Universität Augsburg
Mathematisch-Naturwissenschaftliche Fakultät

Handbook of modules

for the

Master of Science program Materials Science

Summer term 2013

As from: 11th January 2013

Chairman of Examinations Board
Prof. Dr. Dirk Volkmer
Institute of Physics
Augsburg University
Universitaetsstrasse 1
D-86135 Augsburg / GERMANY

Contents

Part I

Objectives and Profile of the Program

Priorities in the activity of the materials scientist are applied research in science and technology, the development of modern materials, supervision of production processes, and the technical distribution of materials. Also, the program aims towards well trained graduates to perform organizational, planning and management duties in research institutes, industry and public administration.
The structure of typical operational areas of material scientists requires a broad knowledge and education in natural sciences that will enable him / her to solve new and not yet resolved problems of applied research and technology.
A solid background in the manufacture and processing, characterization, development and use of new materials is a key parameter in the education. In addition to good knowledge of the physical and chemical principles, materials scientists have to have a profound background of the various classes of materials and must be well acquainted with the fundamentals and problems of materials technology. For this purpose he / she must have a thorough knowledge of various processing, fabrication and analysis methods and has to be able to recognize the essentials.
The Masters degree in Materials Science is meant to supplement the Bachelor's degree in the form of an in-depth recessment to achieve a second professional and qualifying status, and provides the opportunity to work and excel in an experimental environment, general materials science, and selected specialty areas. It provides important practice skills to pursue academic work in industrial or governmental research and development.
The Masters degree provides a professional and qualifying education in material science, usually based upon a successful Bachelor's degree. Holding a Master's degree, it is secured that the candidate is in power of an enhanced expertise in material sciences and has the ability, by using modern scientific methods to tackle Materials Science problems independently and efficiently.

The master program consists of the following module groups. The respective Credit Points (CP) and the respective number of hours per week (SWS) are indicated. Note: 1 SWS has a duration of 45 minutes.

Module group		hrs per week	CP
1	Basics of Materials Science	16	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 adapted to 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 an ongoing 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.

Part 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/

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

Part III

List of modules

1 Basics of Materials Science

MaMawi-11-01	
1. Module title	Materials Physics I
2. Module group/s	Basics of Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Helmut Karl
5. Content	IA. Preliminaries IB. Electrons in solids - Free Electron Gas - Reciprocal Lattice - Band Structure IC. Phonons - Lattice Vibrations ID. General Properties of Materials - Electrical Conductivity - Thermal Properties - 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
6. Acquired skills and knowledge	The students: • know the basic terms of solid state and semi-conductor physics like electrical band structure, doping, charge carrier statistics or optical properties, • are capable to apply derived approximations as the effective mass or quasi Fermi-levels to describe the basic characteristics of semi-conductive materials, • have the competence to apply these concepts for the description of semi-conducting 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.

7. Curriculum inclosures	MaAFM-11-01 / Master Advanced Functional Materials MaMawi-11-01 / Master Materialwissenschaften
8. Recommended semester	1st semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung 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
17. Application	none
18. Further information	**COMPULSORY MODULE**

No courses are provided for this module in the current term

MaMawi-12-01

1. Module title	Materials Physics II
2. Module group/s	Basics of Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Helmut Karl
5. Content	1. Magnetic materials [4] a) Magnetization b) Atomic origin of magnetic moments c) Paramagnetism d) Ferromagnetism e) Anisotropy f) Ferromagnetic materials, hard and soft magnets g) Magnetooptics 2. Superconductivity [4] a) Basic phenomena b) Meissner effect c) Energy gap d) London equation e) Basic ideas of the BCS theory, Cooper pairs f) Type I/II superconductors g) High temperature superconducting materials, flux pinning 3. Thermodynamics of materials [7] a) Review of basic terms b) Equilibrium conditions c) Phase diagrams d) Multiphase-multicomponent equilibria e) Thermodynamics of point defects f) Thermodynamics of interfaces 4. Thermal Properties [4] a) Specific Heat b) Thermal Expansion c) Thermal Transport d) Thermal Radiation e) Thermoelectricity 5. Atomic transport[3] a) Diffusion b) Electro-, thermo-, stress migration
6. Acquired skills and knowledge	The students: • know the physical and chemical fundamentals and the different resulting material properties, • are able to characterize Materials according to their magnetic, thermal, and transportation properties, and to do correspondent calculations using simple models, • have the competence to deal extensively autonomous with scientific problems of the above mentioned areas. • Integrated acquirement of soft skills.
7. Curriculum inclosures	MaAFM-12-01 / Master Advanced Functional Materials MaMawi-12-01 / Master Materialwissenschaften MaPhy-42-02 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours

12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard (occasionally)
17. Application	none
18. Further information	**COMPULSORY MODULE**

The following courses are provided for this module in the current term:

Materials Physics II (see page 104)	3 hours of workload per week
Materials Physics II (Tutorial) (see page 105)	1 hours of workload per week

MaMawi-13-01

1. Module title	Materials Chemistry
2. Module group/s	Basics of Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Dirk Volkmer
5. Content	A) • 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] B) Selected classes of functional materials • Bioinorganic chemistry [2] • Coordination compounds in medical applications [1] • Coordination polymers / metal-organic frameworks [4] • Cluster compounds [2]
6. 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 materials sciences. • Integrated acquirement of soft skills.
7. Curriculum inclosures	MaAFM-13-01 / Master Advanced Functional Materials MaMawi-13-01 / Master Materialwissenschaften MaPhy-41-04 / Master Physik MaPhy-42-06 / Master Physik
8. Recommended semester	1st semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: the lecture course is based on the courses Chemistry I and Chemistry II.
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard (occasionally)
17. Application	none
18. Further information	**COMPULSORY MODULE**

No courses are provided for this module in the current term

MaMawi-14-01

1. Module title	Physics of Surfaces and Interfaces
2. Module group/s	Basics of Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Siegfried Horn
5. Content	1. Introduction [1] - The importance of surfaces and interfaces 2.Some basic facts from solid state physics [3] - Crystal lattice and reciprocal lattice - Electronic structure of solids - Lattice dynamics 3. Physics at surfaces and interfaces [14] - Structure of ideal and real surfaces - Relaxation and reconstruction - Transport (diffusion, electronic) on interfaces - Thermodynamics of interfaces - Electronic structure of surfaces - Chemical reactions on solid state surfaces (catalysis) - Interface dominated materials (nano scale materials) 4. Methods to study chemical composition and electronic structure, application examples [4] - Scanning electron microscopy - Scanning tunneling and scanning force microscopy - Auger – electron – spectroscopy - Photo electron spectroscopy
6. Acquired skills and knowledge	The students: • have knowledge of the structure, the electronical properties, the thermodynamics, and the chemical reactions on surfaces and interfaces, • acquire the skill to solve problems of fundamental research and applied sciences in the field of surface and interface physics, • have the competence to solve certain problems autonomously based on the thought physical basics. • Integrated acquirement of soft skills.
7. Curriculum inclosures	MaAFM-14-01 / Master Advanced Functional Materials MaMawi-14-01 / Master Materialwissenschaften MaPhy-42-03 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: The module ”Physics IV - Solid State Physics” should be completed first.
13. Credit points	5

14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung
17. Application	none
18. Further information	**COMPULSORY MODULE**

The following courses are provided for this module in the current term:

Physics of Surfaces and Interfaces (see page 122)	3 hours of workload per week
Physics of Surfaces and Interfaces (Tutorial) (see page 123)	1 hours of workload per week

2 Methods in Materials Science

MaMawi-21-01

1. Module title	Characterization of Materials
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Klaus Ruhland
5. Content	1. X-ray diffraction [2] 2. Mechanical characterization [2] 3. Optical methods [2] 4. Electrical measurements and characterization [2] 5. NMR spectroscopy [2] 6. Spectroscopy using synchrotron radiation[2] 7. Thermal analysis [2] 8. Ion beam methods [2] 9. Charakterization of organic systems [2] 10. Electron microscopy [2]
6. Acquired skills and knowledge	Basic characterization methods will be introduced to the students in a lecture series with a workload of 4 hrs each. The students: • know the basic characterization methods of materials science, • acquire knowledge how to apply these methods, • acquire the competence to use these techniques for the analysis of structural, chemical, electronical, magnetical, and optical properties of materials.
7. Curriculum inclosures	MaAFM-21-01 / Master Advanced Functional Materials MaMawi-21-01 / Master Materialwissenschaften
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 60 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: Basic knowledge in Materials Science
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung Media and methods: Transparencies / blackboard with additional media Self-study
17. Application	none
18. Further information	**COMPULSARY MODULE**

No courses are provided for this module in the current term

MaMawi-22-01	
1. Module title	Processing of Materials
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Ferdinand Haider
5. Content	1. Processing of polymers 2. Processing of thin films 3. Processing of semiconductors 4. Processing of composites 5. Processing of metals and alloys
6. Acquired skills and knowledge	The students: • know the most important methods of processing and treatment of materials for different material classes; semiconductors, thin film materials, polymers, metals, and composite materials, • handle besides industrial processes also methods which are so far realized rather on bench scale, and • have the competence to deal autonomously with current problems of the above mentioned subject areas. • Integrated acquirement of soft skills.
7. Curriculum inclosures	MaAFM-22-01 / Master Advanced Functional Materials MaMawi-22-01 / Master Materialwissenschaften MaPhy-42-05 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: Good knowledge of basics of Materials Science
13. Credit points	5
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung Media and methods: Beamer presentation
17. Application	none
18. Further information	**COMPULSORY MODULE**

