Christian-Albrechts-Universität zu Kiel Technische Fakultät

Institute for Materials Science

Master Course

Materials Science and Engineering

Module Catalogue

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Kaiserstr. 2
D - 24143 Kiel

As of: March 2018

General Remarks

The responsible examination office for this study course is the one of the Institute for Materials Science. It is located on the east side campus of the university in Kiel.

Examination Office of Materials Science
Building G, Room G-010
Kaiserstr. 2
24143 Kiel

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www.tf.uni-kiel.de/
servicezentrum/en/studium/
pruefungsaemter/mawi?set_language=en

Modules

A module is the smallest graded unit. It might consists out of multiple courses. This module catalogue defines that each module consist in general out of a lecture and an exercises course. Both courses have the same name and module number. For example, you can find in the univis the courses "mawi-702: Solid State Physics 1" and "mawi-702: Solid State Physics 1 - Exercises".
If other courses are recommend for fulfilling a module, they are named in the row "Courses" in the module description.

Credit Points

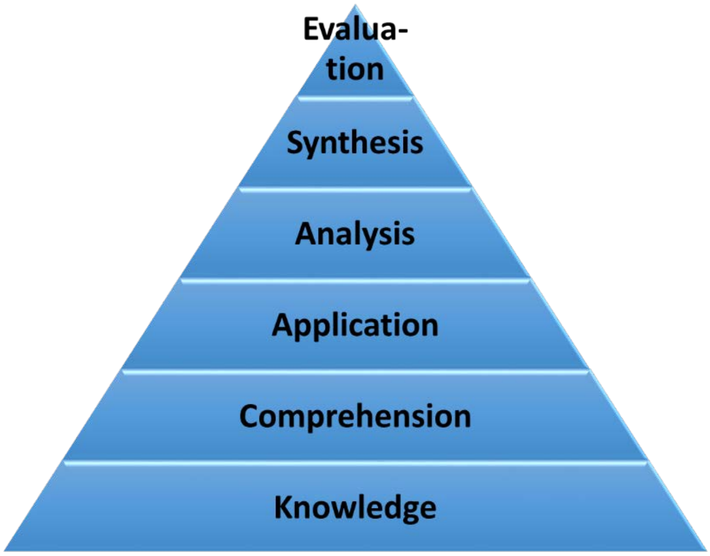
All credits points in this module catalogue all calculated basing on 30 hours of work for 1 credit point. For example, if you spend 150 hours of work per semester in a module you will get 5 credits. Attendance and self-organized work at the university will be counted with 15 hours for one semester hour (SWS, semester periods per week). A module consisting out of 2 SWS lecture and 1 SWS exercises generates a workload of 45 hours per semester, for example.
In addition to this workload, times for self-studies will be counted in the same manner.
If a module description defines 30 hours of self-studies for preparing a lab-course, you should look for this content for at least 2 hours a week during the lecture period.

Examinations

For each module, there will be at least one possibility to give the examination within one semester. The title of the examination is the title of the module. In addition, the module- number (mawi-….) can be used for orientation.
In general, all examinations are compulsory and graded. The module-grade is the grade of the examination. Variations are given in the row "Assessment of course achievements", if needed.
All graded module and the grade of the master thesis are counted into the final master-grade weighted by their credit points. The examination regulations for this master course show an example calculation.

Levelling of the learning outcome

The learning outcomes of the modules are defined basing on the „Bloom Taxonomy “
It is levelling the outcome in six levels:



Each level describes a standard for teaching and working on a topic. From bottom to top the student will deepen and broaden their knowledge, their competences to this knowledge and their experiences to use this in a creative way.
Therefore, topics could be content of different modules several times for increase the level of this topic.

Compulsory Modules of the Master Course

Module number	**Mawi 702**
Module title	**Solid State Physics 1 + 2**
Module level	Deepening Mathematics, Natural and Engineering Sciences
Abbreviation	SSP1, SSP2
Subtitle (if applicable)	
Duration	2 Semesters
Repetition in academic year	Part 1: Winter Term Part 2: Summer Term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Prof. Dr. F. Faupel
Lecturer	Prof. Dr. F. Faupel and staff
Teaching language	English
Assignment to the curriculum	Compulsory subject in term 1 and 2
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded
Module courses	see below
Workload	60 h lecture 30 h exercise 90 h self-organized studies 60 h revision 240 h total workload
Credits	8 ECTS
Prerequisites according to examination order	None

Module courses:

Course Type	*Course Name*	*Compulsory/ compulsory elective*	*SWS*
Lecture	Solid State Physics 1	compulsory	2
Lecture	Solid State Physics 1	compulsory	2
Practical Exercises	Solid State Physics 2	compulsory	1
Practical Exercises	Solid State Physics 2	compulsory	1

<table>
<tr><td>Recommended prerequisites</td><td colspan="4">Basic in higher mathematics
Basics in higher physics</td></tr>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Combined written examination on part 1 and 2</td></tr>
<tr><td>Title</td><td>Compulsory /Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Solid State Physics 1 + 2</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are familiar with quantum mechanical concepts and can apply these to basic problems in solid state physics. In particular, they have a profound understanding of the types of chemical bonds and how these determine structure and properties. They know important crystal structures and are familiar with the reciprocal lattice and Brillouin zones. They can apply this knowledge to describe lattice vibrations and the interaction of waves with solids. They are familiar with the properties of surfaces and amorphous solids. They know the limitations of the harmonic approximation and can classify properties of solids in terms of phononic and electronic. They know how band structures form in the limit of weak and tight binding and how these can be used to classify materials. They are familiar with the concept of doping of semiconductors. They have a deep understanding of heat conductivity and electrical conductivity and are aware of the underlying similar concepts. They have an advanced understanding of magnetic and dielectric properties. They can perform literature searches related to solid state physics problems and can critically assess the results. They can apply their knowledge to the understanding and tailoring of functional materials.</td></tr>
<tr><td>Content</td><td colspan="4">SSP Part 1
Quantum mechanical mathematical tools
Quantum mechanical axioms and operators
Schrödinger equation
Chemical bondings
Covalent bond
Ionic bond
Van der Waals bond
Hydrogen bond
Metallic bond
Crystal structure
Translational lattice
Symmetry
Simple crystal structures
The effect of defects on physical properties
Noncrystalline solids
Diffraction by solids
Crystalline solids and reciprocal lattice
Structure factor
Diffraction by noncrystalline solids</td></tr>
</table>

	• Experimental methods • Diffraction at surfaces • Dynamics of crystal lattices • Lattice vibrations • Thermal expansion • Thermal conduction by phonons • Phonon spectroscopy *SSP Part 2* • Electrons in solids • Free electron gas and Fermi statistics • Specific heat of metals • Thermionic emission of metals - Energy bands in solids • Approximation of quasi free electrons • Examples of band structures and density of states • Influence of external fields • Effective mass • Hole concept • Electrical conductivity of metals • Thermoelectrical effects • Contact potential • Wiedemann-Franz law • Semiconductors • Intrinsic semiconductors • Doping • Experimental methods to determine electronic properties of semiconductors and metals • Amorphous semiconductors • Magnetic properties • Diamagnetism, paramagnetism, ferro- and antiferromagnetism • Dielectric properties • Dielectric constant and polarizability • Optical properties • Ferroelectric solids • Experimental methods to determine the dielectric function
Media	Blackboard, lecture notes Digital presentation (available in the internet)
Literature	• Ch. Kittel, Introduction to Solid State Physics, John Wiley & Sons, New York 1996 • H. Ibach and H. Lüth, Solid State Physics, Springer, New York 1995 • N.W. Ashcroft, N.D. Mermin, Solid State Physics, Saunders College Publishing, New York 1976

<table>
<tr><td>Module number</td><td colspan="4">Mawi 711</td></tr>
<tr><td>Module title</td><td colspan="4">Analytics 1</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">Ana1</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semesters</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Winter Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. E. Quandt</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. E. Quandt and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory subject in term 1</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Business Administration, M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">Graded</td></tr>
<tr><td rowspan="3">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/ Compulsory elective</td><td>SWS</td></tr>
<tr><td>Lecture</td><td>Analytics 1</td><td>compulsory</td><td>2</td></tr>
<tr><td>Practical Exercises</td><td>Analytics 1</td><td>compulsory</td><td>1</td></tr>
<tr><td>Workload</td><td colspan="4">30 h lecture
15 h exercise
45 h self-organized studies
30 h revision

120 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">4 ECTS</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="4">Basic lecture mathematics
Basic lecture physics
Basic lecture chemistry</td></tr>
</table>

Course related work	Submission and presentation of exercises			
Examination(s)	Written or oral examination			
	Title	*Compulsory / Compulsory elective*	*Graded / Ungraded*	*Weighting*
	Analytics 1	Compulsory	Graded	100%
Learning outcome	The students have a deep understanding of advanced analytical techniques listed below. They know the major methods with their potentials and limitations and they can interpret results in a general way. The Students are particularly capable of assessing what kind of analytical tool or combination of tools can serve his future need while pursuing a career in Materials Science and Engineering.			
Content	• Overview over particle beam- and radiation methods for the analysis of interfaces and thin films • Scanning electron microscopy (SEM) • Transmission electron microscopy (TEM) • Ion backscattering methods			
Media	Blackboard, lecture notes Digital presentation (available in the internet)			
Literature	• J.M. Walls (Ed.): Methods of Surface Analysis; Cambridge University Press 1989 • E. Fuchs, H. Oppolzer, H. Rehme: Particle Beam Microanalysis - Fundamentals, Methods and Applications; VCH 1990 • R. Brundle, C.A. Evans Jr., S. Wilson (Eds.): Encyclopedia of Materials Characterization; Butterworth-Heinemann 1992 • Materials Science and Technology (Eds. R.W. Cahn, P. Haasen, E.J. Kramer): Vol.2 Characterization of Materials VCH 1992			

<table>
<tr><td>Module number</td><td colspan="4">Mawi 705</td></tr>
<tr><td>Module title</td><td colspan="4">Advanced Materials A</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">AMatA</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semesters</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Winter Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. J. McCord</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. J. McCord and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory subject in term 1</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="5">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory /Compulsory elective</td><td>SWS</td></tr>
<tr><td>Lecture</td><td>Advanced Materials A - Metals</td><td>compulsory</td><td>2</td></tr>
<tr><td>Lecture</td><td>Advanced Materials A – Electronic Materials 1</td><td>compulsory</td><td>2</td></tr>
<tr><td>Practical Exercises</td><td>Advanced Materials A - Metals</td><td>compulsory</td><td>1</td></tr>
<tr><td>Practical Exercises</td><td>Advanced Materials A – Electronic Materials 1</td><td>compulsory</td><td>1</td></tr>
<tr><td>Workload</td><td colspan="4">60 h lecture
30 h exercise
90 h self-organized studies
60 h revision

240 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">8 ECTS</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
</table>

<table>
<tr><td>Recommended prerequisites</td><td colspan="4">Basic lecture mathematics
Basic lecture physics
Basic lecture chemistry</td></tr>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td rowspan="4">Examination(s)</td><td colspan="4">Combined examination consisting of a written examination after each part.</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Advanced Materials A - Metals</td><td>Compulsory</td><td>Graded</td><td>50%</td></tr>
<tr><td>Advanced Materials A – Electronic Materials 1</td><td>Compulsory</td><td>Graded</td><td>50%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students can compare and contrast the relevant types of bonding for metallic and macromolecular materials, the structural features on all length scales, and the material specific defects. They know the correlation to the mechanical properties and selected functional properties and the revers relation to bonding and microstructure. In this context, they identify and understand the role of defects in determining materials properties. They can use this knowledge to tailor the property profile of engineering metallic and macromolecular materials. They can perform literature searches for solving specific problems and can critically assess the results.

