</td><td>MaMawi-41-20</td></tr>
<tr><td>Semester and recurrence</td><td>2^{nd} and 4^{th} Semester / every year in summer term</td></tr>
<tr><td>Responsible for module</td><td>Prof. Dr. Rathgeber / Prof. Dr. Reller</td></tr>
<tr><td>Lecturers</td><td>Dr. Meissner / Philipp Mette / Prof. Dr. Rathgeber /
Prof. Dr. Reller / Dr. Thorenz</td></tr>
<tr><td>Language</td><td>German</td></tr>
<tr><td>Curriculum inclosures</td><td>Master Materials Science (elective module)</td></tr>
<tr><td>Lecture type and hours</td><td><table>
<tr><td>Type</td><td>SWS</td><td>Group size</td></tr>
<tr><td>lecture</td><td>2</td><td>30</td></tr>
<tr><td>exercise</td><td>2</td><td>30</td></tr>
</table></td></tr>
<tr><td>Work load
(hours)</td><td><table>
<tr><td></td><td>Presence time</td><td>Self-study</td><td>Total</td></tr>
<tr><td>lecture</td><td>20</td><td>20</td><td>40</td></tr>
<tr><td>exercise</td><td>20</td><td>80</td><td>100</td></tr>
<tr><td>written exa-
men</td><td></td><td>40</td><td>40</td></tr>
<tr><td></td><td></td><td></td><td>180</td></tr>
</table></td></tr>
<tr><td>Credit points</td><td>6</td></tr>
<tr><td>Prerequisites acc.to the regulations of study</td><td>None</td></tr>
<tr><td>Recommended prerequi-
sites</td><td>None</td></tr>
<tr><td>Acquired skills and know-
ledge</td><td>The students know the basics of geographic distribution and the technical relevancy of different resources like energy sources and metals. Furthermore, the students know risk management methods, which are used to identify, measure and manage resource price risks. For this purpose, resource scarcity indicators, risk measures and instruments for risk protection are being presented, which enable the students to make economically well-grounded decisions in dealing with resources. Moreover, the students know how resource-based strategies with the help of environmental management contribute to environmental risk management. All topics are being illustrated with examples (from practical projects).</td></tr>
<tr><td>Content</td><td>- Introduction (global resource consumption)
- Overview of resource types
- Definition of mineral resources
- Introduction to resource management
- Identification of resource price risks
- Measurement of resource price risks
- Management of resource price risks
- Introduction in basics of environmental management
- Corporate environmental management
- Economical closed-loop systems</td></tr>
<tr><td>Requirements for credits</td><td>One written exam, 60 min, and practise sheets</td></tr>
<tr><td>Media and methods</td><td>Slides/blackboard with the help of other media</td></tr>
<tr><td>Literature</td><td>- Holger Rogall: Nachhaltige Ökonomie, Metropolis, Marburg, 2009.
- Hans-Dieter Haas, Dieter Matthew Schlesinger: Umweltökonomie und Ressourcenmanagement, Wissenschaftliche Buchgesellschaft, Darmstadt, 2007.
- Colin W. Clark: Mathematical Bioeconomics, Wiley, New York, 1976.
- Werner Gocht: Handbuch der Metallmärkte, 2. Aufl., Springer, New York / Tokyo, 1985.</td></tr>
<tr><td>Further information</td><td></td></tr>
</table>

Modul description	**Practical Laboratory Project**				
Signature	MaMawi-42-01, MaAFM-42-01				
Semester and recurrence	3rd or 4th semester / each semester				
Responsible for module	Chairman of Examination Board				
Lecturer	All Lecturers and Professors of the Institute of Physics				
language	English / German				
Curriculum inclosures	Master Materials Science; Master Advanced Functional Materials				
Lecture type and hours	*type*	*SWS*	*Group size*		
	lectures	N/A	N/A		
	tutorial	N/A	N/A		
	Practical course	N/A	N/A		
Work load (hours)		*Presence time*	*Self-study*	*Total*	
	lectures				
	tutorial				
	Practical course	180		180	
	examination				
				180	
Credit points	6				
Prerequisites acc. to the regulations of study					
Recommended prerequisites	Solid knowledge in (solid state) Physics, Chemistry and Materials Science, both experimentally and theoretically				
Acquired skills and knowledge	The students ● know the basic terms, skills and concepts to pursuit a real research project in the existing laboratories within the research groups, ● experience the day to day life in a research group from within ● prepare themselves to conduct a research project during their Masters thesis.				
Content	Experimental or theoretical work in a laboratory / research group in the Institute of Physics. Has to be conducted within 3 months.				
Requirements for credits	1 written report, editing time 2 weeks				
Media and methods	Face to face tutoring				
Literature	● various				
Further information	-				

5. Final Thesis and Colloquium

(1) The finals are part of the Master's examination and are ment to show that the candidate is in a position to solve a problem from the program independently according to scientific methods. The finals consist of the the written thesis and a colloquium in the form of an oral examination after submitting the thesis. For the thesis, 26 credit points are awarded and for the final colloquium 4 points.

(2) The processing time for the thesis between reception of the topic and submission of the thesis shall not exceed 6 months. The topic can be returned only once and only for good reasons within a period of four weeks after the issue of the topic. Consent of the Chairperson of the Examination Committee is required. If the thesis work needs to be redone, a change of the topic is not admitted.

(3) At the request of the candidate, and in exceptional cases, the processing time may be extended by a maximum of eight weeks. Again, the consent of the committee is required. Periods of medical disability (Doctor’s testimony), or such for which the candidate cannot be held responsible, should be not counted towards the processing time. Here, too, the decision is with the examination board. Master thesis not being submitted in time will be assessed with "not sufficient".

(4) Working on the Masters thesis can only be started after the successful acquisition of at least 60 credit points from the module area 1 thru 5.

(5) The master's thesis should be written in English. Exceptions can only be given after consultation and decision of the examination board.

(6) The final colloquium is usually held during a period of four to six weeks after submitting the thesis. Subjects of the colloquium are the basic content of the courses in the Master program "Advanced Functional Materials well as the written thesis. The duration of the colloquium should not be less than 45 minutes and not exceeding 75 minutes. The colloquium starts with a presentation of approximately 15 minutes duration on the contents of the final work. A colloquium graded "insufficient" can be repeated within six months.

(7) A final Masters thesis graded with an "insufficient" may be repeated once. In this case, the topic has to be modified with respect to the original one.