The following courses are provided for this module in the current term:

Processing of Materials (see page 127)	3 hours of workload per week

MaMawi-23-01

1. Module title	Theoretical Concepts and Simulation
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Dr. Michael Dzierzawa
5. Content	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
6. Acquired skills and knowledge	The students: • know the principal concepts of thermodynamics and statistical physics as well as the numerical methods relevant in material science, • are able to solve simple problems numerically. They are able to write the codes and to present the results, • have the expertise to find the numerical method appropriate 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 software while using English documentations, ability to investigate abstract circumstances with the help of a computer and present the results in written and oral form, capacity for teamwork.
7. Curriculum inclosures	MaAFM-23-01 / Master Advanced Functional Materials MaMawi-23-01 / Master Materialwissenschaften
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: basic knowledge of quantum mechanics, thermodynamics, and numerical methods as well as of a programming language
13. Credit points	6
14. Requirements for credits	Seminar talk with discussion Project work in small groups, including a written summary of the results (ca. 10-20 pages) as well as an oral presentation
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum Media and methods: Blackboard presentation, occasionally supplemented by beamer or overhead presentations; in the project work with a computer in order to numerically implement a given concrete problem.
17. Application	none

18. Further information	**COMPULSORY MODULE** Links to software related to the course: • http://www.bloodshed.net/ • http://www.cplusplus.com/doc/tutorial/ • http://www.cygwin.com/ • http://xmd.sourceforge.net/download.html • http://www.rasmol.org/ • http://felt.sourceforge.net/

The following courses are provided for this module in the current term:

Theoretical Concepts and Simulation (see page 131)	3 hours of workload per week
Theoretical Concepts and Simulation (Project) (see page 132)	1 hours of workload per week

MaMawi-24-02

1. Module title	Method Course: Electron Microscopy
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Ferdinand Haider
5. Content	1. Scanning electron microscopy (SEM) 2. Transmission electron microscopy (TEM)
6. Acquired skills and knowledge	The students: • get introduced to the basics of scanning electron microscopy and transmission electron microscopy, using lectures to teach the theoretical basics, which are afterwards deepened using practical courses, • are able to characterize materials using different electron microscopy techniques and to decide, if the technique is feasible for a certain problem.
7. Curriculum inclosures	MaAFM-24-02 / Master Advanced Functional Materials MaMawi-24-02 / Master Materialwissenschaften
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 72 hours / self-study: 146 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: knowledge of solid-state physics, reciprocal lattice
13. Credit points	8
14. Requirements for credits	Written report (one report per group)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum
17. Application	none
18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Method Course: Electron Microscopy (see page 107)	6 hours of workload per week
Method Course: Electron Microscopy (Practical Course) (see page 108)	—

MaMawi-24-04

1. Module title	Method Course: Electronics for Physicists and Material Scientists
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Dr. Andreas Hörner
5. Content	1. Basics in electronic and electrical engineering [4] 2. Quadrupole theory [2] 3. Analog technique, transistor and opamp circuits [5] 4. Boolean algebra and 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]
6. Acquired skills and knowledge	The students: • know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the laboratory, • 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.
7. Curriculum inclosures	MaAFM-24-04 / Master Advanced Functional Materials MaMawi-24-04 / Master Materialwissenschaften
8. Recommended semester	1st semester
9. Duration of module	1 semester
10. Recurrence of module	every semester
11. Work load (total)	compulsory attendance: 100 hours / self-study: 140 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	8
14. Requirements for credits	oral examination (30 minutes) written report (one per group)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum, Übung Media and methods: Lectures: slides/blackboard talk with help of other media and experiments Tutorial: practical circuit design Self-study
17. Application	none

18. Further information	**ELECTIVE MODULE** 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.**

The following courses are provided for this module in the current term:

Method Course: Electronics for Physicists and Materials Scientists (see page 109)	3 hours of workload per week
Method Course: Electronics for Physicists and Materials Scientists (Practical Course) (see page 110)	3 hours of workload per week
Method Course: Electronics for Physicists and Materials Scientists (Tutorial) (see page 111)	1 hours of workload per week

MaMawi-24-05

1. Module title	Method Course: Materials Synthesis
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Wolfgang Scherer
5. Content	Content of the practical course and the lecture are the theoretical basics, the synthesis and characterization of the following functional materials: 1. Organic polymers [4+2] 2. Zeolites and mesoporous materials [4+2] 3. Porous coordination polymers [4+2] 4. Ionic liquids [4+2] 5. Bio materials [4+2] 6. Oxides „sol-gel processing and ceramic methods" [4+2] 7. Lower dimensional structure materials [4+2] 8. Ferrofluides [2+1]
6. Acquired skills and knowledge	The students: • gain basic practical knowledge about chemical materials synthesis and analytical methods (e.g. ICP / EA / REM-EDX), including the characterization via X-ray diffraction and spectroscopic techniques (e.g. IR / NMR) as well as physical methods (e.g. thermoelectric properties, magnetism), • possess the ability to perform materials syntheses under instruction, • are able to choose the appropriate characterization method for certain materials.
7. Curriculum inclosures	MaAFM-24-05 / Master Advanced Functional Materials MaMawi-24-05 / Master Materialwissenschaften
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 90 hours / self-study: 150 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: the practical course is based on the modules Chemistry I, Chemistry II, Chemi-stry III and the practical course in physical chemistry
13. Credit points	8
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum Media and methods: Beamer presentation, blackboard, handouts
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-24-06	
1. Module title	Method Course: Methods in Biophysics
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Stefan Thalhammer
5. Content	1. Unit radiation biophysics - Concepts in radiation protection - Low-dose irradiation biophysics - DNA repair dynamics of living cells after ionizing radiation - Confocal scanning laser microscopy 2. Unit microfluidic - Microfluidic systems - Accoustic driven microfluidics - Calculation of microfluidic problems 3. Unit analysis
6. Acquired skills and knowledge	The students: • know basic terms, concepts and phenomena in radiation biophysics, • acquire basic knowledge of fluidic and biophysical phenomena on small length scales and applications and technologies of microfluidic analytical systems, • learn skills in tissue culture and immun-histochemical staining procedures, • learn skills in fluorescence and confocal scanning microscopy, • learn skills to calculate fluidic problems on small length scales, • learn skills to handle microfluidic channel systems.
7. Curriculum inclosures	MaAFM-24-06 / Master Advanced Functional Materials MaMawi-24-06 / Master Materialwissenschaften
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	upon request
11. Work load (total)	compulsory attendance: 85 hours / self-study: 95 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: attendance of the lecture Biophysics and Biomaterials
13. Credit points	8
14. Requirements for credits	written lab report
15. Examination	General examination for module
16. Teaching methods	Praktikum Media and methods: Intensive mentoring in small groups Self-study
17. Application	none
18. Further information	**ELECTIVE MODULE** The course will partly take place at the Helmholtz Center Munich. Practical course requires attendance of the Biophysics Lecture!

No courses are provided for this module in the current term

MaMawi-24-07

1. Module title	Method Course: Optical Properties of Solids
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Alois Loidl
5. Content	1. Electrodynamics of solids [24] - Maxwell equations - Electromagnetic waves - Refraction and Interference, Fresnel equations 2. FTIR spectroscopy [30] - Fourier transformation - Michelson-Morley and Genzel interferometer - Sources and detectors 3. Submillimeter spectroscopy (12) - Mach-Zehnder interferometer - Backward-wave oscillators and detectors 4. Terahertz Time Domain spectroscopy (12) - Generation of pulsed THz radiation - Gated detection, Austin switches 5. Elementary excitations in solids (12) - Infrared-active phonons - Magnetic-dipole excitations - Crystal-field excitations
6. 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.
7. Curriculum inclosures	MaAFM-24-07 / Master Advanced Functional Materials MaMawi-24-07 / Master Materialwissenschaften
8. Recommended semester	1st and 2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every semester
11. Work load (total)	compulsory attendance: 90 hours / self-study: 150 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: basic knowledge in solid-state physics, basic knowledge in electrodynamics and optics
13. Credit points	8
14. Requirements for credits	Seminar talk with discussion (20 minutes) Written homework, written report on the experiments (editing time 3 weeks, max. 30 pages)

15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum Media and methods: Projector, slides, blackboard, web resources, exercises, teamwork, students' presentations
17. Application	none
18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Method Course: Optical Properties of Solids (see page 115)	2 hours of workload per week
Method Course: Optical Properties of Solids (Practical Course) (see page 116)	4 hours of workload per week

MaMawi-24-09

1. Module title	Method Course: Spectroscopy on Condensed Matter
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Alois Loidl
5. Content	1. Dielectric Spectroscopy [8] - Methods - Cryo-techniques - Measurement quantities - Relaxation processes - Dielectric phenomena 2. Ferroelectric Materials [7] - Mechanism of ferroelectric polarization - Hysteresis loop measurements - Dielectric spectroscopy 3. Glassy Matter [8] - Introduction - Glassy Phenomena - Dielectric Spectroscopy 4. Multiferroic Materials [7] - Introduction - Microscopic origins of multiferroicity - Pyrocurrent measurements - Dielectric Spectroscopy
6. 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, including analysis of measurement results and their interpretation in the framework of models and theories.
7. Curriculum inclosures	MaAFM-24-09 / Master Advanced Functional Materials MaMawi-24-09 / Master Materialwissenschaften
8. Recommended semester	1st and 2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every semester
11. Work load (total)	compulsory attendance: 92 hours / self-study: 114 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: basic knowledge in solid state physics, basic knowledge in physics of glasses and supercooled liquids
13. Credit points	8
14. Requirements for credits	written examination (120 minutes) written report on the experiments (editing time 2 weeks)
15. Examination	General examination for module