On completion of this module the students understand the physical properties of metallic, conductors, semiconductors, and dielectric materials. The students review the fundamentals of electrical, semiconductor and dielectric devices based on the discussion of the selected functional materials and devices. The students examine technological aspects such as processing of electrical materials.
The students will be able to relate the properties of electronic materials to specific applications and will be able to use their knowledge for the selection of the appropriate material and method for engineering problems.</td></tr>
<tr><td>Content</td><td colspan="4">Metals
• Alloys
• Thermodynamic considerations
• Intermetallic phases
• Mechanical Properties
• Plastic deformation in single crystals via dislocations
• Deformation twinning
• Deformation of polycrystals
• Creep
• Fracture
• Solid solution hardening
• Thermally Activated Processes
• Diffusion
• Recrystallization</td></tr>
</table>

	• Transformation in the solid state • Particle Hardened Alloys • Ferrous and nonferrous alloys • Electronic and magnetic metals Electronic Materials • Conductors • Conduction in metals and alloys • Conductor materials • Ionic conductors and their applications • Superconductivity • Thermoelectricity • Thermal conduction Dielectric properties and materials (incl. ceramics) • Theory of dielectrics • Dielectric materials • Polarization mechanisms incl. frequency behaviour • Complex dielectric function • Ferroelectricity and ferroelectric materials • Piezoelectricity and piezoelectricity materials • Pyroelectrical behaviour • Electro-optic materials
Media	Blackboard, lecture notes Digital presentation (available in the internet)
Literature	• G. Gottstein, Physical Foundations of Materials Science, Springer 2004 (German edition available) • R.E. Reed-Hill and R. Abbaschian, Physical Metallurgy Principles, PWS-Kent 2010 • W.D. Callister, Materials Science and Engineering, Wiley 2000 (or later) • D.R. Askeland, P.P. Fulay & W.J. Wright, The Science and Engineering of Materials, Cengage Learning 2010. • P. Haasen, Physical Metallurgy, Cambridge University Press, Cambridge 1996 (German edition available) • K. Easterling, Modern Physical Metallurgy, Butterworths 1983 • Cottrell, An Introduction to Metallurgy, The Institute of Metals 1995 (reprint at 1975 edition) • N. Stoloff, Physical Metallurgy and Processing, Chapman 1994 • R.E. Smallman and R.J. Bishop, Modern Physical Metallurgy of Materials Engineering, Butterworth/Heinemann/1999 • R. Cahn und P. Haasen (Eds.), Physical Metallurgy, Elsevier Science 1996 • • S. Kasap: Principles of Electronic Materials and Devices, McGraw-Hill, New York • R.E. Hummel: Electronic Properties of Materials, Springer, New York • L.A.A. Warnes: Electronic Materials, MacMillan, London • Moulson, A.J., Herbert, J. M.: Electroceramics (Materials, Properties, Applications); Chapman & Hall, London • Kingery, W.D., Bowen, H.K., Uhlmann, D.R.: Introduction to Ceramics, Wiley-Interscience, New York

	• C. Carter, M. Norton: Ceramic Materials, Springer, New York • Hench, L.L., West, J.K.: Principles of Electronic Ceramics; Wiley-Interscience, New York • G.M. Fasching, Werkstoffe für die Elektrotechnik, Springer, New York

Module number	**Mawi 706**
Module title	**Advanced Materials B**
Module level	Deepening Materials Science
Abbreviation	AMatB
Subtitle (if applicable)	
Duration	1 Semesters
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Prof. Dr. F. Faupel
Lecturer	Prof. Dr. F. Faupel, Prof. J. McCord and staff
Teaching language	English
Assignment to the curriculum	Compulsory subject in term 2
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded

Module courses

Course Type	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
Lecture	Advanced Materials B - Polymers	compulsory	2
Lecture	Advanced Materials B - Electronic Materials 2	compulsory	2
Practical Exercises	Advanced Materials B - Polymers	compulsory	1
Practical Exercises	Advanced Materials B - Electronic Materials 2	compulsory	1

Workload	60 h lecture 30 h exercise 90 h self-organized studies 60 h revision 240 h total workload
Credits	8 ECTS

Prerequisites according to examination order	None

<table>
<tr><td>Recommended prerequisites</td><td colspan="4">Basics materials science
Basics in semiconductors technology
Basics in advanced mathematics</td></tr>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td rowspan="4">Examination(s)</td><td colspan="4">Combined examination consisting of a written examination after each part.</td></tr>
<tr><td>Title</td><td>Compulsory /Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Advanced Materials B - Polymers</td><td>Compulsory</td><td>Graded</td><td>50%</td></tr>
<tr><td>Advanced Materials B - Electronic Materials 2</td><td>Compulsory</td><td>Graded</td><td>50%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">On completion of this module the students understand the physical properties of semiconductors, optical and magnetic materials. The students review the fundamentals of semiconductor, optical, and magnetic devices based on the discussion of the selected functional materials and devices. The students examine technological aspects such as processing of magnetic materials.
The students will be able to relate the properties of optical and magnetic materials to specific applications and will be able to use their knowledge for the selection of the appropriate material and method for engineering problems.</td></tr>
<tr><td>Content</td><td colspan="4">Polymers
• Properties and Classification of Plastics
• Binding Forces and Structure
• Polymer Synthesis
• Polymers in Melts and Solutions
Thermodynamics and chain kinetics
• Crystallization and Glass Formation
• Mechanical Properties
• Dielectric and Optical Properties
• Conducting Polymers
• Sorption, Diffusion and Permeation
• Chemical and Physical Aging, Recycling, Plastics technology

Semiconductors
• Fundamentals of semiconductors
• Semiconductor processing
• Semiconductor devices

Optical properties of materials
• Light waves
• Group velocity, reflection and transmission
• Absorption, complex refractive index
• Absorption, scattering, luminescence
Polarization, birefringence, magneto-optics</td></tr>
</table>

	Magnetic properties of materials • Fundamentals, magnetic moments, diamagnetism • Paramagnetism and ordered magnetism • Magnetic anisotropy • Magnetization processes and magnetic domains • Soft magnetic materials • Hard magnetic materials • Ferrites •
Media	Blackboard, lecture notes Digital presentation (available in the internet)
Literature	• S. Kasap: Principles of Electronic Materials and Devices, McGraw-Hill, New York • S. Kasap: Optoelectronics and Photonics, McGraw-Hill, New York • J.M.D. Coey: Magnetism and Magnetic Materials, Cambridge University Press, Cambridge • G.M. Fasching, Werkstoffe für die Elektrotechnik, Springer, New York • Hyperscripte • R.J. Young, P.A. Lovell: Introduction to Polymers, Chapman & Hall 1991. • L.H. Sperling: Introduction to Physical Polymer Science, John Wiley 1992. • U. Eisele: Introduction to Polymer Physics, Springer 1990. • N.G. McCrum, C.P. Buckley, C.B. Bucknall, Principles of Polymer Engineering, Oxford Science Publications 1995. • G. Menges: Werkstoffkunde Kunststoffe, Hanser 1990 (German) • G. W. Ehrenstein: Polymerwerkstoffe, Hanser 1978 (German) • W. Retting, H.M.Laun: Kunststoffphysik, Hanser 1991 (German). • Hyperscripte: http://www.tf.uni-kiel.de/matwis/amat/admat_en/index.html http://www.tf.uni-kiel.de/matwis/amat/elmat_en/index.html

<table>
<tr><td>Module number</td><td colspan="4">Mawi 707</td></tr>
<tr><td>Module title</td><td colspan="4">Advanced Mathematics</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Mathematics, Natural and Engineering Sciences</td></tr>
<tr><td>Abbreviation</td><td colspan="4">AMath, CompMath</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Winter Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible Institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Dr. J. Carstensen</td></tr>
<tr><td>Lecturer</td><td colspan="4">Dr. J. Carstensen and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory subject in term 1</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="4">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/ Compulsory elective</td><td>SWS</td></tr>
<tr><td>Lecture</td><td>Mathematics for Material Science</td><td>compulsory</td><td>2</td></tr>
<tr><td>Practical Exercises</td><td>Computational Mathematics</td><td>compulsory</td><td>1</td></tr>
<tr><td>Practical Exercises</td><td>Mathematics for Material Science</td><td>compulsory</td><td>1</td></tr>
<tr><td>Workload</td><td colspan="4">30 h lecture
30 h exercise
60 h self-organized studies
60 h revision

180 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">6 ECTS</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
</table>

<table>
<tr><td>Recommended prerequisites</td><td colspan="4">Basics in mathematics</td></tr>
<tr><td>Course related work</td><td colspan="4">• Submission and presentation of exercises
• Short summary of team (2 students) work in computational mathematics</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Written examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Mathematics for Material Science</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students can access a robust "toolbox" containing the listed topics. They have the ability for solving mathematical problems in material science analytically and numerically.
They can write programs in Mathlab for visualizing results in 2D and 3D, analyse measured data and solve transcendent equations and differential equations. The students have a reasonable theoretical mathematical background and a basic understanding of numerical algorithms for an efficient use of computers.</td></tr>
<tr><td>Content</td><td colspan="4">Mathematics for Material Science

Algebra
• Complex numbers
• Complex e-function
• Other complex functions
• Vectors in N-dimensional space
• Matrices
• Square matrices and determinants
• Systems of Linear Equations
• Eigenvalues and Eigenvectors
• Scalar and vector product
• Hermite and unitary matrices with complex components
Calculus I: Functions of one Variable
• Derivatives and Integrals
• Calculation rules of derivatives and integrals
• Sequences and Series
• Taylor series and their application
• Linear Optimization
• Fitting to an orthonormal set of functions
• Functions as vectors
• Schmidt's orthonormalization procedure
• Fourier series
• Fourier-Transforms
• Solution of DEQs by Fourier Transformation
• Fourier Series vs. Fourier Transformation
• Error function
• Gamma function
• Delta function
Calculus II: Functions of multiple variables
• Partial derivatives / Derivatives in certain directions</td></tr>
</table>