16. Teaching methods	Vorlesung, Praktikum Media and methods: Slides/blackboard talk with help of other media and experiments self-study
17. Application	none
18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Method Course: Spectroscopy on Condensed Matter (see page 117)	2 hours of workload per week
Method Course: Spectroscopy on Condensed Matter (Practical Course) (see page 118)	4 hours of workload per week

MaMawi-24-11

1. Module title	Method Course: Thin Film Analysis with Ion Beams
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Helmut Karl
5. Content	1. Introduction to ion beam analysis techniques and concepts 2. Rutherford backscattering spectroscopy 3. Theory of particle scattering and cross-section 4. Experimental setup 5. Dynamic secondary ion mass spectroscopy (SIMS) 6. Simulation and data evaluation of Rutherford backscattering spectrometry (RBS) experiments
6. 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.
7. Curriculum inclosures	MaAFM-24-11 / Master Advanced Functional Materials MaMawi-24-11 / Master Materialwissenschaften
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every year
11. Work load (total)	compulsory attendance: 90 hours / self-study: 150 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: solid knowledge in solid state and experimental physics
13. Credit points	8
14. Requirements for credits	Seminar talk with discussion 1 written report
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum
17. Application	none
18. Further information	**ELECTIVE MODULE** Experimental work in the laboratory in the Institute of Physics has to be conducted within 3 months.

No courses are provided for this module in the current term

MaMawi-24-12

1. Module title	Method Course: X-ray and Neutron Diffraction Techniques
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Wolfgang Scherer
5. Content	Subjects of the practical training and the accompanying lecture are the theoretical basics and the practical application of X-ray and neutron diffraction techniques: 1. Basic introduction to X-ray and neutron crystallography [4+2] 2. X-ray/neutron scattering [4+2] 3. Data collection and reduction techniques [4+2] 4. Symmetry and space group determination [4+2] 5. Structural refinements: - The Rietveld method - Difference Fourier synthesis [4+2] 6. Structure determination: - Patterson method - Direct methods [4+2] 7. Interpretation of structural refinement results [4+2] 8. Electronic structure determination and analysis [2+1]
6. Acquired skills and knowledge	The students: • gain basic practical knowledge on structural characterization methods for single-crystalline and powder samples employing X-ray and neutron diffraction techniques, • have the skill to, under guidance, perform phase-analyses and structure determinations, • are competent to analyze the structure-property relationships of new materials.
7. Curriculum inclosures	MaAFM-24-12 / Master Advanced Functional Materials MaMawi-24-12 / Master Materialwissenschaften
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 90 hours / self-study: 150 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: the practical course is based on the module “Chemisch-Physikalisches Praktikum für Materialwissenschaftler”.
13. Credit points	8
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum Media and methods: Beamer presentation, blackboard, handouts
17. Application	none

18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-24-13

1. Module title	Method Course: Coordination Materials
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Dirk Volkmer
5. Content	1. Synthesis of metal complexes: 2. analytical characterization of metal complexes (thermal analysis, UV/vis spectroscopy, cyclic voltammetry, X-ray diffraction) 3. Functional coordination materials (spin-crossover materials, information storage materials) 4. Catalysis (oxidation reactions)
6. Acquired skills and knowledge	The students will learn how to: • prepare transition metal complexes employing modern preparation techniques (e.g. microwave synthesis) and inert conditions (Schlenk technique), • characterize coordination compounds by selected analytical techniques, • develop functional coordination materials based on organic / inorganic hybrid compounds, • screen metal complexes in catalytic reactions, • employ X-ray diffraction methods for structural analysis.
7. Curriculum inclosures	MaAFM-24-13 / Master Advanced Functional Materials MaMawi-24-13 / Master Materialwissenschaften
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 120 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	8
14. Requirements for credits	Seminar talk with discussion written report (protocols)
15. Examination	General examination for module
16. Teaching methods	Praktikum, Seminar Media and methods: presentation, publications, self-study
17. Application	none
18. Further information	**ELECTIVE MODULE** upon request

No courses are provided for this module in the current term

MaMawi-24-15

1. Module title	Method Course: Characterization of Porous Materials
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Dirk Volkmer
5. Content	1. Synthesis of porous functional materials (e.g. Metal-Organic Frameworks, Zeolites) 2. Characterization methods - Thermal analysis (TGA, EGA) - Structure determination (XRD, VTXRPD) - Absorption and diffusion (BET, BET isotherms) - Catalytic properties (UV/VIS, TPO, TPR) - Computational Modeling (calculation and predictions of framework structures)
6. 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.
7. Curriculum inclosures	MaAFM-24-15 / Master Advanced Functional Materials MaMawi-24-15 / Master Materialwissenschaften
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 120 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: lecture Porous Materials (MaMawi-41-18, MaAFM-41-18)
13. Credit points	8
14. Requirements for credits	written examination (45 minutes) written report (editing time 1 week)
15. Examination	General examination for module
16. Teaching methods	Praktikum Media and methods: Slices / blackboard, face to face tutorial, self-study
17. Application	none
18. Further information	**ELECTIVE MODULE** Further information upon request

The following courses are provided for this module in the current term:

Method Course: Characterization of Porous Materials (Practical Course) (see page 106)	4 hours of workload per week

MaMawi-24-16

1. Module title	Method Course: Modern Solid State NMR Spectroscopy
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Leo van Wüllen
5. Content	1. Physical foundations of NMR spectroscopy [6] 2. Internal interactions in NMR spectroscopy [6] - Chemical shift interaction - Dipole interaction and - Quadrupolar interaction 3. Magic Angle Spinning techniques [4] 4. Modern applications of NMR in materials science [14] 5. Experimental work at the Solid-State NMR spectrometers, computer-aided analysis and interpretation of acquired data [60]
6. Acquired skills and knowledge	The students: • gain basic knowledge of the physical foundations of modern Solid-State NMR spectroscopy, • gain basic practical knowledge of operating a solid-state NMR spectrometer, • can – under guidance – plan, perform, and analyze modern solid-state NMR experiments for the structural characterization of advanced materials.
7. Curriculum inclosures	MaAFM-24-16 / Master Advanced Functional Materials MaMawi-24-16 / Master Materialwissenschaften
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every semester
11. Work load (total)	compulsory attendance: 90 hours / self-study: 150 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	8
14. Requirements for credits	written examination (90 minutes) written report on the experiments (editing time approx. 2 weeks)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum Media and methods: Beamer presentation, blackboard, handouts
17. Application	none
18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Method Course: Modern Solid State NMR Spectroscopy (see page 113)	2 hours of workload per week
Method Course: Modern Solid State NMR Spectroscopy (Practical Course) (see page 114)	4 hours of workload per week

MaMawi-24-17

1. Module title	Method Course: Functional Silicate-analogous Materials
2. Module group/s	Methods in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Henning Höppe
5. Content	Synthesis and characterization of functional materials according to the topics: 1. Silicate-analogous compounds 2. Luminescent materials / phosphors 3. Pigments 4. Characterization methods: XRD, spectroscopy (luminescence, UV/vis, FT-IR), thermal analysis
6. Acquired skills and knowledge	The students will know how to: • develop functional materials based on silicate-analogous materials, • apply classical and modern preparation techniques (e.g. solid state reaction, sol-gel reaction, precipitation, autoclave reactions, use of silica ampoules), • work under non-ambient atmospheres (e.g. reducing, inert conditions), • solve and refine crystal structures from single-crystal data, • describe and classify these structures properly.
7. Curriculum inclosures	MaAFM-24-17 / Master Advanced Functional Materials MaMawi-24-17 / Master Materialwissenschaften
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every semester
11. Work load (total)	compulsory attendance: 120 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: attendance to the lecture ”Advanced Solid State Materials” (MaMawi-41-17, MaAFM-41-17)
13. Credit points	8
14. Requirements for credits	Seminar talk with discussion written report (protocol)
15. Examination	General examination for module
16. Teaching methods	Praktikum
17. Application	none
18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Method Course: Functional Silicate-analogous Materials (Practical Course) (see page 112)	6 hours of workload per week

3 Materials Science Seminar

MaMawi-31-01

1. Module title	Introduction to Materials
2. Module group/s	Materials Science Seminar
3. Specific field	None
4. Responsible for module	Prof. Dr. Ferdinand Haider
5. Content	Varying topics for each year, giving an overview into scope, application, requirements and preparation of all types of modern materials.
6. Acquired skills and knowledge	The students: • know the major principles, applications and processes of modern materials • acquire the competence to compile knowledge for examples of material specific topics and to present this knowledge in given time to an audience
7. Curriculum inclosures	MaAFM-31-01 / Master Advanced Functional Materials MaMawi-31-01 / Master Materialwissenschaften
8. Recommended semester	1st semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 28 hours / self-study: 80 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: Basic knowledge in materials science
13. Credit points	4
14. Requirements for credits	Presentation with term paper (30 - 45 minutes)
15. Examination	General examination for module
16. Teaching methods	Seminar Media and methods: Powerpoint presentation
17. Application	none
18. Further information	**COMPULSORY MODULE**