	• Total Derivatives • Minimization problems • Simple N-dimensional integrals *Computational Mathematics* General programming • The program Matlab • Variables • Functions • Algorithms • Representation of numbers in computers • Numerical errors Data Visualization • Curves, Histograms, log-scale • 2D • 3D Interpolation • Polynomial interpolation • Cubic spline Finding Zeros • Iterative Methods • Fix Points • Bisectioning • Newton algorithm Numerical Minimization • Linear optimization • Nonlinear optimization • Golden section search • Fitting of data Solving linear systems of equation • Gaußian algorithm • Pivotization Numerical integration • Trapezium rule • Simpson rule • Higher order rules Integration of ordinary differential equations • Euler method • Runge-Kutta method • Stiff sets of differential equations • Implicit algorithms
Media	Blackboard, lecture notes Digital presentation (available in the internet)
Literature	*Mathematics for Material Science* • Script for "Mathematics for Material Science" • Engineering mathematics: a foundation for electronic, electrical, communications and systems engineers, Anthony Croft. - 3. ed. - Harlow, England [u.a.] : Prentice Hall, 2001 • Basic mathematics for electronic engineers: models and applications, John E. Szymanski. - London : Van Nostrand Reinhold, 1989

	• Modern engineering mathematics, Glyn James. - 3rd ed. - Harlow [u.a.] : Prentice Hall, 2001 • Advanced modern engineering mathematics, Glyn James. - 2. ed. - Harlow, England [u.a.] : Addison-Wesley, 1999 *Computational Mathematics* • Script for " Computational Mathematics" • Numerical methods in engineering with MATLAB, Jaan Kiusalaas. - Cambridge [England] : Cambridge University Press, 2005 (auch E-book) • MATLAB for engineers explained, Fredrik Gustafsson. - 2. pr. - London [u.a.] : Springer, 2003 • Getting started with MATLAB 7: a quick introduction for scientists and engineers, Rudra Pratap. - New York [u.a.] : Oxford Univ. Press, 2006 • Numerical recipes in C: the art of scientific computing, William H. Press. - 2. ed.. - Cambridge [u.a.] : Cambridge Univ. Press, 1992

Module number	**Mawi 708**
Module title	**Thermodynamics and Kinetics 1**
Module level	Deepening Chemistry, Physics and Engineering Sciences
Abbreviation	TdK1
Subtitle (if applicable)	Thermodynamics of classical and quantum mechanical particles
Duration	1 Semester
Repetition in academic year	Winter term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Dr. J. Carstensen
Lecturer	Dr. J. Carstensen and staff
Teaching language	English
Assignment to the curriculum	Compulsory subject in term 1
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded

Module courses	*Course Type*	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
	Lecture	Thermodynamics and Kinetics 1	compulsory	2
	Practical Exercises	Thermodynamics and Kinetics 1	compulsory	1

Workload	30 h lecture 15 h exercise 45 h exercise (self-organized studies) 30 h lecture (revision) 120 h total workload
Credits	4 ECTS
Prerequisites according to examination order	Thermodynamics and Kinetics Part 1
Recommended prerequisites	Basic lecture mathematics Basic lecture physics Basic lecture chemistry

<table>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td rowspan="4">Examination(s)</td><td colspan="4">Written examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Thermodynamics and Kinetics 1</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students have an in-depth understanding of chemical thermodynamics and kinetics for material scientists.
The students can deduct the function of model systems, e.g. perfect gas, ideal solution etc. for the calculation of the materials properties. They know how to modify simple models to represent a more realistic point of view, thus enabling the description of real systems. The students have knowledge in practical fields, e.g. how the properties of materials and their technological application are related to their thermodynamic and chemical properties.
The students can combine and use their skills in mathematics, physics and chemistry to the interdisciplinary aspects of thermodynamics and kinetics.</td></tr>
<tr><td>Content</td><td colspan="4">Thermodynamics and Kinetics 1
• Basic properties of gases
• Model of the perfect gas
• Models for real gases
• The First Law
• Theory of state functions
• Heat and work
• Theory of heat capacity
• Enthalpy
• Joule- and Joule-Thomson experiment
• The Second Law
• Heat engines
• Entropy and spontaneity of processes
• Gibbs- and Helmholtz energies
• Thermodynamic potentials and Legendre transformation
• Physical transformations of pure substances
• Phase rule of Gibbs
• Simple phase diagrams (pVT-plots)
• Clapeyron’s equation and its application to phase diagrams
• Ehrenfest classification
• Simple mixtures
• Ideal vs. real mixture
• Entropy of mixing, excess enthalpies
• Chemical potential of real systems, fugacity and activity
• Partial molar quantities- theory and application
• Ideal and ideal dilute solutions
• Raoult’s, Henry’s law and deviations
• Activities of solutions, Activity coefficients</td></tr>
</table>

	• Binary phase diagrams, phase separation, fractional distillation • Equilibrium conditions: mass action law • Response of equilibriums to conditions (T, p) • Electrochemical reactions: Nernst-equation
Media	Blackboard, lecture notes Digital presentation (available in the internet)
Literature	• P. Atkins, Physical Chemistry, 8th ed, Oxford 2006 • Balluffi et al. Kinetics of Materials, Wiley 2004 • David R. Gaskell, Introduction to the Thermodynamics of Materials, Taylor & Francis, New York 2003 • H. Weingärtner: Chemische Thermodynamik, Teubner 2003 • B. S. Bokstein, M. I. Mendelev, D. J. Srolovoitz: Thermodynamics & Kinetics in Materials Science, Oxford University Press 2003

Module number	**Mawi 709**
Module title	**Master Lab 1**
Module level	Deepening Materials Science
Abbreviation	MLC1
Subtitle (if applicable)	
Duration	1 Semester
Repetition in academic year	Winter and summer term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Dr. O. Riemenschneider
Lecturer	Dr. O. Riemenschneider and staff
Teaching language	English
Assignment to the curriculum	Compulsory subject in term 1, 2 or 3
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	ungraded
Module courses	*Course Type* / *Course Name* / *Compulsory/ Compulsory elective* / *SWS* Lab course / Master Lab 1 / compulsory / 3
Workload	24 h lab course (8 experiments) 16 h preparation time (self-organized studies) 80 h lab report writing (revision) 120 h total workload
Credits	4 ECTS
Prerequisites according to examination order	None
Recommended prerequisites	Knowledge of basics obtained during bachelors course
Course related work	None
Examination(s)	8 certificates including colloquium, experimentation and report

Module courses:

Course Type	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
Lab course	Master Lab 1	compulsory	3

	Title	Compulsory / Compulsory elective	Graded / Ungraded	Weighting
	Master Lab 1	Compulsory	Ungraded	100%

Learning outcome	The students have experiences in practical working in a modern science lab. Depending on their selection they know the most important preparative (P) or analytic (A) tools for solid materials and how to use them. (The learning outcome of the module consist of the selection of the experiments and their specific leaning outcomes.) They have realized the need and importance of safe lab working and acquired the ability to provide rules and equipment for this. The students can work safe and effective under lab conditions They work in a team and know how to arrange tasks and time. The students are able to document their work in an appropriate way and can summarize their results in intelligible and precise lab reports.
Content	Hands-on experiments on selected topics in Materials Science and Engineering and related fields. (P -) indicates preparative and (A -) analytic tools and the specific learning outcome. 8 experiments out of the following list without repetition in module mawi-709, mawi-804 and mawi-938: • M101 Evaporation Methods (P – knowledge of and experiences in evaporation deposition) • M102 Spin Coating (P – knowledge of and experiences in thin film deposition by means of spin coating) • M103 Nanostructuring of Copper surfaces (P – knowledge of properties nanostructured surfaces and experiences of their preparation) • M104 Etching of Semiconductors (P – knowledge of and experiences in etching of semiconductors) • M105 Micro Electromechanical Systems (P – knowledge of and experiences in lithography processes needed to process MEMS) • M106 Vibrating Sample Magnetometry (A – knowledge of and experiences in magnetic characterization of ferromagnetic samples) • M107 Chemical Solution Deposition of Lead Zirconate Titanate Thin Films (P/A – knowledge of piezo electric materials and experiences in their preparation) • M108 Atomic Force Microscopy (A – knowledge of and experiences in studying surface morphology) • M109 Scanning Electron Microscopy (A - knowledge of and experiences in studying bulk morphology) • M110 Differential Thermal Analysis (A - knowledge of and experiences in thermal analysis of materials) • M111 Biocompatibility Tests of Materials (P/A - knowledge of and experiences in testing the biocompatibility of materials) • M112 Scanning Tunnel Microscopy (A - knowledge of and experiences in contact free studying surface morphology)

	• M202 Sorption and Diffusion in Membranes (P - knowledge of and experiences in thermal gravimetric analysis) • M203 Photocatalysis (A - knowledge of and experiences in characterizing photo catalysis) • M205 Magnetostrictive Materials (P/A - knowledge of and experiences in characterizing of magneto restrictive materials) • M206 Tunnelling Magneto Resistance (A - knowledge of and experiences in characterizing magento resistance) • M208 Impedance Spectroscopy (A - knowledge of and experiences in impedance spectroscopy) • M209 MOKE Microscopy (A - knowledge of and experiences in characterizing materials by means of magneto-optical kerr effect) • M210 X-ray Photoelectron Spectroscopy (A - knowledge of and experiences in chemical characterizing of a surface) • M211 Dynamical-Mechanical Analysis of Polymers (A - knowledge of and experiences in characterizing mechanical properties of solid materials) • M213 Shape Memory Alloys (A - knowledge of and experiences in characterizing mechanical properties of shape memory alloys) • M214 Delta-E-Effect Sensor (A - knowledge of and experiences in delta-E-sensors and their characteristics) • M215 Composition Analysis of Heterostructure Lasers (A - knowledge of and experiences in characterizing materials by means of TEM)
Media	Transmission and measurement equipment
Literature	Manuals are available for all experiments at www.tf.uni-kiel.de/servicezentrum/en/studium/praktika?set_language=en. They contain individual literature references for all experiments.

Module number	**Mawi 803**
Module title	**Thermodynamics and Kinetics 2**
Module level	Deepening Chemistry, Physics and Engineering Sciences
Abbreviation	TdK2
Subtitle (if applicable)	Thermodynamics of classical and quantum mechanical particles
Duration	1 Semester
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Dr. J. Carstensen
Lecturer	Dr. J. Carstensen and staff
Teaching language	English
Assignment to the curriculum	Compulsory subject in term 2
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded

Module courses:

Course Type	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
Lecture	Thermodynamics and Kinetics 2	compulsory	2
Practical Exercises	Thermodynamics and Kinetics 2	compulsory	1

Workload	30 h lecture 15 h exercise 45 h exercise (self-organized studies) 30 h lecture (revision) 120 h total workload
Credits	4 ECTS
Prerequisites according to examination order	None
Recommended prerequisites	Basic lecture mathematics Basic lecture physics Basic lecture chemistry

<table>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Written examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Thermodynamics and Kinetics 2</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students have knowledge about transport mechanisms and models, the statistical approach for calculating partition functions and thermodynamic potentials. They can combine these to aspects of solid state physics by discussing non-linear dynamics e.g. of a Laser and the relaxation time approximation of the Boltzmann equation.
The students can combine and use their skills in mathematics, physics and chemistry to the interdisciplinary aspects of thermodynamics and kinetics.</td></tr>
<tr><td>Content</td><td colspan="4">• Kinetic model of free classical particles (ideal gas)
• Maxwell speed distribution
• Simple transport model: mean free path
• Non stationary condition: continuity equation
• Configuration, weights, and probabilities
• Distribution functions
• Information and grand canonical ensemble
• Fermi-, Bose, Boltzmann-distribution
• The free Boson
• Description of non-equilibrium: Laser as example
• The Boltzmann equation: relaxation time approximation
• Solution for free electron gas: ohms law, diffusion, heat transport</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">• P. Atkins, Physical Chemistry, 8th ed, Oxford 2006
• Balluffi et al. Kinetics of Materials, Wiley 2004
• David R. Gaskell, Introduction to the Thermodynamics of Materials, Taylor & Francis, New York 2003
• H. Weingärtner: Chemische Thermodynamik, Teubner 2003
• B. S. Bokstein, M. I. Mendelev, D. J. Srolovoitz: Thermodynamics & Kinetics in Materials Science, Oxford University Press 2003</td></tr>
</table>