No courses are provided for this module in the current term

4 Specialization in Materials Science

MaMawi-41-01	
1. Module title	Physics and Technology of Semiconductor Devices
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Achim Wixforth
5. Content	1. Basic properties of semiconductors (electronic bandstructure, doping, carrier excitations and carrier transport) [10] 2. Semiconductor diodes and transistors [8] 3. Semiconductor technology [4] 4. Optoelectronics [4]
6. Acquired skills and knowledge	• 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 describe the basic properties of semiconductors. • Application of these concepts to describe and understand the operation principles of semiconductor devices such as diodes, transistors, and optically active elements (LEDs, detectors and lasers). • Knowledge of the technologically relevant methods and tools in semiconductor micro- and nanofabrication. • Integrated acquisition of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working.
7. Curriculum inclosures	BaMawi-64-01 / Bachelor Materialwissenschaften MaAFM-41-01 / Master Advanced Functional Materials MaMawi-41-01 / Master Materialwissenschaften MaPhy-24-01 / Master Physik
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: basic knowledge in solid-state physics and quantum mechanics.
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Lecture: slides/blackboard supported by other media and experiments Tutorial: intensive support in small groups Self-study
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-02

1. Module title	Nanostructures / Nanophysics
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Achim Wixforth
5. Content	1. Semiconductor quantum wells, wires and dots, low dimensional electron systems [5] 2. Magnetotransport in low-dimensional systems, Quanten-Hall-Effect, Quantized conductance [5] 3. Optical properties of quantum wells and quantum dots and their application in modern optoelectonic devices [5] 4. Nanowires, Carbon Nanotubes, Graphene [3] 5. Nanophotonics, photonic band gap materials, photonic crystals 6. Emerging concepts such as Quantum Computing and Quantum Information Processing [4]
6. Acquired skills and knowledge	• Basic knowledge oft he fundamental concepts in modern nanoscale science • Profound knowledge of low-dimensional semiconductor structures and how these systems can be applied for novel functional devices for high-frequency electronics and optoelectronics • Knowledge of different fabrication approaches using bottom-up and top-down techniques • Application of these concepts to tackle present problems in nanophysics • Integrated acquirement of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working.
7. Curriculum inclosures	MaAFM-41-02 / Master Advanced Functional Materials MaMawi-41-02 / Master Materialwissenschaften MaPhy-24-02 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: knowledge in quantum mechanics and semiconductor physics.
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Lecture: slides/blackboard supported by other media and experiments Tutorial: intensive support in small groups Self-study
17. Application	none
18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Nanostructures / Nanophysics (see page 119)	3 hours of workload per week
Nanostructures / Nanophysics (Tutorial) (see page 120)	1 hours of workload per week

MaMawi-41-03

1. Module title	Electronics for Physicists and Materials Scientists
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Dr. Andreas Hörner
5. Content	1. Basics in electronic and electrical engineering [4] 2. Quadrupole theory [2] 3. Analog technique, transistor and opamp circuits [5] 4. Boolean algebra and 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]
6. 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. • Integrated acquirement of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working.
7. Curriculum inclosures	BaMawi-64-02 / Bachelor Materialwissenschaften MaAFM-41-03 / Master Advanced Functional Materials MaMawi-41-03 / Master Materialwissenschaften MaPhy-24-03 / Master Physik
8. Recommended semester	1st semester
9. Duration of module	1 semester
10. Recurrence of module	every semester
11. Work load (total)	compulsory attendance: 60 hours / self-study: 130 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	6
14. Requirements for credits	oral examination (30 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Lectures: slides / blackboard talk with help of other media and experiments Tutorial: practical circuit design Self-study
17. Application	none

18. Further information	**ELECTIVE MODULE** 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.**

The following courses are provided for this module in the current term:

Electronics for Physicists and Materials Scientists (see page 100)	3 hours of workload per week
Electronics for Physicists and Materials Scientists (Tutorial) (see page 101)	1 hours of workload per week

MaMawi-41-04

1. Module title	Biophysics and Biomaterials
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Stefan Thalhammer
5. Content	1. Radiation Biophysics a) Radiation sources b) Interaction of radiation with biological matter c) Radiation protection principles d) Low dose radiation e) LNT model in radiation biophysics 2. Microfluidics a) Life at Low Reynolds Numbers b) The Navier-Stokes Equation c) Low Reynolds Numbers – The Stokes Equation d) Breaking the Symmetry 3. Membranes a) Thermodynamics and Fluctuations b) Thermodynamics of Interfaces c) Phase Transitions – 2 state model d) Lipid membranes and biological membranes, membrane elasticity 4. Membranal transport a) Random walk, friction and diffusion b) Transmembranal ionic transport and ion channels c) Electrophysiology of cells d) Neuronal Dynamics
6. Acquired skills and knowledge	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. • Integrated acquirement of soft skills: autonomous working with specialist literature in english, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working.
7. Curriculum inclosures	MaAFM-41-04 / Master Advanced Functional Materials MaMawi-41-04 / Master Materialwissenschaften MaPhy-24-04 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every semester
11. Work load (total)	compulsory attendance: 45 hours / self-study: 80 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: mechanics, thermodynamics, statistical physics, basic knowledge in molecular biology
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module

16. Teaching methods	Vorlesung Media and methods: Lecture: transparencies / blackboard with additional media Tutorial: talks to current problems in biophysics
17. Application	none
18. Further information	**ELECTIVE MODULE** This lecture is part and requirement for the methodical course Methods in Biophysics. Lecture alone will be awarded 6 CP, Method Course 8 CP.

The following courses are provided for this module in the current term:

Biophysics and Biomaterials (see page 95)	4 hours of workload per week

MaMawi-41-05

1. Module title	Solid State Spectroscopy with Synchrotron Radiation
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Christine Kuntscher
5. Content	1. Electromagnetic radiation: description, generation, detection [5] 2. Spectral analysis of electromagnetic radiation: monochromators, spectrometer, 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]
6. Acquired skills and knowledge	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, • have the competence to deal with current problems in solid state spectroscopy autonomously, and are able to judge proper measurement methods for application. • Integrated acquirement of soft skills..
7. Curriculum inclosures	BaMawi-64-03 / Bachelor Materialwissenschaften MaAFM-41-05 / Master Advanced Functional Materials MaMawi-41-05 / Master Materialwissenschaften MaPhy-24-05 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: basic knowledge in solid-state physics
13. Credit points	6
14. Requirements for credits	oral examination (30 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation
17. Application	none
18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Solid State Spectroscopy with Synchrotron Radiation (see page 129)	3 hours of workload per week
Solid State Spectroscopy with Synchrotron Radiation (Tutorial) (see page 130)	1 hours of workload per week

MaMawi-41-06

1. Module title	Chemical Physics I
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Wolfgang Scherer
5. Content	1. Basics of quantum chemical methods [8] a) Extended Hueckel Method (EHM) b) Modern quantum chemical methods of chemical physics c) Application: Exemplary calculations and interpretation of simple electronical structures 2. Molecular symmetry and group theory a) Symmetry operations and matrix transformations b) Point groups c) Reducible and irreducible representations d) Character tables e) Application: infrared- and raman-spectroscopy, NMR-spectroscopy 3. The electronical structure of transition metal complexes a) Ligand field theory and Angular-Overlap Model (AOM) b) The physical basics of the spectrochemical series c) Molecular orbital theory of transition metal complexes d) Application: UV/vis-spectroscopy, molecular magnetism
6. Acquired skills and knowledge	The students: • know the basics of the Extended-Hückel-Method and the density functional theory, • know the basics of group theory, • are able to apply the knowledge gained through consideration of symmetry from vibration-, NMR-, and UV/Vis-spectroscopy, and • are able to interpret and predict the basical geometric, electronical and magnetical properties of transition metal complexes. • Integrated acquirement of soft skills: ability to specialize in a scientific topic and to apply the the acquired knowledge for solving scientific problems.
7. Curriculum inclosures	BaMawi-64-04 / Bachelor Materialwissenschaften MaAFM-41-06 / Master Advanced Functional Materials MaMawi-41-06 / Master Materialwissenschaften MaPhy-24-06 / Master Physik MaPhy-41-02 / Master Physik
8. Recommended semester	1st semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: it is recommended to complete the experiments FP11 (IR-spectroscopy) and FP17 (Raman-spectroscopy) of the module ”Physikalisches Fortgeschrittenenpraktikum”.
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module

16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard
17. Application	none
18. Further information	**ELECTIVE MODULE** It is possible for students to do EHM calculations autonomously and analyze electronical structures of molecules on a computer cluster within the scope oh the tutorial. The lecture Chemical Physics I is one of the regular lectures of the physics master program and is therefore only offered in German language.

No courses are provided for this module in the current term

MaMawi-41-07

1. Module title	Chemical Physics II
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Wolfgang Scherer
5. Content	1. Charge density distribution from experiment and theory 2. Analysis der topology of spin- and charge density distribution a) Quantum theory of atoms in molecules (QTAIM) b) Electron localization function (ELF) and electron localizability indicator (ELI) 3. The nature of chemical bondings 4. Analysis of wave functions with localized orbitals 5. Modern quantum chemical methods: configuration interaction
6. Acquired skills and knowledge	The students: • know the basic quantum chemical methods of chemical physics to interpret electronical structures in molecules and solid-state bodies, • have therefore the ability to apply amongst other things the quantum theory of atoms in molecules (QTAIM) and established electron localization functions (such as ELF) to analyze charge- and spin density distributions, • have the competence to do autonomously simple quantum chemical calculations using the density functional theory (DFT) and to interpret the electronical structure of functional molecules and materials with regard to chemical and physical properties. • Integrated acquirement of soft skills: ability to specialize in a scientific topic and to apply the the acquired knowledge for solving scientific problems.
7. Curriculum inclosures	BaMawi-64-05 / Bachelor Materialwissenschaften MaAFM-41-07 / Master Advanced Functional Materials MaMawi-41-07 / Master Materialwissenschaften MaPhy-24-07 / Master Physik MaPhy-41-03 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: it is highly recommended to complete the module Chemical Physics I first.
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard
17. Application	none

18. Further information	**ELECTIVE MODULE** It is possible for students to do quantum chemical calculations autonomously and analyze electronical structures of molecules on a computer cluster within the scope of the tutorial. The lecture Chemical Physics II is one of the regular lectures of the physics master program and is therefore only offered in German language.