Module number	**Mawi 804**			
Module title	**Master Lab 2**			
Module level	Deepening Materials Science			
Abbreviation	MLC2			
Subtitle (if applicable)				
Duration	1 Semester			
Repetition in academic year	Summer Term			
Responsible faculty	Faculty of Engineering			
Responsible institute	Institute for Materials Science			
Responsible staff member	Dr. O. Riemenschneider			
Lecturer	Dr. O. Riemenschneider and staff			
Teaching language	English			
Assignment to the curriculum	Compulsory subject in term 1, 2 or 3			
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering			
Evaluation	ungraded			
Module courses	*Course Type*	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
	Lab course	Master Lab 2	compulsory	3
Workload	24 h lab course (8 experiments) 16 h preparation time (self-organized studies) 80 h lab report writing (revision) 120 h total workload			
Credits	4 ECTS			
Prerequisites according to examination order	None			
Recommended prerequisites	Knowledge of basics obtained during bachelors course			
Course related work	None			
Examination(s)	8 certificates including colloquium, experimentation and report			

<table>
<tr><td rowspan="2"></td><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Master Lab 2</td><td>Compulsory</td><td>Ungraded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students have experiences in practical working in a modern science lab.
Depending on their selection they know the most important preparative (P) or analytic (A) tools for solid materials and how to use them. (The learning outcome of the module consist of the selection of the experiments and their specific leaning outcomes.)
They have realized the need and importance of safe lab working and acquired the ability to provide rules and equipment for this.
The students can work safe and effective under lab conditions
They work in a team and know how to arrange tasks and time.
The students are able to document their work in an appropriate way and can summarize their results in intelligible and precise lab reports.</td></tr>
<tr><td>Content</td><td colspan="4">Hands-on experiments on selected topics in Materials Science and Engineering and related fields. (P -) indicates preparative and (A -) analytic tools and the specific learning outcome.

8 experiments out of the following list without repetition in module mawi-709, mawi-804 and mawi-938:

• M101 Evaporation Methods (P – knowledge of and experiences in evaporation deposition)
• M102 Spin Coating (P – knowledge of and experiences in thin film deposition by means of spin coating)
• M103 Nanostructuring of Copper surfaces (P – knowledge of properties nanostructured surfaces and experiences of their preparation)
• M104 Etching of Semiconductors (P – knowledge of and experiences in etching of semiconductors)
• M105 Micro Electromechanical Systems (P – knowledge of and experiences in lithography processes needed to process MEMS)
• M106 Vibrating Sample Magnetometry (A – knowledge of and experiences in magnetic characterization of ferromagnetic samples)
• M107 Chemical Solution Deposition of Lead Zirconate Titanate Thin Films (P/A – knowledge of piezo electric materials and experiences in their preparation)
• M108 Atomic Force Microscopy (A – knowledge of and experiences in studying surface morphology)
• M109 Scanning Electron Microscopy (A - knowledge of and experiences in studying bulk morphology)
• M110 Differential Thermal Analysis (A - knowledge of and experiences in thermal analysis of materials)
• M111 Biocompatibility Tests of Materials (P/A - knowledge of and experiences in testing the biocompatibility of materials)
• M112 Scanning Tunnel Microscopy (A - knowledge of and experiences in contact free studying surface morphology)</td></tr>
</table>

	• M202 Sorption and Diffusion in Membranes (P - knowledge of and experiences in thermal gravimetric analysis) • M203 Photocatalysis (A - knowledge of and experiences in characterizing photo catalysis) • M205 Magnetostrictive Materials (P/A - knowledge of and experiences in characterizing of magneto restrictive materials) • M206 Tunnelling Magneto Resistance (A - knowledge of and experiences in characterizing magento resistance) • M208 Impedance Spectroscopy (A - knowledge of and experiences in impedance spectroscopy) • M209 MOKE Microscopy (A - knowledge of and experiences in characterizing materials by means of magneto-optical kerr effect) • M210 X-ray Photoelectron Spectroscopy (A - knowledge of and experiences in chemical characterizing of a surface) • M211 Dynamical-Mechanical Analysis of Polymers (A - knowledge of and experiences in characterizing mechanical properties of solid materials) • M213 Shape Memory Alloys (A - knowledge of and experiences in characterizing mechanical properties of shape memory alloys) • M214 Delta-E-Effect Sensor (A - knowledge of and experiences in delta-E-sensors and their characteristics) • M215 Composition Analysis of Heterostructure Lasers (A - knowledge of and experiences in characterizing materials by means of TEM)
Media	Transmission and measurement equipment
Literature	Manuals are available for all experiments at www.tf.uni-kiel.de/servicezentrum/en/studium/praktika?set_language=en. They contain individual literature references for all experiments.

Module number	**Mawi 805**			
Module title	**Analytics 2**			
Module level	Deepening Materials Science			
Abbreviation	Ana2			
Subtitle (if applicable)				
Duration	1 Semester			
Repetition in academic year	Summer Term			
Responsible faculty	Faculty of Engineering			
Responsible institute	Institute for Materials Science			
Responsible staff member	Prof. Dr. E. Quandt			
Lecturer	Prof. Dr. E. Quandt and staff			
Teaching language	English			
Assignment to the curriculum	Compulsory elective subject in term 2			
Usability of the module	1-subject study course M.Sc. Materials Science and Business Administration, M.Sc. Materials Science and Engineering			
Evaluation	Graded			
Module courses	*Course Type*	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
	Lecture	Analytics 2	compulsory	2
	Practical Exercises	Analytics 2	compulsory	1
Workload	30 h lecture 15 h exercise 45 h self-organized studies 30 h revision 120 h total workload			
Credits	4 ECTS			
Prerequisites according to examination order	None			
Recommended prerequisites	Basic lecture mathematics Basic lecture physics Basic lecture chemistry			

<table>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Written or oral examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Analytics 2</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students have a deep understanding of advanced analytical techniques as listed below. They know the major methods with their potentials and limitations and they can interpret results in a general way.
The Students are particularly capable of assessing what kind of analytical tool or combination of tools can serve his future need while pursuing a career in Materials Science and Engineering.</td></tr>
<tr><td>Content</td><td colspan="4">• Secondary ion mass spectroscopy
• Overview over methods for analysis of surfaces and interfaces
• Electron emission spectroscopy methods
• Scanning probe microscopy
• X-ray methods</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">• J.M. Walls (Ed.): Methods of Surface Analysis; Cambridge University Press 1989
• E. Fuchs, H. Oppolzer, H. Rehme: Particle Beam Microanalysis - Fundamentals, Methods and Applications; VCH 1990
• R. Brundle, C.A. Evans Jr., S. Wilson (Eds.): Encyclopedia of Materials Characterization; Butterworth-Heinemann 1992
• Materials Science and Technology (Eds. R.W. Cahn, P. Haasen, E.J. Kramer): Vol.2 Characterization of Materials VCH 1992</td></tr>
</table>

Module number	**Mawi 938**			
Module title	**Master Lab 3**			
Module level	Deepening Materials Science			
Abbreviation	MLC3			
Subtitle (if applicable)				
Duration	1 Semester			
Repetition in academic year	Winter Term			
Responsible faculty	Faculty of Engineering			
Responsible institute	Institute for Materials Science			
Responsible staff member	Dr. O. Riemenschneider			
Lecturer	Dr. O. Riemenschneider and staff			
Teaching language	English			
Assignment to the curriculum	Compulsory subject in term 1, 2 or 3			
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering			
Evaluation	ungraded			
Module courses	*Course Type*	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
	Lab course	Master Lab 3	compulsory	3
Workload	24 h lab course (8 experiments) 16 h preparation time (self-organized studies) 80 h lab report writing (revision) 120 h total workload			
Credits	4 ECTS			
Prerequisites according to examination order	None			
Recommended prerequisites	Knowledge of basics obtained during bachelors course			
Course related work	None			
Examination(s)	8 certificates including colloquium, experimentation and report			

<table>
<tr><td rowspan="2"></td><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Master Lab 3</td><td>Compulsory</td><td>Ungraded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students have experiences in practical working in a modern science lab.
Depending on their selection they know the most important preparative (P) or analytic (A) tools for solid materials and how to use them. (The learning outcome of the module consist of the selection of the experiments and their specific leaning outcomes.)
They have realized the need and importance of safe lab working and acquired the ability to provide rules and equipment for this.
The students can work safe and effective under lab conditions
They work in a team and know how to arrange tasks and time.
The students are able to document their work in an appropriate way and can summarize their results in intelligible and precise lab reports.</td></tr>
<tr><td>Content</td><td colspan="4">Hands-on experiments on selected topics in Materials Science and Engineering and related fields. (P -) indicates preparative and (A -) analytic tools and the specific learning outcome.

8 experiments out of the following list without repetition in module mawi-709, mawi-804 and mawi-938:

• M101 Evaporation Methods (P – knowledge of and experiences in evaporation deposition)
• M102 Spin Coating (P – knowledge of and experiences in thin film deposition by means of spin coating)
• M103 Nanostructuring of Copper surfaces (P – knowledge of properties nanostructured surfaces and experiences of their preparation)
• M104 Etching of Semiconductors (P – knowledge of and experiences in etching of semiconductors)
• M105 Micro Electromechanical Systems (P – knowledge of and experiences in lithography processes needed to process MEMS)
• M106 Vibrating Sample Magnetometry (A – knowledge of and experiences in magnetic characterization of ferromagnetic samples)
• M107 Chemical Solution Deposition of Lead Zirconate Titanate Thin Films (P/A – knowledge of piezo electric materials and experiences in their preparation)
• M108 Atomic Force Microscopy (A – knowledge of and experiences in studying surface morphology)
• M109 Scanning Electron Microscopy (A - knowledge of and experiences in studying bulk morphology)
• M110 Differential Thermal Analysis (A - knowledge of and experiences in thermal analysis of materials)
• M111 Biocompatibility Tests of Materials (P/A - knowledge of and experiences in testing the biocompatibility of materials)
• M112 Scanning Tunnel Microscopy (A - knowledge of and experiences in contact free studying surface morphology)</td></tr>
</table>

	• M202 Sorption and Diffusion in Membranes (P - knowledge of and experiences in thermal gravimetric analysis) • M203 Photocatalysis (A - knowledge of and experiences in characterizing photo catalysis) • M205 Magnetostrictive Materials (P/A - knowledge of and experiences in characterizing of magneto restrictive materials) • M206 Tunnelling Magneto Resistance (A - knowledge of and experiences in characterizing magento resistance) • M208 Impedance Spectroscopy (A - knowledge of and experiences in impedance spectroscopy) • M209 MOKE Microscopy (A - knowledge of and experiences in characterizing materials by means of magneto-optical kerr effect) • M210 X-ray Photoelectron Spectroscopy (A - knowledge of and experiences in chemical characterizing of a surface) • M211 Dynamical-Mechanical Analysis of Polymers (A - knowledge of and experiences in characterizing mechanical properties of solid materials) • M213 Shape Memory Alloys (A - knowledge of and experiences in characterizing mechanical properties of shape memory alloys) • M214 Delta-E-Effect Sensor (A - knowledge of and experiences in delta-E-sensors and their characteristics) • M215 Composition Analysis of Heterostructure Lasers (A - knowledge of and experiences in characterizing materials by means of TEM)
Media	Transmission and measurement equipment
Literature	Manuals are available for all experiments at www.tf.uni-kiel.de/servicezentrum/en/studium/praktika?set_language=en. They contain individual literature references for all experiments.