The following courses are provided for this module in the current term:

Chemical Physics II (see page 98)	3 hours of workload per week
Chemical Physics II (Tutorial) (see page 99)	1 hours of workload per week

MaMawi-41-08

1. Module title	Ion-Solid Interaction
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Helmut Karl
5. Content	1. Introduction (areas of scientific and technological application, principles) [2] 2. Fundamentals of atomic collision processes (scattering, cross-sections, energy loss models, potentials in binary collision models) [6] 3. 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] 4. Transport phenomena [2] 5. Analysis with ion beams [4]
6. Acquired skills and knowledge	The students: • know the physical principles and the basical mechanisms of the interaction between particles and solid state bodies in the energy range of eV to MeV, • are able to choose adequate physical models for specific technological and scientific applications, and • have the competence to work extensively autonomous on problems concerning the interaction between ions and solid state bodies. • Integrated acquirement of soft skills.
7. Curriculum inclosures	MaAFM-41-08 / Master Advanced Functional Materials MaMawi-41-08 / Master Materialwissenschaften MaPhy-24-09 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: basic knowledge of Physik I–IV, solid-sate physics, nuclear physics
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard, transparencies
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-09	
1. Module title	Physics of Thin Films
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Wolfgang Brütting
5. Content	1. Layer growth [2] 2. Thin film technology [10] 3. Analysis of thin films [8] 4. Properties and applications of thin films [10]
6. 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. • Integrated acquirement of soft skills: practicing technical English, working with English specialist literature, ability to interpret experimental results.
7. Curriculum inclosures	BaMawi-64-07 / Bachelor Materialwissenschaften MaAFM-41-09 / Master Advanced Functional Materials MaMawi-41-09 / Master Materialwissenschaften MaPhy-24-10 / Master Physik
8. Recommended semester	2nd or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every 2nd year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-10

1. Module title	Organic Semiconductors
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Wolfgang Brütting
5. Content	1. Introduction [15] - Materials and preparation - Structural properties - Electronic structure - Optical and electrical properties 2. Devices and Applications [15] - Organic metals - Light-emitting diodes - Field-effect transistors - Solar cells and laser
6. 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. • Integrated acquirement of soft skills: practicing technical English, working with English specialist literature, ability to interpret experimental results
7. Curriculum inclosures	MaAFM-41-10 / Master Advanced Functional Materials MaMawi-41-10 / Master Materialwissenschaften MaPhy-24-11 / Master Physik
8. Recommended semester	2nd or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every 2nd year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: it is strongly recommended to complete the module solid-state physics first. In addition, knowledge of molecular physics is desired.
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard
17. Application	none

18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Organic Semiconductors (see page 121)	4 hours of workload per week

MaMawi-41-11

1. Module title	Magnetism
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Hans-Albrecht Krug von Nidda
5. 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 and domain walls [2] 7. Magnetization processes and micro magnetic treatment [2] 8. AC susceptibility and ESR [2] 9. Spintransport / spintronics [2] 10. Recent problems of magnetism [2]
6. 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, and • have the competence independently to treat fundamental and typical topics and problems of magnetism. • Integrated acquirement of soft skills.
7. Curriculum inclosures	BaMawi-64-10 / Bachelor Materialwissenschaften MaAFM-41-11 / Master Advanced Functional Materials MaMawi-41-11 / Master Materialwissenschaften MaPhy-24-12 / Master Physik
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: basics of solid-state physics and quantum mechanics
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, transparencies, blackboard
17. Application	none

18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Magnetism (see page 102)	3 hours of workload per week
Magnetism (Tutorial) (see page 103)	1 hours of workload per week

MaMawi-41-12

1. Module title	Low Temperature Physics
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Reinhard Tidecks
5. Content	1. Introduction - History, methods, realizations, and significance 2. Thermodynamic fundamentals - Temperature, working cycles, real gases, Joul-Thomson-Effect 3. Gas liquification - Air, hydrogen, helium - Separation of Oxygen and nitrogen - Storage and transfer of liquefied gases, superinsulation 4. Properties of liquid helium - Production and thermodynamic properties of ^{4}He and ^{3}He - Phase diagrams (^{4}He, ^{3}He) - Superfluidity of ^{4}He - Experiments, Two-Fluid-Model - Bose-Einstein-Condensation - Excitation spectrum, critical velocity - Rotating Helium - Normal and superfluid ^{3}He - ^{4}He / ^{3}He-mixtures 5. Cryogenic engineering - Bath-Cryostats (Helium-4, Helium-3), - ^{4}He / ^{3}He-Dilution-Refrigerators - Pomeranchuck-Cooling - Adiabatic demagnetization - Primary and secondary thermometers
6. 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.
7. Curriculum inclosures	MaAFM-41-12 / Master Advanced Functional Materials MaMawi-41-12 / Master Materialwissenschaften MaPhy-24-14 / Master Physik
8. Recommended semester	2nd or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every 2nd year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: Physik IV - Solid-state physics

13. Credit points	6
14. Requirements for credits	oral examination (30 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard, and transparencies
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-13

1. Module title	Spintronics
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	N.N.
5. Content	1. Introduction into magnetism [4] 2. Basic spintronic effects and devices [4] 3. Novel materials for spintronic applications [4] 4. Spin-sensitive experimental methods [4] 5. Semiconductor based spintronics [4]
6. 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.
7. Curriculum inclosures	MaAFM-41-13 / Master Advanced Functional Materials MaMawi-41-13 / Master Materialwissenschaften
8. Recommended semester	2nd or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every 2nd year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-14

1. Module title	Materials Synthesis
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Wolfgang Scherer
5. 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
6. 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. • Integrated acquirement of soft skills : ability to specialize in a scientific topic and to apply the acquired knowledge for the solution of scientific problems.
7. Curriculum inclosures	BaMawi-64-09 / Bachelor Materialwissenschaften MaAFM-41-14 / Master Advanced Functional Materials MaMawi-41-14 / Master Materialwissenschaften MaPhy-41-05 / Master Physik MaPhy-42-07 / Master Physik
8. Recommended semester	1st semester
9. Duration of module	1 semester
10. Recurrence of module	every year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard
17. Application	none

18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-15	
1. Module title	Oxidation and Corrosion
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Ferdinand Haider
5. Content	1 .Introduction 2. Review of thermodynamics 3. Chemical equilibria 4. Electrochemistry 5. Electrode kinetics 6. High temperature oxidation 7. Localized corrosion - Shallow pit corrosion - Pitting corrosion - Crevice corrosion - Intercrystalline corrosion - Stress corrosion cracking - Fatigue corrosion - Erosion corrosion - Galvanic corrosion 8. Water and seawater corrosion 9. Corrosion monitoring 10. Corrosion properties of specific materials 11. Specific corrosion problems in certain branches - Oil and Gas industry - Automobile industry - Food industry 12. Corrosion protection - Passive layers - Reaction layers (Diffusion layers . . .) - Coatings (organic, inorganic) - Cathodic, anodic protection - Inhibitors
6. Acquired skills and knowledge	The students: • know the the fundamental basics, mechanics, and types of corrosion processes, • obtain specific knowledge of one type of corrosion.
7. Curriculum inclosures	MaAFM-41-15 / Master Advanced Functional Materials MaMawi-41-15 / Master Materialwissenschaften
8. Recommended semester	3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 68 hours / self-study: 100 hours

12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: good knowledge in materials science, basic knowledge in physical chemistry
13. Credit points	6
14. Requirements for credits	Seminar talk with discussion (45 minutes) Practical course, written report
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Praktikum Media and methods: Powerpoint presentation
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-16

1. Module title	Seminar on Glass Physics
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Peter Lunkenheimer
5. Content	1. Technical glasses 2. Polymers 3. Metallic glasses 4. Relaxation phenomena 5. Models of the glass transition 6. Aging phenomena in glasses 7. Non-structural glasses 8. Ionic conductivity 9. Electrons in glasses
6. 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, • have acquired knowledge concerning the preparation of scientific presentations, • are able to independently acquaint themselves with a physical or material-science topic using various sources of information, • are capable of preparing a graphically attractive scientific talk using modern, computer-based presentation techniques, • are able to present a talk in a clear and informative way, adhering to a fixed time limit, • 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 • Integrated acquirement of soft skills: autnomous working with educational books and English specialist literature, acquirement of capacity for abstract thinking using the example of the glass concept in physics, ability to compare competitive models for the explanation of experimental results, skills in presentation techniques, practice in technical English.
7. Curriculum inclosures	MaAFM-41-16 / Master Advanced Functional Materials MaMawi-41-16 / Master Materialwissenschaften MaPhy-31-09 / Master Physik
8. Recommended semester	2nd or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 30 hours / self-study: 90 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: basic knowledge of solid-state physics
13. Credit points	4
14. Requirements for credits	Seminar talk with discussion (60 minutes), not graded
15. Examination	General examination for module

16. Teaching methods	Seminar Media and methods: Beamer presentation
17. Application	none
18. Further information	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Seminar on Glass Physics (see page 128)	2 hours of workload per week

MaMawi-41-17

1. Module title	Advanced Solid State Materials
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Henning Höppe
5. Content	1. Luminescent materials [5] 2. Pigments [3] 3. Ion conductors [3] 4. Magnetic/data storage materials [3] 5. Thermoelectric materials [2] 6. Catalysts [4] 7. Hard materials [2]
6. 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. • Integrated acquirement of soft skills.
7. Curriculum inclosures	MaAFM-41-17 / Master Advanced Functional Materials MaMawi-41-17 / Master Materialwissenschaften MaPhy-41-07 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: content of the modules Chemistry I and Chemistry II of the Bachlor of Science ”Materials Science” program
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard
17. Application	none

18. Further information	**ELECTIVE MODULE** Due to overlapping contents of the modules „Advanced Solid State Materials (MaPhy-41-07)“ and „Materials Chemistry (MaPhy-41-04)“ is it forbidden for students who passed Materials Chemistry in the winter term of 2009/10 to choose ”Advanced Solid State Materials”.