Technical Compulsory Elective Modules of the Master Course

Module number	**Mawi 903**			
Module title	**Electron Microscopy**			
Module level	Deepening Materials Science			
Abbreviation	ELM			
Subtitle (if applicable)				
Duration	1 Semester			
Repetition in academic year	Summer Term			
Responsible faculty	Faculty of Engineering			
Responsible institute	Institute for Materials Science			
Responsible staff member	Prof. Dr. L. Kienle			
Lecturer	Prof. Dr. L. Kienle and staff			
Teaching language	English			
Assignment to the curriculum	Compulsory elective subject in term 3			
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering			
Evaluation	graded			
Module courses	*Course Type*	*Course Name*	*Compulsory /Compulsory elective*	*SWS*
	Lecture	Electron Microscopy	compulsory	3
	Practical Exercises	Electron Microscopy	compulsory	2
Workload	45 h lecture 30 h exercise 75 h self-organized studies 60 h revision 210 h total workload			
Credits	7 ECTS			
Prerequisites according to examination order	None			
Recommended prerequisites	Basic lecture in physics			
Course related work	Submission and presentation of exercises			

<table>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Oral examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Electron Microscopy</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">On successful completion of this module students have gained knowledge about the setup and the technology of electron microscopes. They have gained an insight in the work, the handling, and the possibilities of a TEM. The students are able to outline strategies for analysing unknown materials using the methods introduced in the lectures.</td></tr>
<tr><td>Content</td><td colspan="4">• Introduction to TEM and SEM
• Hardware
• Imaging, Diffraction, Spectroscopy
• Electron crystallography
• Theory of domain crystals
• Advanced analytical techniques
• Characterization of magnetic structure
• EM in Material Science
• In situ observations
• TEM on nanomaterials
• Real structure and diffuse scattering
• Crystal defects, e.g. twinning
• Combined approach for structure analysis</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">• Williams, C. B. Carter : Transmission Electron Microscopy- A Textbook for Materials Science 2nd Edition Springer 2009
• L. Reimer, H. Kohl: Transmission Electron Microscopy: Physics of Image Formation, Springer 2009</td></tr>
</table>

<table>
<tr><td>Module number</td><td colspan="4">Mawi 904</td></tr>
<tr><td>Module title</td><td colspan="4">Micro- and Nanosystem Technology</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">MNST</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Summer Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. E. Quandt
Prof. Dr. B. Wagner</td></tr>
<tr><td>Lecturers</td><td colspan="4">Prof. Dr. E. Quandt, Prof. Dr. B. Wagner and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory elective subject in term 3</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="3">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/ Compulsory elective</td><td>SWS</td></tr>
<tr><td>Lecture</td><td>Micro- and Nanosystem Technology</td><td>compulsory</td><td>3</td></tr>
<tr><td>Lab course</td><td>Micro- and Nanosystem Technology</td><td>compulsory</td><td>2</td></tr>
<tr><td>Workload</td><td colspan="4">45 h lecture
30 h lab course
75 h self-organized studies
60 h revision

210 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">7</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="4">Basics in solid state physics
Basics in materials science
Basics in optics</td></tr>
</table>

<table>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Written examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Micro- and Nanosystem Technology</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students have knowledge about the theoretical background and practical exercise in the clean room laboratory in view of a typical device fabrication. They know specific techniques involved in MEMS fabrication as UV-lithography and plasma enhanced chemical vapour deposition and have practical experiences on this. The students can work safe and to specific cleanroom regulations.</td></tr>
<tr><td>Content</td><td colspan="4">• Introduction to micro- and nanosystem technology
• Cleanroom technology
• Optical and electron beam lithography
• Thin film deposition: PECVD, sputtering, evaporation, pulse laser deposition
• Wet and dry etching
• Optical and scanning electron microscope inspection
• MEMS materials
• MEMS technologies
• Doping of silicon
• Micromechanical sensors
• Piezoelectric transducers
• Thermal sensors and actuators
• MOEMS
• MEMS packaging</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">• Marc J. Madou, Fundamentals of microfabrication: the science of miniaturization, CRC Press, 2002
• J. Plummer, M. Deal, P. Griffin, Silicon VLSI technology, Prentice Hall 2000
• M.A. McCord, M.J. Rooks, Handbook of Microlithography, Micromachining and Microfabrication – Vol 1, SPIE Optical Engineering Press, 1997
• P. Rai-Choudhury, Handbook of microlithography, micromachining, and microfabrication – Vol 2, SPIE Optical Engineering Press [u.a.], 1997
• Chang Liu, Foundations of MEMS, Pearson Education, New Jersey, 2006
• Sergey E. Lyshevski, MEMS and NEMS: Systems, Devices, and Structures, Series: Nano- and Microscience, Engineering, Technology and Medicine Volume: 2, CRC Press, New York, 2002</td></tr>
</table>

<table>
<tr><td>Module number</td><td colspan="4">Mawi 907</td></tr>
<tr><td>Module title</td><td colspan="4">Semiconductors and Defects</td></tr>
<tr><td>Module level</td><td colspan="4">Advanced Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">SCD</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Summer Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. R. Adelung</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. R. Adelung and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory elective subject in term 3</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="3">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/ Compulsory elective</td><td>SWS</td></tr>
<tr><td>Lecture</td><td>Semiconductors and Defects</td><td>compulsory</td><td>2</td></tr>
<tr><td>Practical Exercises</td><td>Semiconductors and Defects</td><td>compulsory</td><td>1</td></tr>
<tr><td>Workload</td><td colspan="4">30 h lecture
15 h exercise
75 h self-organized studies
30 h revision

150 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">5 ECTS</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="4">Lecture Advanced Mathematics
Basic in semiconductor theory
Basics in silicon technology
Basics in thin film technology</td></tr>
</table>

Course related work	Exercises are seminar-styled. Student groups (2-3) present a specified topic and write it down in a formalized way (paper as in conference proceedings)			
Examination(s)	Oral examination			
	Title	*Compulsory / Compulsory elective*	*Graded / Ungraded*	*Weighting*
	Semiconductors and Defects	Compulsory	Graded	100%
Learning outcome	The students know the essentials of semiconductor physics and technology with a focus on semiconductors other than Si, important products, and key technologies. They have a thorough understanding of semiconductor physics, from the free electron gas to topics like Shockley-Read-Hall theory, advanced junction theory or quantitative Laser conditions. The students have a good understanding of various semiconductors in terms of properties and limits. They have a thorough understanding of the basics of LED's and semiconductor Lasers plus a deeper insight into some selected specialities. The students have basic knowledge of some special semiconductors (e.g. organic semiconductors, selected II-VI's, or SiC). Students are able to understand the rapid advances of semiconductor products and technology within a framework consisting of theory, specific material properties and limitations, and available technology. They emerge with a broad competence in dealing with the specific physical semiconductor culture (including the "slang") and are able to deal with the mathematics, often encountered in the form of rather long equations because they understand the underlying basic principles. They are ready to assume suitable engineering positions in the industry with a minimum of introductory time.			
Content	*Band theory* Essentials of the Free Electron Gas; Energy Gaps and General Band Structure; Periodic Potentials and Bloch's Theorem; Band Structures and Standard Representations. *Semiconductor physics* Intrinsic properties in equilibrium; Doping, carrier concentration, mobility, and conductivity; Lifetime and diffusion length; Effective masses; Quasi Fermi energies; Shockley-Read-Hall recombination; Junctions and devices. *Fundamentals of optoelectronics* Materials and radiant recombination; Recombination and luminescence; Doping of compound semiconductors; Wavelength engineering; Light and semiconductors; Total efficiency of light generation; Absorption and emission of light. *Heterojunctions* Ideal heterojunctions; Isotype junctions, modulation doping, and quantum effects; Real heterojunctions; Quantum devices; Single and multiple quantum wells. *Principles of the semiconductor LASER*			

	LASER conditions; Interaction of light and electrons and inversion; Light amplification in semiconductors; From amplification to oscillation; Second Laser condition; Laser modes. *Light emitting devices* Basic requirements and design principles; Products, market, materials, and technologies; Selected LED concepts; Optimizing light confinement and gain in Laser diodes; Double heterojunctions; Key technologies. *Special Semiconductor* Siliconcarbide, Materials aspects and applications; Galliumnitride; II - VI Semiconductors; Semiconducting polymers.
Media	Blackboard, lecture notes Digital presentation (available in the internet)
Literature	Complete interactive internet script http://www.tf.uni-kiel.de/matwis/amat/semi_en/index.html Selected text books for special topics given in script

<table>
<tr><td>Module number</td><td colspan="4">Mawi 909</td></tr>
<tr><td>Module title</td><td colspan="4">Smart Materials</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">SM</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Summer Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. E. Quandt</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. E. Quandt and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory elective subject in term 3</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="3">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/Compulsory elective</td><td>SWS</td></tr>
<tr><td>Lecture</td><td>Smart Materials</td><td>compulsory</td><td>2</td></tr>
<tr><td>Practical Exercises</td><td>Smart Materials</td><td>compulsory</td><td>1</td></tr>
<tr><td>Workload</td><td colspan="4">30 h lecture
15 h exercise
75 h self-organized studies
30 h revision

150 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">5</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="4">Basics in solid state physics
Basics in materials science</td></tr>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td>Examination(s)</td><td colspan="4">Written examination</td></tr>
</table>

<table>
<tr><td rowspan="2"></td><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Smart Materials</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students have basic knowledge about the domain of smart materials.
The students know the correlation between composition, microstructure and properties of smart and multiferroic materials.
They have a compendium for themselves over smart materials for understanding new approaches to materials sciences problems.
The students know scientific purchase as well as bulk fabrication rules.</td></tr>
<tr><td>Content</td><td colspan="4">Smart Materials
Classification
Application Areas
Piezoelectric Materials
Piezoeffect
Piezoelectric Materials
Ferroelectricity
Fabrication
Applications
Magnetostrictive Materials
Magnetostriction
Cryogenic Materials
Rare Earth - Fe phases
Thin Film Materials
Applications
Shape Memory Alloys
Shape Memory Effects
Superelasticity
TiNi - based materials
Shape Memory Thin Films
Applications
Multiferroic Materials
Magnetic Shape Memory Materials
Magnetoelectric Composites</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">K. Uchino, Ferroelectric Devices, New York: Marcel Dekker, 2000
Giant magnetostrictive materials: physics and device applications, Ed: G. Engdahl. San Diego: Academic Press, 2000
C. M. Wayman und K. Otsuka, Shape Memory Materials, Cambridge University Press, 1999</td></tr>
</table>

<table>
<tr><td>Module number</td><td colspan="4">Mawi 911</td></tr>
<tr><td>Module title</td><td colspan="4">Thin Films</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">TF</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Summer Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. K. Rätzke</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. K. Rätzke and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory elective subject in term 3</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="3">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/Compulsory elective</td><td>SWS</td></tr>
<tr><td>Lecture</td><td>Thin Films</td><td>compulsory</td><td>3</td></tr>
<tr><td>Practical Exercises</td><td>Thin Films</td><td>compulsory</td><td>2</td></tr>
<tr><td>Workload</td><td colspan="4">45 h lecture
30 h exercise
75 h self-organized studies
60 h revision

210 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">7</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="4">Lectures “Advanced Materials A”, “Solid State Physics” and “Analytics”</td></tr>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td>Examination(s)</td><td colspan="4">Written examination</td></tr>
</table>

<table>
<tr><td rowspan="2"></td><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Thin Films</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are familiar with vacuum technology and deposition systems, can compare different techniques for that and select the appropriate method for their experiments. They can perform simple calculations with respect to vacuum. They can perform experiments on thin film deposition apparatus and understand the background of the machines (not black boxes anymore). They know the relation between deposition parameters and the corresponding thin film microstructure and can select proper methods to analyse their samples. They can develop own experiments and justify their decisions.</td></tr>
<tr><td>Content</td><td colspan="4">• Vacuum physics
• Deposition methods
• Properties of Thin Films
• Thin film growth characterization
• Epitaxy
• Microstructural evolution
• Interdiffusion and reactive diffusion
• Mechanical properties
• Electrical, magnetic and optical properties
• Thin polymeric films</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">• M. Ohring, The Materials Science of Thin films, Academic Press, 1992, 2000 2nd edition
• D.L. Smith, Thin Film Deposition, McGraw Hill, 1995
• K.N. Tu et al. Electronic Thin Film Science, Macmillan, 1992
• R.C. O'Handley, Modern Magnetic Materials, Wiley, 2000</td></tr>
</table>

Module number	**Mawi 913**
Module title	**Cell Mechanics**
Module level	Deepening Materials Science
Abbreviation	CM
Subtitle (if applicable)	
Duration	1 Semester
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible Institute	Institute for Materials Science
Responsible staff member	Prof. Dr. C. Selhuber
Lecturer	Prof. Dr. C. Selhuber and staff
Teaching language	English
Assignment to the curriculum	Compulsory elective subject in term 3
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded
Module courses	*Course Type* / *Course Name* / *Compulsory/Compulsory elective* / *SWS* Lecture / Cell Mechanics / compulsory / 2 Practical Exercises / Cell Mechanics / compulsory / 2
Workload	30 h lecture 30 h exercise 45 h self-organized studies 45 h revision 150 h total workload
Credits	5 ECTS
Prerequisites according to examination order	None
Recommended Prerequisites	Knowledge in Mathematics and Mechanics from Bachelor courses
Course related work	Submission and presentation of exercises

Module courses:

Course Type	*Course Name*	*Compulsory/Compulsory elective*	*SWS*
Lecture	Cell Mechanics	compulsory	2
Practical Exercises	Cell Mechanics	compulsory	2

<table>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Written examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Cell Mechanics</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students can predict the physical properties of polymer under given conditions and apply this knowledge to the most common biological polymers in cells.
They are able to apply elasticity theory in two and three dimensions, to predict properties of networks with different number of coordination and symmetries, e.g. in membrane-associated networks.
They know how to estimate the forces between surfaces of living organisms, e.g. in adhesion processes.
The students discuss the origin of simple motion of living organisms and design principles for e.g. achieving an optimum size.
They evaluate experimental techniques for studying physical properties of living matter, in particular cell-material interactions.
The students can apply the different language of biology and in this way increase their competence to carry out interdisciplinary research in general.
The students have experiences in reading and extracting literature and discuss the status of international research by working with recent research articles</td></tr>
<tr><td>Content</td><td colspan="4">The course focuses on the mechanical properties of living cells. Particular emphasis will be given to the interaction of cells and materials.
Content of the lectures:
• Introduction to cell organization and structure
• Mechanical properties of polymers
• 2D and 3D polymer networks
• Intermembrane forces
• Dynamic filaments
• Molecular motors
• Mechanical design of cells
• Cell adhesion
• Imaging the cell-material contact
• Force measurements on cells
• Cell-material interactions
In the exercises, current experimental and theoretical topics in cell mechanics will be discussed.</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">David Boal: Mechanics of the Cell, Cambridge University Press, 2001.
Additional literature (scientific articles, notes) will be handed out during the course.</td></tr>
</table>

Module number	**Mawi 918**
Module title	**Advanced Metallic Materials**
Module level	Deepening Materials Science
Abbreviation	AMM
Subtitle (if applicable)	
Duration	1 Semester
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible Institute	Institute for Materials Science
Responsible staff member	Prof. Dr. F. Faupel
Lecturer	Prof. Dr. F. Faupel and staff
Teaching language	English
Assignment to the curriculum	Compulsory elective subject in term 3
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded
Module courses	*Course Type*: Advanced Seminar; *Course Name*: Advanced Metallic Materials; *Compulsory/Compulsory elective*: compulsory; *SWS*: 2
Workload	30 h seminar 45 h self-organized studies 15 h preparation of presentation 90 h total workload
Credits	3 ECTS
Prerequisites according to examination order	None
Recommended Prerequisites	Basics in Metals
Course related work	None

Module courses:

Course Type	*Course Name*	*Compulsory/Compulsory elective*	*SWS*
Advanced Seminar	Advanced Metallic Materials	compulsory	2

<table>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Presentation with written summery</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Advanced Metallic Materials</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are able to make themselves familiar with complex materials concepts and design principles related to metallic materials. They can draw information not only from textbooks but also from state of the art review articles and original literature. They can critically assess the search results and can select the crucial information and condense it into a review talk. They can prepare an interesting presentation in terms of both layout of the slides and presentation style. They can defend their presentation in a scientific discussion. They are able to discuss critically the presentations of fellow students. They can chair sessions. They are able to assess their own performance and that of fellow students.</td></tr>
<tr><td>Content</td><td colspan="4">Each participant gives a talk on a topic in the field of advanced metallic materials. The topics range from processing through structural and functional properties to applications. The talks are followed by a discussion.</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">It is part of the task to find appropriate literature. On request, the lecturer gives hints also with respect to the outline of the presentation.</td></tr>
</table>

<table>
<tr><td>Module number</td><td colspan="4">Mawi 919</td></tr>
<tr><td>Module title</td><td colspan="4">Advanced Organic Materials</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">AOM</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Summer Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. F. Faupel</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. F. Faupel and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory elective subject in term 3</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="2">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/ Compulsory elective</td><td>SWS</td></tr>
<tr><td>Advanced Seminar</td><td>Advanced Organic Materials</td><td>compulsory</td><td>2</td></tr>
<tr><td>Workload</td><td colspan="4">30 h seminar
45 h self-organized studies
15 h preparation of presentation

90 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">3 ECTS</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
<tr><td>Recommended Prerequisites</td><td colspan="4">Basics in Polymers</td></tr>
<tr><td>Course related work</td><td colspan="4">None</td></tr>
</table>

<table>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Presentation with written summery</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Advanced Organic Materials</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are able to make themselves familiar with complex materials concepts and design principles related to organic materials. They can draw information not only from textbooks but also from state of the art review articles and original literature. They can critically assess the search results and can select the crucial information and condense it into a review talk. They can prepare an interesting presentation in terms of both layout of the slides and presentation style. They can defend their presentation in a scientific discussion. They are able to discuss critically the presentations of fellow students. They can chair sessions. They are able to assess their own performance and that of fellow students.</td></tr>
<tr><td>Content</td><td colspan="4">Each participant gives a talk on a topic in the field of advanced organic materials. The topics range from processing through structural and functional properties to applications. The talks are followed by a discussion.</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">It is part of the task to find appropriate literature. On request, the lecturer gives hints also with respect to the outline of the presentation.</td></tr>
</table>

Module number	**Mawi 921**
Module title	**Magnetic Materials: Physics and Applications**
Module level	Deepening Materials Science
Abbreviation	MagMat
Subtitle (if applicable)	
Duration	1 Semester
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Prof. Dr. J. McCord
Lecturer	Prof. Dr. J. McCord and staff
Teaching language	English
Assignment to the curriculum	Compulsory elective subject in term 3
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded
Module courses	*Course Type* / *Course Name* / *Compulsory/ Compulsory elective* / *SWS* Lecture / Magnetic Materials: Physics and Applications / compulsory / 2 Practical Exercises / Magnetic Materials: Physics and Applications / compulsory / 1
Workload	30 h lecture 15 h exercise 60 h self-organized studies 45 h revision 150 h total workload
Credits	5 ECTS
Prerequisites according to examination order	None
Recommended Prerequisites	Basic lecture materials science

<table>
<tr><td>Course related work</td><td colspan="4">Submission and presentation of exercises</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Oral examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Magnetic Materials: Physics and Applications</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are able to plan and conduct magnetic material analyses to obtain key properties of magnetic systems.
They assess magnetic materials for a specific application based on their right material properties and select and correlate the relevant material properties with respect to their applicability to an exemplary application.
The students interpret which underlying magnetic process causes a measurable quantity. Furthermore, they can illustrate magnetization reversal processes with their influencing mechanisms and, additionally, sketch various magnetic sensing principles.
The students explain various characterization methods as well as approaches to model magnetization behaviour. They list specific analysis methods for various magnetic quantities, memorize examples for materials with extraordinary properties, and name effects and methods related to magnetic materials.</td></tr>
<tr><td>Content</td><td colspan="4">• Fundamentals of magnetism
• Manifestations of magnetism
• Magnetic anisotropies
• Magnetization processes
• Magnetic domains
• Soft magnetic materials
• Hard magnetic materials
• 8. Spin electronics and magnetic recording</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">Robert C. O'Handley - Modern Magnetic Materials: Principles and Applications
B. D. Cullity , C. D. Graham - Introduction to Magnetic Materials
J. M. D. Coey - Magnetism and Magnetic Materials</td></tr>
</table>

Module number	**Mawi 924**
Module title	**Bioinspired Materials**
Module level	Introduction into bio-inspired materials
Abbreviation	BIM
Subtitle (if applicable)	
Duration	1 Semester
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Prof. Dr. C. Selhuber-Unkel
Lecturer	Prof. Dr. C. Selhuber-Unkel and staff
Teaching language	English
Assignment to the curriculum	Compulsory elective subject in term 3
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded
Module courses	*Course Type* / *Course Name* / *Compulsory/Compulsory elective* / *SWS* Advanced Seminar / Bioinspired Materials / compulsory / 2
Workload	30 h seminar 45 h self-organized studies 15 h preparation of presentation 90 h total workload
Credits	3 ECTS
Prerequisites according to examination order	None
Recommended Prerequisites	Advanced Materials A
Course related work	None