The following courses are provided for this module in the current term:

Advanced Solid State Materials (see page 93)	3 hours of workload per week
Advanced Solid State Materials (Tutorial) (see page 94)	1 hours of workload per week

MaMawi-41-18

1. Module title	Porous Materials
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Dirk Volkmer
5. Content	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]
6. Acquired skills and knowledge	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. • Integrated acquirement of soft skills.
7. Curriculum inclosures	MaAFM-41-18 / Master Advanced Functional Materials MaMawi-41-18 / Master Materialwissenschaften MaPhy-41-08 / Master Physik MaPhy-42-08 / Master Physik
8. Recommended semester	2nd semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: participation in the Course Materials Chemistry (MaPhy-41-04, MaPhy-42-06, MaMaWi-13-01, MaAFM-13-01)
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Beamer presentation, blackboard
17. Application	none
18. Further information	**ELECTIVE MODULE** 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.

The following courses are provided for this module in the current term:

Porous Materials (see page 124)	3 hours of workload per week
Porous Materials (Tutorial) (see page 125)	1 hours of workload per week

MaMawi-41-19

1. Module title	Superconductivity
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	PD Dr. Reinhard Tidecks
5. Content	1. Introductory Remarks and Literature[1] 2. History and Main Properties of the Superconducting State, an Overview [1] 3. Phenomenological Thermodynamics and Electrodynamics of the SC [4] 4. Ginzburg-Landau Theory [4] 5. Microscopic Theories[4] 6. Fundamental Experiments on the Nature of the Superconducting State [3] 7. Josephson-Effects [4] 8. High Temperature Superconductors [5] 9. Application of Superconductivity [4]
6. 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, • are informed about the most important technical applications of superconductivity. • Special attention will be drawn to the basic concepts of the main phenomeno-logical and microscopic theories of the superconducting state, to explain the experimental observations. • For self-studies a comprehensive list of further reading will be supplied.
7. Curriculum inclosures	MaAFM-41-19 / Master Advanced Functional Materials MaMawi-41-19 / Master Materialwissenschaften MaPhy-24-18 / Master Physik
8. Recommended semester	2nd or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every 2nd year
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: Physik IV – Solid-state physics, Theoretical physics I-III
13. Credit points	6
14. Requirements for credits	oral examination (30 minutes) Oral examination, 20-30 min
15. Examination	General examination for module
16. Teaching methods	Vorlesung Media and methods: Handwritten lecture at the overhead projector, occasional use of transparencies
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-20

1. Module title	Sustainable Resource Management
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Armin Reller
5. Content	1. Introduction (global resource consumption) 2. Overview of resource types 3. Definition of mineral resources 4. Introduction to resource management 5. Identification of resource price risks 6. Measurement of resource price risks 7. Management of resource price risks 8. Introduction in basics of environmental management 9. Corporate environmental management 10. Economical closed-loop systems
6. Acquired skills and knowledge	• 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).
7. Curriculum inclosures	MaAFM-41-20 / Master Advanced Functional Materials MaMawi-41-20 / Master Materialwissenschaften
8. Recommended semester	2. oder 4. Semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 40 hours / self-study: 140 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: none
13. Credit points	6
14. Requirements for credits	written examination (60 minutes) Practice sheets
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Slides / blackboard with the help of other media
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-41-21

1. Module title	Characterization of Composite Materials
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Dr. Markus Sause
5. Content	The following topics are presented: • Introduction to composite materials • Applications of composite materials • Mechanical testing • Thermophysical testing • Nondestructive testing
6. Acquired skills and knowledge	The students: • acquire knowledge in the field of materials testing and evaluation of composite materials. • are introduced to important concepts in measurement techniques, and material models applied to composites. • are able to independently acquire further information of the scientific topic using various forms of information.
7. Curriculum inclosures	MaAFM-41-21 / Master Advanced Functional Materials MaMawi-41-21 / Master Materialwissenschaften
8. Recommended semester	2. oder 4. Semester
9. Duration of module	1 semester
10. Recurrence of module	every summer term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: Basic knowledge in materials science, particularly in composite materials.
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Lecture: Slides and blackboard in combination with beamer presentation Exercise: Talks and exercises on recent topics, specialization of lecture contents
17. Application	**ELECTIVE MODULE**

The following courses are provided for this module in the current term:

Characterization of Composite Materials (see page 96)	3 hours of workload per week
Characterization of Composite Materials (Tutorial) (see page 97)	1 hours of workload per week

MaMawi-41-22

1. Module title	Fiber Reinforced Composites: Processing and Materials Properties
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Prof. Dr. Siegfried Horn Dr. Judith Moosburger-Will
5. Content	The following topics are treated: • production of fibers (e.g. glass, carbon, or ceramic fibers) • Physical and chemical properties of fibers and their precursor materials • Physical and chemical properties of commonly used polymeric and ceramic matrix materials • Semi-finished products • Composite production technologies • Application of fiber reinforced materials
6. Acquired skills and knowledge	The students: • know the application areas of composite materials. • know the basics of production technologies of fibers, polymeric, and ceramic matrices and fiber reinforced materials. • are introduced to physical and chemical properties of fibers, matrices, and fiber reinforced materials. • are able to independently acquire further knowledge of the scientific topic using various forms of information.
7. Curriculum inclosures	MaAFM-41-22 / Master Advanced Functional Materials MaMawi-41-22 / Master Materialwissenschaften
8. Recommended semester	1st or 3rd semester
9. Duration of module	1 semester
10. Recurrence of module	every winter term
11. Work load (total)	compulsory attendance: 60 hours / self-study: 120 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: Basic knowledge in materials science
13. Credit points	6
14. Requirements for credits	written examination (90 minutes)
15. Examination	General examination for module
16. Teaching methods	Vorlesung, Übung Media and methods: Lecture: Slides and blackboard in combination with beamer presentation Exercise: Exercises on recent topics, specialization of lecture contents
17. Application	none
18. Further information	**ELECTIVE MODULE**

No courses are provided for this module in the current term

MaMawi-42-01	
1. Module title	Practical Laboratory Project
2. Module group/s	Specialization in Materials Science
3. Specific field	None
4. Responsible for module	Vorsitzender/Vorsitzende des Prüfungsausschusses
5. Content	Experimental or theoretical work in a laboratory / research group in the Institute of Physics. Has to be conducted within 3 months.
6. 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.
7. Curriculum inclosures	MaAFM-42-01 / Master Advanced Functional Materials MaMawi-42-01 / Master Materialwissenschaften
8. Recommended semester	3rd or 4th semester
9. Duration of module	3 months
10. Recurrence of module	every semester
11. Work load (total)	compulsory attendance: 180 hours / self-study: 0 hours
12. Prerequisites	Requirements acc. to the regulations of study: none Recommended prerequisites: solid knowledge in (solid state) Physics, Chemistry and Materials Science, both experimentally and theoretically
13. Credit points	6
14. Requirements for credits	1 written report (editing time 2 weeks)
15. Examination	General examination for module
16. Teaching methods	Praktikum Media and methods: Face to face tutoring
17. Application	none
18. Further information	**ELECTIVE COURSE**

The following courses are provided for this module in the current term:

Practical Laboratory Project (see page 126)	—

Part IV

List of courses

Title	**Advanced Solid State Materials**
Module assignment	MaAFM-41-17, MaMawi-41-17 (see page 81), MaPhy-41-07
Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 40 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Prof. Dr. Henning Höppe
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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	Due to overlapping contents of the modules „Advanced Solid State Materials (MaPhy-41-07)“ and „Materials Chemistry (MaPhy-41-04)“ is it forbidden for students who passed Materials Chemistry in the winter term of 2009/10 to choose ”Advanced Solid State Materials”.

Title	**Advanced Solid State Materials (Tutorial)**
Module assignment	MaAFM-41-17, MaMawi-41-17 (see page 81), MaPhy-41-07
Teaching methods	Übung
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 30 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Prof. Dr. Henning Höppe
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Further information	Due to overlapping contents of the modules „Advanced Solid State Materials (MaPhy-41-07)“ and „Materials Chemistry (MaPhy-41-04)“ is it forbidden for students who passed Materials Chemistry in the winter term of 2009/10 to choose ”Advanced Solid State Materials”.

Title	**Biophysics and Biomaterials**
Module assignment	MaAFM-41-04, MaMawi-41-04 (see page 58), MaPhy-24-04
Teaching methods	Vorlesung Media and methods: Transparencies / blackboard with additional media
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 40 hours
Examination/s, method/s of examination	1 written examination (90 min)
Application	none
Lecturer	PD Dr. Thomas Franke Dr. Gerhard Schmid PD Dr. Stefan Thalhammer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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 Bio-physics. Lecture alone will be awarded 6 CP, Method Course 8 CP.

Title	**Characterization of Composite Materials**
Module assignment	MaAFM-41-21, MaMawi-41-21 (see page 87)
Teaching methods	Vorlesung Media and methods: Slides and blackboard in combination with beamer presentation
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 45 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Dr. Markus Sause
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• Morgan: Carbon fibers and their composites • Henning, Moeller: Handbuch Leichtbau • Schürmann: Konstruieren mit Faser-Kunststoff-Verbunden • Neitzel, Mitschang: Handbuch Verbundwerkstoffe • Dowling: Mechanical behaviour of materials • Issler: Festigkeitslehre - Grundlagen • Landau, Lifschitz: Theoretische Physik Vol. 7 Further literature - actual scientific papers and reviews - will be announced at the beginning of the lecture.

Title	**Characterization of Composite Materials (Tutorial)**
Module assignment	MaAFM-41-21, MaMawi-41-21 (see page 87)
Teaching methods	Übung Media and methods: Talks and exercises on recent topics, specialization of lecture contents
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 45 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Dr. Markus Sause
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	see lecture

Title	**Chemical Physics II**
Module assignment	BaMawi-64-05, MaAFM-41-07, MaMawi-41-07 (see page 64), MaPhy-24-07, MaPhy-41-03
Teaching methods	Vorlesung Teaching methods: Beamer presentation, blackboard
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 45 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Dr. Georg Eickerling Prof. Dr. Wolfgang Scherer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• 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)
Further information	It is possible for students to do EHM calculations autonomously and analyze electronical structures of molecules on a computer cluster within the scope oh the tutorial. The lecture Chemical Physics II is one of the regular lectures of the physics master program and is therefore only offered in German language.

Title	**Chemical Physics II (Tutorial)**
Module assignment	BaMawi-64-05, MaAFM-41-07, MaMawi-41-07 (see page 64), MaPhy-24-07, MaPhy-41-03
Teaching methods	Übung
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 45 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Dr. Georg Eickerling Prof. Dr. Wolfgang Scherer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Further information	It is possible for students to do quantum chemical calculations autonomously and analyze electronical structures of molecules on a computer cluster within the scope oh the tutorial.

Title	**Electronics for Physicists and Materials Scientists**
Module assignment	BaMawi-64-02, MaAFM-41-03, MaMawi-41-03 (see page 56), MaPhy-24-03
Teaching methods	Vorlesung Media and methods: Slides / blackboard talk with help of other media and experiments
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 40 hours
Examination/s, method/s of examination	Oral examination (max. 30 min)
Application	none
Lecturer	Dr. Andreas Hörner
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• Paul Horowitz: The Art of Electronics (Cambridge University Press) • National Instruments: MultiSim software package (available during)
Further information	none

Title	**Electronics for Physicists and Materials Scientists (Tutorial)**
Module assignment	BaMawi-64-02, MaAFM-41-03, MaMawi-41-03 (see page 56), MaPhy-24-03
Teaching methods	Übung Media and Methods Practical circuit design Self-study
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 40 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Dr. Andreas Hörner
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Magnetism**
Module assignment	BaMawi-64-10, MaAFM-41-11, MaMawi-41-11 (see page 70), MaPhy-24-12
Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard, overhead transperencies
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 30 hours
Examination/s, method/s of examination	written examination, 90 min
Application	None
Lecturer	Dr. Joachim Deisenhofer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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.)

Title	**Magnetism (Tutorial)**
Module assignment	BaMawi-64-10, MaAFM-41-11, MaMawi-41-11 (see page 70), MaPhy-24-12
Teaching methods	Übung
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 60 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Dr. Joachim Deisenhofer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Materials Physics II**
Module assignment	MaAFM-12-01, MaMawi-12-01 (see page 18), MaPhy-42-02
Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard (occasionally)
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 55 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Prof. Dr. Bernd Stritzker
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• Charles kittel: Introduction to Solid State Physics (Wiley & Sons) • Werner Buckel und Reinhold Kleiner: Supraleitung (Wiley-VCH)

Title	**Materials Physics II (Tutorial)**
Module assignment	MaAFM-12-01, MaMawi-12-01 (see page 18), MaPhy-42-02
Teaching methods	Übung
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 35 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Prof. Dr. Bernd Stritzker
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Method Course: Characterization of Porous Materials (Practical Course)**
Module assignment	MaAFM-24-15, MaMawi-24-15 (see page 45)
Teaching methods	Praktikum Media and methods: Face to face tutorial, self-study
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 90 hours / self-study: 20 hours
Examination/s, method/s of examination	written report, editing time 1 week
Application	none
Lecturer	Prof. Dr. Dirk Volkmer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Method Course: Electron Microscopy**
Module assignment	MaAFM-24-02, MaMawi-24-02 (see page 31)
Teaching methods	Vorlesung
Content of course	SEM: 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 TEM: 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
Acquired skills and knowledge	
Work load	compulsory attendance: 24 hours / self-study: 48 hours
Examination/s, method/s of examination	Written report (one report per group)
Application	none
Lecturer	Prof. Dr. Ferdinand Haider
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• D.B.Williams and C.B.Carter, Transmission Electron Microscopy,Plenum Press, New York/London, 1996 • M.A. Hirsch, A. Howie, R. Nicholson, D.W. Pashley, M.J. Whelan, Electron microscopy of thin crystals, Krieger Publishing Company, Malabar (Florida), 1977 • L. Reimer, Transmission electron microscopy, Springer Verlag, Berlin/Heidelberg/New York, 1984 • P.J. Goodhew, Thin foil preparation for electron microscopy,Elsevier, Amsterdam, 1985 • P.R. Buseck, J.M. Cowley, L. Eyring, High-resolution transmission electron microscopy, Oxford University Press, 1988 • E. Hornbogen, B. Skrotzki, Werkstoff-Mikroskopie, Springer Verlag, Berlin/Heidelberg/New York, 1995 • K. Wetzig, In situ scanning electron microscopy in materials research, Akad.-Verl., 1995 • J. I. goldstein, Scanning electron microscopy and x-ray microanalysis, Plenum Press, 1992 • L. Reimer, Scanning electron microscopy, Springer Verlag, 1985 • S. L. Flegler, J. W. Heckman, K. L. Klomparens, Elektronenmikroskopie, Spektrum, Akad. Verl., 1995

Title	**Method Course: Electron Microscopy (Practical Course)**
Module assignment	MaAFM-24-02, MaMawi-24-02 (see page 31)
Teaching methods	Praktikum SEM: 1. Sample preparation: cutting, polishing and etching 2. Introduction to the SEM instrument 3. Modes of imaging 4. Energy Dispersive X-ray Spectroscopy (EDX) TEM: 1. Visit to TEM Labs, 2. Preparation of Al samples 3. Preparation of Si plan view samples 4. TEM inspection of Al samples at TEM 5. Fundamental alignments 6. Recording of single crystalline diffraction patterns, indexing of diffraction spots, calibration of camera length & image rotation 7. Observation of stacking faults, thickness fringes, strain contrast in crystalline samples 8. Lattice imaging of a compound semiconductor 9. Observation of Kikuchi patterns 10. Recording of elemental maps
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 48 hours / self-study: 48 hours
Examination/s, method/s of examination	Written report (one report per group)
Application	none
Lecturer	Prof. Dr. Ferdinand Haider
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Method Course: Electronics for Physicists and Materials Scientists**
Module assignment	MaAFM-24-04, MaMawi-24-04 (see page 32)
Teaching methods	Vorlesung Media and methods: Slides / blackboard talk with help of other media and experiments Self-study
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 40 hours
Examination/s, method/s of examination	Oral examination (max. 30 min)
Application	none
Lecturer	Dr. Andreas Hörner
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• Paul Horowitz: The Art of Electronics (Cambridge University Press) • National Instruments: MultiSim software package (available in lecture)

Title	**Method Course: Electronics for Physicists and Materials Scientists (Practical Course)**
Module assignment	MaAFM-24-04, MaMawi-24-04 (see page 32)
Teaching methods	Praktikum
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 40 hours / self-study: 10 hours
Examination/s, method/s of examination	written report (one per group)
Application	none
Lecturer	Dr. Andreas Hörner
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Method Course: Electronics for Physicists and Materials Scientists (Tutorial)**
Module assignment	MaAFM-24-04, MaMawi-24-04 (see page 32)
Teaching methods	Übung Media and methods: Practical circuit design Self-study
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 40 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Dr. Andreas Hörner
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Method Course: Functional Silicate-analogous Materials (Practical Course)**
Module assignment	MaAFM-24-17, MaMawi-24-17 (see page 48)
Teaching methods	Praktikum
Content of course	Synthesis and characterization of functional materials according to the topics: 1. Silicate-analogous compounds 2. Luminescent materials / phosphors 3. Pigments 4. Characterization methods: XRD, spectroscopy (luminescence, UV/vis, FT-IR), thermal analysis
Acquired skills and knowledge	The students will know how to: • develop functional materials based on silicate-analogous materials, • apply classical and modern preparation techniques (e.g. solid state reaction, sol-gel reaction, precipitation, autoclave reactions, use of silica ampoules), • work under non-ambient atmospheres (e.g. reducing, inert conditions), • solve and refine crystal structures from single-crystal data, • describe and classify these structures properly.
Work load	compulsory attendance: 120 hours / self-study: 120 hours
Examination/s, method/s of examination	written report (protocol)
Application	none
Lecturer	Prof. Dr. Henning Höppe
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Method Course: Modern Solid State NMR Spectroscopy**
Module assignment	MaAFM-24-16, MaMawi-24-16 (see page 46)
Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard, handouts
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 30 hours / self-study: 30 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	N.N.
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• M. H. Levitt, spin Dynamics, John Wiley and Sons, Ltd., 2008. • H. Günther NMR spectroscopy, Wiley, 2001. • M. Duer, Introduction to Solid-State NMR spectroscopy, Blackwell Publishing Ltd., 2004. • D. Canet, NMR - concepts and methods, Springer, 1994.