Examination(s)	Presentation and written examination			
	Title	*Compulsory / Compulsory elective*	*Graded / Ungraded*	*Weighting*
	Written examination	Compulsory	Graded	50%
	Presentation	Compulsory	Graded	50%
Learning outcome	The students know classical biological systems that can serve as inspiration for materials science and judge strategies for generating bioinspired materials. They prepare a talk on an interdisciplinary subject as well as evaluate experimental techniques that are suitable for studying bioinspired systems. The students can apply the different language of biology and in this way increase their competence to carry out interdisciplinary research in general. The students have experiences in reading and extracting literature and discuss the status of international research by working with recent research articles.			
Content	The lecture will introduce into bio-inspired systems that control: • adhesion • friction • mobility • sensing • mechanics In particular, a focus will be on bio-inspiration from: • plants • animals (vertebrates, invertebrates) • human tissue The students will discuss techniques to investigate biological systems and learn about how to put the knowledge from biology into materials.			
Media	Blackboard, lecture notes Digital presentation (available in the internet)			
Literature	Scientific articles handed out during the seminar			

<table>
<tr><td>Module number</td><td colspan="4">Mawi 929</td></tr>
<tr><td>Module title</td><td colspan="4">Chemistry and Physics of Biomaterials</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">CaPoB</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. R. Willumeit-Römer</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. R. Willumeit-Römer and staff</td></tr>
<tr><td>Teaching Language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory elective subject in term 3</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="4">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/ Compulsory elective</td><td>SWS</td></tr>
<tr><td>Lecture</td><td>Chemistry and Physics of Biomaterials -Biomaterial applications</td><td>compulsory</td><td>3</td></tr>
<tr><td>Seminar</td><td>Chemistry and Physics of Biomaterials - Biological Materials</td><td>compulsory</td><td>1</td></tr>
<tr><td>Practical Exercises</td><td>Chemistry and Physics of Biomaterials -</td><td>compulsory</td><td>1</td></tr>
<tr><td>Workload</td><td colspan="4">45 h lecture
15 h seminar
15 h exercise
75 h self-organized studies
60 h lecture revision

210 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">7 ECTS</td></tr>
</table>

<table>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
<tr><td>Recommended Prerequisites</td><td colspan="4">Advanced Materials A
Seminar “Biochemie für Materialwissenschaftler”</td></tr>
<tr><td>Course related work</td><td colspan="4">None</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Written examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Chemistry and Physics of Biomaterials</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Assessment of course achievements</td><td colspan="4">The students judge biomaterial properties with respect to their medical application and know how to use theory to understand mechanical / chemical properties of biomaterials. They can calculate the forces acting on biomaterials and can deduct which material is suitable for which tissue. The students can decide which experimental techniques are useful to study biomaterials.</td></tr>
<tr><td>Content</td><td colspan="4">The course focuses on the interaction of the living environment with artificial materials.
Content of the lectures:
• Basics of biochemistry
• Definition: what is a biomaterial?
• Biomimetics – Friction as an example of application
• Wetting properties focused on the aspects of cell adhesion
• Tissue and implant requirements
• Different implant types: metallic, polymeric, ceramic implants
• Drug delivery
• Biomedical devices and approval procedure
In the exercises and seminars, current experimental and theoretical topics in biomaterials research will be discussed.</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">• Lehninger: Biochemistry (or a similar text book).
• DF Williams, Biomaterials 35 (2014) 10009 - 10014.
• J. Park and R.S. Lakes: Biomaterials – an Introduction. Springer 2007
• J.J Sela and I.A. Bab: Principles of Bone Regeneration. Springer 2012
• B. Ratner et al.: Biomaterial Science: An Introduction to Materials in Medicine. Academic Press 1996
• Additional material (scientific articles, book chapters) will be handed out during the course.</td></tr>
</table>

Module number	**Mawi 930**			
Module title	**Nano Medicine**			
Module level	Deepening Materials Science			
Abbreviation	NaMed			
Subtitle (if applicable)				
Duration	1 Semester			
Repetition in academic year	Summer Term			
Responsible faculty	Faculty of Engineering			
Responsible institute	Institute for Materials Science			
Responsible staff member	Prof. Dr. C. Selhuber-Unkel			
Lecturer	Prof. Dr. C. Selhuber-Unkel			
Teaching language	English			
Assignment to the curriculum	Compulsory elective subject in term 3			
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering			
Evaluation	graded			
Module courses	*Course Type*	*Course Name*	*Compulsory/Compulsory elective*	*SWS*
	Advanced Seminar	NanoMedicine	compulsory	2
Teaching methods	2 SWS seminar			
Workload	30 h seminar 15 h seminar revision 45 h self-organized studies 90 h total workload			
Credits	3 ECTS			
Prerequisites according to examination order	None			
Recommended Prerequisites	Knowledge about magnetism and cell biology are helpful			
Course related work	None			

Examination(s)	Written examination			
	Title	*Compulsory / Compulsory elective*	*Graded / Ungraded*	*Weighting*
	Advanced Topics in Organic Materials	Compulsory	Graded	100%
Assessment of course achievements	The students have knowledge about biomedical application of nanoparticles and techniques needed for biomedical research. They have an overview of the state of the art in development and application of magnetic nanomaterials and sensors in medicine. They know how to basic design biocompatible materials according to biomedical requirements. They have experiences in interdisciplinary work, extracting information from papers and designing projects.			
Content	This module will convey an overview of the highly interdisciplinary field of nano medicine and the biomedical application of novel multifunctional nanomaterials. A special focus will lie on magnetic particles and biosensors. Basic principles and applications will be introduced. Representative nanoparticles and sensors will be discussed in more detail with regards to their overall properties, distinctive features and specific biomedical use.			
Media	Blackboard, lecture notes Digital presentation			
Literature	Nanomedicine: Design and Applications of Magnetic Nanomaterials, Nanosensors and Nanosystems Vijay K. Varadan, Dr LinFeng Chen, Jining Xie ISBN: 978-0-470-03351-7 Further literature will be suggested during the course.			

Module number	**Mawi 931**
Module title	**Selected Topics in Materials Science**
Module level	Deepening Materials Science
Abbreviation	STMS
Subtitle (if applicable)	
Duration	1 Semester
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Dr. O. Riemenschneider
Lecturer	Professors of the Institute and staff
Teaching language	English
Assignment to the curriculum	Compulsory elective subject in term 3
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded
Module courses	*Course Type* / *Course Name* / *Compulsory/Compulsory elective* / *SWS* Advanced Seminar / Selected Topics in Materials Science / compulsory / 1
Teaching methods	1 SWS seminar
Workload	15 h seminar 15 h seminar revision 60 h self-organized studies 90 h total workload
Credits	3 ECTS
Prerequisites according to examination order	None
Recommended prerequisites	Deepened knowledge in Materials Science
Course related work	• Interested students must attend a preparatory meeting (compulsory attendance)

<table>
<tr><td></td><td colspan="4">Each student can select a topic offered by the research group “Synthesis and Real Structure”
All students must attend all presentations</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Presentations (30 min) given by the students. Content and presentation technique will be discussed (30 min). Written summery (10 pages)</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Selected Topics in Materials Science</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are familiar performing autonomously literature search for a given, unknown topic. They can summarize the gained knowledge in a short manuscript and in a scientific talk.</td></tr>
<tr><td>Content</td><td colspan="4">Every student will get a topic of actual research, which she/he has to work on. One responsible professor will coach each of them.</td></tr>
<tr><td>Media</td><td colspan="4">Digital presentation</td></tr>
<tr><td>Literature</td><td colspan="4">Given by the responsible professor.</td></tr>
</table>

Module number	**Mawi 932**
Module title	**Selected Topics in Solid State Chemistry**
Module level	Deepening Materials Science
Abbreviation	STSSC
Subtitle (if applicable)	
Duration	1 Semester
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Prof. Dr. L. Kienle
Lecturer	Prof. Dr. L. Kienle and staff
Teaching language	English
Assignment to the curriculum	Compulsory elective subject in term 3
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded
Module courses	*Course Type* / *Course Name* / *Compulsory/ Compulsory elective* / *SWS* Advanced Seminar / Selected Topics in Solid State Chemistry / compulsory / 1
Workload	15 h seminar 15 h seminar revision 60 h self-organized studies 90 h total workload
Credits	3 ECTS
Prerequisites according to examination order	None
Recommended Prerequisites	General knowledge of chemistry basics, particularly solid state chemistry, solid state physics, crystallography and structural chemistry (e.g. as treated in the lecture Material Science 3)
Course related work	• Up to five topics (for five students) will be announced!

<table>
<tr><td></td><td colspan="4">Interested students must attend a preparatory meeting (compulsory attendance)
Each student can select a topic offered by the research group “Synthesis and Real Structure”
All students must attend all presentations</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Presentations (30 min) given by the students. Content and presentation technique will be discussed (30 min). Written summery (10 pages).</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Selected Topics in Solid State Chemistry</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">On successful completion of this module students are familiarize with a given, unknown topic performing autonomously literature search. They can summarize the gained knowledge in a short manuscript and in a scientific talk.</td></tr>
<tr><td>Content</td><td colspan="4">Each student must perform literature search of relevant source articles independently (ISI-web or similar scientific search engines, no plain web pages). The literature list must be discussed with Prof. Kienle and/or staff. Afterwards each students must write successfully a summary paper of 10 pages (template will be provided).</td></tr>
<tr><td>Media</td><td colspan="4">Digital presentation</td></tr>
<tr><td>Literature</td><td colspan="4">need to be searched by the candidate</td></tr>
</table>

Module number	**Mawi 933**			
Module title	**Optical Materials**			
Module level	Deepening Materials Science			
Abbreviation	OEM			
Subtitle (if applicable)				
Duration	1 Semester			
Repetition in academic year	Summer Term			
Responsible faculty	Faculty of Engineering			
Responsible institute	Institute for Materials Science			
Responsible staff member	Prof. Dr. J. McCord			
Lecturer	Prof. Dr. J. McCord and staff			
Teaching language	English			
Assignment to the curriculum	Compulsory elective subject in term 3			
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering			
Evaluation	graded			
Module courses	*Course Type*	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
	Advanced Seminar	Optical Materials	compulsory	2
Workload	30 h seminar 45 h preparation 15 h revision 90 h total workload			
Credits	3 ECTS			
Prerequisites according to examination order	None			
Recommended Prerequisites	Advanced Materials B Solid State Physics Semiconductors			
Course related work	None			

<table>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Presentation and written summery.</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Optical Materials</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are able to make themselves familiar with complex optical materials concepts. They prepare information from textbooks and secondary literature for a lecture to an undergraduate student audience. They can prepare a university lecture style presentation.
The students comprehend the optical and optoelectronic material properties and devices. On completion of this module, the students will be able to relate the properties of optical materials to specific applications.</td></tr>
<tr><td>Content</td><td colspan="4">Contents to be reviewed and prepared by the students:
• Wave nature of light
• Dielectric waveguides and optical fibers
• Semiconductor science and Light-Emitting Diodes
• Stimulated emission devices: Optical amplifiers and lasers
• Photodetectors and image sensors
• Polarization and modulation of light</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation</td></tr>
<tr><td>Literature</td><td colspan="4">S.O. Kasap, Optoelectronics & Photonics: Principles & Practices (Pearson, 2013)</td></tr>
</table>