Title	**Method Course: Modern Solid State NMR Spectroscopy (Practical Course)**
Module assignment	MaAFM-24-16, MaMawi-24-16 (see page 46)
Teaching methods	Praktikum
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 60 hours / self-study: 90 hours
Examination/s, method/s of examination	written report on the experiments, editing time approx. 2 weeks
Application	none
Lecturer	N.N.
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Method Course: Optical Properties of Solids**
Module assignment	MaAFM-24-07, MaMawi-24-07 (see page 37)
Teaching methods	Vorlesung Media and methods: Projector, slides, blackboard, web resources
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 30 hours / self-study: 35 hours
Examination/s, method/s of examination	Written homework; short presentation, 20 min
Application	none
Lecturer	Dr. Joachim Deisenhofer Prof. Dr. Alois Loidl
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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)

Title	**Method Course: Optical Properties of Solids (Practical Course)**
Module assignment	MaAFM-24-07, MaMawi-24-07 (see page 37)
Teaching methods	Praktikum Media and methods: Exercises, teamwork, students' presentations
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 60 hours / self-study: 35 hours
Examination/s, method/s of examination	written report on the experiments, editing time 3 weeks, max. 30 pages
Application	none
Lecturer	Dr. Joachim Deisenhofer Prof. Dr. Alois Loidl
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Method Course: Spectroscopy on Condensed Matter**
Module assignment	MaAFM-24-09, MaMawi-24-09 (see page 39)
Teaching methods	Vorlesung Media and methods: Slides / blackboard talk with help of other media and experiments Self-study
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 30 hours / self-study: 30 hours
Examination/s, method/s of examination	1 written examination (120 min)
Application	none
Lecturer	Dr. Stephan Krohns
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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)

Title	**Method Course: Spectroscopy on Condensed Matter (Practical Course)**
Module assignment	MaAFM-24-09, MaMawi-24-09 (see page 39)
Teaching methods	Praktikum
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 60 hours / self-study: 60 hours
Examination/s, method/s of examination	1 written report on the experiments (editing time 2 weeks)
Application	none
Lecturer	Dr. Stephan Krohns
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Nanostructures / Nanophysics**
Module assignment	MaAFM-41-02, MaMawi-41-02 (see page 54), MaPhy-24-02
Teaching methods	Vorlesung Media and methods: Slides / blackboard supported by other media and experiments
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 40 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Dr. Hubert Krenner Prof. Dr. Achim Wixforth
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• 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 University 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

Title	**Nanostructures / Nanophysics (Tutorial)**
Module assignment	MaAFM-41-02, MaMawi-41-02 (see page 54), MaPhy-24-02
Teaching methods	Übung Media and methods: Intensive support in small groups Self study
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 40 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Dr. Hubert Krenner Prof. Dr. Achim Wixforth
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Organic Semiconductors**
Module assignment	MaAFM-41-10, MaMawi-41-10 (see page 68), MaPhy-24-11
Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 60 hours / self-study: 60 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Prof. Dr. Wolfgang Brütting
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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)

Title	**Physics of Surfaces and Interfaces**
Module assignment	MaAFM-14-01, MaMawi-14-01 (see page 22), MaPhy-42-03
Teaching methods	Vorlesung
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 45 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Prof. Dr. Siegfried Horn
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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)

Title	**Physics of Surfaces and Interfaces (Tutorial)**
Module assignment	MaAFM-14-01, MaMawi-14-01 (see page 22), MaPhy-42-03
Teaching methods	Übung
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 45 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Prof. Dr. Siegfried Horn
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Porous Materials**
Module assignment	MaAFM-41-18, MaMawi-41-18 (see page 83), MaPhy-41-08, MaPhy-42-08
Teaching methods	Vorlesung Media and methods: Beamer presentation, blackboard
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 30 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Prof. Dr. Dirk Volkmer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• Paul A. Wright, Microporous Framework Solids (RSC Materials Monographs, 2008) • As well as selected reviews and journal articles cited on the slides
Further information	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

Title	**Porous Materials (Tutorial)**
Module assignment	MaAFM-41-18, MaMawi-41-18 (see page 83), MaPhy-41-08, MaPhy-42-08
Teaching methods	Übung
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 60 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Prof. Dr. Dirk Volkmer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Practical Laboratory Project**
Module assignment	MaAFM-42-01, MaMawi-42-01 (see page 89)
Teaching methods	Praktikum Media and Methods: Face to face tutoring
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 180 hours / self-study: 0 hours
Examination/s, method/s of examination	1 written report (editing time 2 weeks)
Application	none
Lecturer	N.N.
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• Various

Title	**Processing of Materials**
Module assignment	MaAFM-22-01, MaMawi-22-01 (see page 27), MaPhy-42-05
Teaching methods	Vorlesung Media and methods: Beamer presentation
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 56 hours / self-study: 56 hours
Examination/s, method/s of examination	1 written examination, 90 min
Application	none
Lecturer	Prof. Dr. Ferdinand Haider Prof. Dr. Siegfried Horn Prof. Dr. Klaus Ruhland Prof. Dr. Bernd Stritzker Prof. Dr. Achim Wixforth
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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)

Title	**Seminar on Glass Physics**
Module assignment	MaAFM-41-16, MaMawi-41-16 (see page 79), MaPhy-31-09
Teaching methods	Seminar Media and methods: Beamer presentation
Content of course	1. Technical glasses 2. Polymers 3. Metallic glasses 4. Relaxation phenomena 5. Models of the glass transition 6. Aging phenomena in glasses 7. Non-structural glasses 8. Ionic conductivity 9. Electrons in glasses
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, • have acquired knowledge concerning the preparation of scientific presentations, • are able to independently acquaint themselves with a physical or material-science topic using various sources of information, • are capable of preparing a graphically attractive scientific talk using modern, computer-based presentation techniques, • are able to present a talk in a clear and informative way, adhering to a fixed time limit, • 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 • Integrated acquirement of soft skills: autnomous working with educational books and English specialist literature, acquirement of capacity for abstract thinking using the example of the glass concept in physics, ability to compare competitive models for the explanation of experimental results, skills in presentation techniques, practice in technical English.
Work load	compulsory attendance: 30 hours / self-study: 90 hours
Examination/s, method/s of examination	Talk with discussion, about 60 min
Application	none
Lecturer	PD Dr. Peter Lunkenheimer
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended 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)

Title	**Solid State Spectroscopy with Synchrotron Radiation**
Module assignment	BaMawi-64-03, MaAFM-41-05, MaMawi-41-05 (see page 60), MaPhy-24-05
Teaching methods	Vorlesung Media and methods: Beamer presentation
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 45 hours
Examination/s, method/s of examination	Oral examination, 30 min
Application	none
Lecturer	Prof. Dr. Christine Kuntscher
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• H. Kuzmany, Solid State Spectroscopy (Springer) • N. W. Ashcroft, N. D. Mermin, Solid State Physics (Holt, Rinehart and Winston) • J. M. Hollas, Modern Spectroscopy

Title	**Solid State Spectroscopy with Synchrotron Radiation (Tutorial)**
Module assignment	BaMawi-64-03, MaAFM-41-05, MaMawi-41-05 (see page 60), MaPhy-24-05
Teaching methods	Übung
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 45 hours
Examination/s, method/s of examination	see lecture
Application	none
Lecturer	Prof. Dr. Christine Kuntscher
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus

Title	**Theoretical Concepts and Simulation**
Module assignment	MaAFM-23-01, MaMawi-23-01 (see page 29)
Teaching methods	Vorlesung Media and methods: Blackboard presentation, occasionally supplemented by beamer or overhead presentations
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 45 hours / self-study: 30 hours
Examination/s, method/s of examination	Project work in small groups, including a written summary of the results (ca. 10-20 pages) as well a
Application	none
Lecturer	Dr. Michael Dzierzawa
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus
Recommended literature	• Tao Pang, An Introduction to Computational Physics (Cambridge University Press) • J. M. Thijssen, Computational Physics (Cambridge University Press) • Koonin, Meredith, Computational Physics (Addison-Weseley) • D. C. Rapaport, The Art of Molecular Dynamics Simulation, (Cambridge University Press) • W. H. Press et al, Numerical Recipes (Cambridge University Press)

Title	**Theoretical Concepts and Simulation (Project)**
Module assignment	MaAFM-23-01, MaMawi-23-01 (see page 29)
Teaching methods	Praktikum Media and methods: Work with a computer in order to numerically implement a given concrete problem.
Content of course	
Acquired skills and knowledge	
Work load	compulsory attendance: 15 hours / self-study: 60 hours
Examination/s, method/s of examination	Project work, including a written summary of the results (ca. 10-20 pages)
Application	none
Lecturer	Dr. Michael Dzierzawa
Room / time	Will be announced by notice or digitally in the university calendar or in Digicampus