<table>
<tr><td>Module number</td><td colspan="4">mawi 934</td></tr>
<tr><td>Module title</td><td colspan="4">Advanced Topics in Organic Materials</td></tr>
<tr><td>Module level</td><td colspan="4">Deepening Materials Science</td></tr>
<tr><td>Abbreviation</td><td colspan="4">ATOM</td></tr>
<tr><td>Subtitle (if applicable)</td><td colspan="4"></td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Repetition in academic year</td><td colspan="4">Summer Term</td></tr>
<tr><td>Responsible faculty</td><td colspan="4">Faculty of Engineering</td></tr>
<tr><td>Responsible institute</td><td colspan="4">Institute for Materials Science</td></tr>
<tr><td>Responsible staff member</td><td colspan="4">Prof. Dr. F. Faupel</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. F. Faupel and staff</td></tr>
<tr><td>Teaching language</td><td colspan="4">English</td></tr>
<tr><td>Assignment to the curriculum</td><td colspan="4">Compulsory elective subject in term 3</td></tr>
<tr><td>Usability of the module</td><td colspan="4">1-subject study course M.Sc. Materials Science and Engineering</td></tr>
<tr><td>Evaluation</td><td colspan="4">graded</td></tr>
<tr><td rowspan="2">Module courses</td><td>Course Type</td><td>Course Name</td><td>Compulsory/ Compulsory elective</td><td>SWS</td></tr>
<tr><td>Advanced Seminar</td><td>Advanced Topics in Organic Materials</td><td>compulsory</td><td>2</td></tr>
<tr><td>Workload</td><td colspan="4">30 h seminar
30 h literature work
30 h preparation for exam

90 h total workload</td></tr>
<tr><td>Credits</td><td colspan="4">3 ECTS</td></tr>
<tr><td>Prerequisites according to examination order</td><td colspan="4">None</td></tr>
<tr><td>Recommended prerequisites</td><td colspan="4">Advanced knowledge on polymers and materials science, basic knowledge on solid state physics and organic chemistry</td></tr>
</table>

<table>
<tr><td>Course related work</td><td colspan="4">None</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Written examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Advanced Topics in Organic Materials</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are able to make themselves familiar with complex materials concepts and design principles related to organic materials. They can draw information not only from textbooks but also from state of the art review articles and original literature. They can critically assess the search results and can select the crucial information and condense it into a review talk. They can prepare an interesting presentation in terms of both layout of the slides and presentation style. They can defend their presentation in a scientific discussion. They are able to discuss critically the presentations of fellow students. They can chair sessions. They are able to assess their own performance and that of fellow students.</td></tr>
<tr><td>Content</td><td colspan="4">Depending on time, interests of the students, and the latest developments in the field, the following topics will be covered:
Reinforcement of polymers on all length scales
Functional polymer nanocomposites
Liquid crystalline polymers
Conducting and semiconducting polymers
Polymers in microelectronics
Polymer electrolytes
Ferroelectric polymers
Polymer electrets
Organic thin films
Polymer surfaces
Shape-memory polymers
Electroactive polymers
Polymer gels
Adhesives</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">Since the lecture aims at including the latest developments in the field, the updated literature will be given in the lecture and in the lecture notes which are available on the website of the Chair for Multicomponent Materials.</td></tr>
</table>

Module number	**mawi 935**			
Module title	**Advanced Topics in Metallic Materials**			
Module level	Deepening Materials Science			
Abbreviation	ATMM			
Subtitle (if applicable)				
Duration	1 Semester			
Repetition in academic year	Summer Term			
Responsible faculty	Faculty of Engineering			
Responsible institute	Institute for Materials Science			
Responsible staff member	Prof. Dr. K. Rätzke			
Lecturer	Prof. Dr. K. Rätzke and staff			
Teaching language	English			
Assignment to the curriculum	Compulsory elective subject in term 3			
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering			
Evaluation	graded			
Module courses	*Course Type*	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
	Advanced Seminar	Advanced Topics in Metallic Materials	compulsory	2
Workload	30 h seminar 30 h literature work 30 h preparation for exam 90 h total workload			
Credits	3 ECTS			
Prerequisites according to examination order	None			
Recommended prerequisites	General knowledge of chemistry, basics solid state physics, crystallography and structural chemistry lecture advanced materials A / metals			

<table>
<tr><td>Course related work</td><td colspan="4">None</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Written examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Advanced Topics in Metallic Materials</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students have an in depth understanding of structure and properties of metals. They understand alloy design, can read phase diagrams and can apply it to new problems. The students can predict properties from alloy content and thermal history. They can select proper alloys for given applications and motivate their choice. They are familiar with basic structure-property relations. They know latest developments in metal science and can critically assess latest developments.</td></tr>
<tr><td>Content</td><td colspan="4">• Ferrous alloys (Steel, cast iron)
• Non ferrous engineering alloys (Al, Cu, Mg, …)
• Special alloys (metallic glasses, quasicrystals, intermetallics, metallic foams, High entropy alloys)
• Special properties (superplasticity, electromigration, hydrogen in metals and others)</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">• Askeland, Science and Engineering of Materials
• Shackelford, Introduction into Materials Science for Engineers
• Haasen, Physical Metallugry</td></tr>
</table>

Module number	**mawi 936**			
Module title	**Finite Elements Modelling**			
Module level	Deepening Materials Science			
Abbreviation	FEM			
Subtitle (if applicable)				
Duration	1 Semester			
Repetition in academic year	Summer Term			
Responsible faculty	Faculty of Engineering			
Responsible institute	Institute for Materials Science			
Responsible staff member	Dr. D. Steglich			
Lecturer	Dr. D. Steglich and stuff			
Teaching language	English			
Assignment to the curriculum	Compulsory elective subject in term 3			
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering			
Evaluation	graded			
Module courses	*Course Type*	*Course Name*	*Compulsory /Compulsory elective*	*SWS*
	Lecture	Finite-Element Modelling in the Mechanics of Materials	compulsory	2
	Practical Exercises	Finite-Element Modelling in the Mechanics of Materials	compulsory	1
Workload	30 h lecture 15 h computer exercises 45 h revision 60 h self-organized studies 150 h total workload			
Credits	5 ECTS			
Prerequisites according to examination order	None			

<table>
<tr><td>Recommended prerequisites</td><td colspan="4">Vector und tensor analysis, structural mechanics, knowledge of windows operating systems</td></tr>
<tr><td>Course related work</td><td colspan="4">Four homework to hand in two weeks after issued</td></tr>
<tr><td rowspan="3">Examination(s)</td><td colspan="4">Oral examination</td></tr>
<tr><td>Title</td><td>Compulsory / Compulsory elective</td><td>Graded / Ungraded</td><td>Weighting</td></tr>
<tr><td>Finite Elements Modelling</td><td>Compulsory</td><td>Graded</td><td>100%</td></tr>
<tr><td>Learning outcome</td><td colspan="4">The students are able to model in theory and praxis and to realise stability analysis by the model of finite elements. They have the knowledge to create and optimise models, doing error free simulation, interpretation and critical review.
They can abstract from 3D into 2D and understand and assess mechanical treatment. They can communicate with structure mechanics.</td></tr>
<tr><td>Content</td><td colspan="4">Models in engineering and science are addressed in general. The terminology used to formulate field problems will introduced. Modelling errors and their respective treatment based on model verification and validation are explained. The general structure of a FE program will be treated: necessary input data, flow of solution steps, post-processing of resulting data. The hybrid method of mechanical testing and FE simulation for parameter identification is illustrated and trained. The course will be accompanied with practical exercises using the commercial FE-code ABAQUS.</td></tr>
<tr><td>Media</td><td colspan="4">Blackboard, lecture notes
Digital presentation (available in the internet)</td></tr>
<tr><td>Literature</td><td colspan="4">• K. Knothe, Finite Elemente - Einführung für Ingenieure, Springer 1992
• J. N. Reddy, An introduction to the finite element method, McGrw-Hill, 2006
• Hyperscripte:</td></tr>
<tr><td></td><td colspan="2">C. A. Felippa, Introduction to Finite Elements Methods</td><td colspan="2">A. F. Bower, Applied Mechanics of Solids
http://solidmechanics.org/</td></tr>
</table>

	http://www.colorado.edu/engineering/cas/courses.d/IFEM.d/

Module number	**mawi 937**
Module title	**Engineering Technology in Medical Application**
Module level	Deepening Materials Science
Abbreviation	ETiMA
Subtitle (if applicable)	
Duration	1 Semester
Repetition in academic year	Summer Term
Responsible faculty	Faculty of Engineering
Responsible institute	Institute for Materials Science
Responsible staff member	Dr. E. Lage
Lecturer	Dr. E. Lage and staff
Teaching language	English
Assignment to the curriculum	Compulsory elective subject in term 3
Usability of the module	1-subject study course M.Sc. Materials Science and Engineering
Evaluation	graded

Module courses	*Course Type*	*Course Name*	*Compulsory/ Compulsory elective*	*SWS*
	Lecture	Engineering Technology in Medical Application	compulsory	1
	Seminar	Engineering Technology in Medical Application	compulsory	2

Workload	15 h lecture 30 h seminar 40 h self-organized studies 65 h preparation of exercises 150 h total workload
Credits	5 ECTS
Prerequisites according to examination order	None
Recommended prerequisites	Basics of Electrical Engineering Basics knowledge of Matlab

Course related work	Submission and presentation of exercises			
Examination(s)	Presentation and written summery.			
	Title	*Compulsory / Compulsory elective*	*Graded / Ungraded*	*Weighting*
	Engineering Technology in Medical Application	Compulsory	Graded	100%
Learning outcome	The students develop a concept for an implant material with enhanced properties and assemble a basic electric amplifier circuit used for electrophysiological quantities. They choose a suitable method to record a selected physiological measurand, based on accuracy, costs and user-friendliness. The students categorize the required properties for medical devices and employ suitable methods to address the requirements. They sketch the layout of medical devices and implement non-linear device properties into numerical methods in order to calculate the expected device output. They explain the operating principle of various measurement methods and review the strengths and weaknesses of competing technologies. They can sort measurement principles with respect to various physiological measurands, recognize crucial components, and relate their corresponding sources for disturbances.			
Content	During the lectures, the origin and relevance of physiological measures will be discussed. Furthermore, the various sensing mechanism in medical technology will be motivated. In the guided exercises practical examples will be allow the student to apply sensing principles and tools for signal processing. Requirements for medical devices.			
Media	Lectures and computer aided exercises, external resources			
Literature	• G. Baura, Medical Device Technologies, Academic Press 2011 • R. Kramme, K-P Hoffmann, Springer Handbook of Medical Technology, Springer 2011 • J.D. Bronzino, Medical Devices and Systems, CRC Press 2006			