



OTTO-VON-GUERICKE-UNIVERSITY MAGDEBURG
Faculty of Mechanical Engineering

MODULE CATALOGUE

Master's Program in
Materials Science

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1 Continuum Mechanics

Name of module	Continuum Mechanics
Teaching aims	<p>The participants will gain experience in a powerful tool of description the behavior of materials and structures based on equations partly rational, partly engineering based. The course is split into three parts: basics of tensor calculus, material independent equations (kinematics, loads, and balances) and material dependent equations. The kinematical relations are, for example, translations, rotations, displacements, strains, strain rates. etc. The balances are the extension of the classical equilibrium and conservation laws. The focus is on mass, momentum, moment of momentum, energy and entropy. The material depending equations describe the individual response of the material on loadings. They are introduced applying the deductive and inductive approach and the rheological modeling.</p> <p>The students will be taught in the rational modeling of solids and fluids, which is necessary for numerical solution of engineering problems.</p>
Content of the module	<p>Content:</p> <ul style="list-style-type: none"> • Tensor calculus (algebra, analysis) • Kinematical relations • Stresses, etc. • Balances • Constitutive equations
Type of lecture	Lectures and exercises
Preconditions for attending	Good skills in mechanics, material science and mathematics
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	<p>Time of attendance:</p> <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 2 SWS <p>Self-study:</p> <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every winter term
Duration of module	One semester
Responsible lecturer	Prof. Dr.-Ing. Daniel Juhre

2 Engineering Ceramics

Name of module	Engineering Ceramics
Teaching aims	<p>Aim of the course is to generate a deeper understanding of engineering ceramics based on theoretical aspects, concepts and selected material samples. An insight into atomic and microstructural design, relevant manufacturing processes and resulting applications will be part of the course.</p> <p>The students acquire a deep insight into ceramic materials, processing strategies, (micro)structure, properties and processing-structure-properties-relations; the ceramic materials treated in the lecture will be set in the entire materials context.</p> <p>Traditional pottery and its methods will be mentioned marginally, but this is not included to a larger extend in this lecture!</p>
Content of the module	<p>Content of the module:</p> <ul style="list-style-type: none"> theory of chemical bonds and properties correlations such as density, melting behavior, thermal, mechanical, optical, chemical properties; manufacturing: shaping of ceramic parts, structure consolidation by sintering, resulting properties for applications; <p>selected material systems: aspects of manufacturing/most relevant manufacturing processes; examples for applications (this includes silicate ceramics, refractories and selected functional materials such as ZrO₂)</p>
Type of lecture	Lectures and exercises
Preconditions for attending	Lecture in Basics of Materials
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	<p>Time of attendance:</p> <ul style="list-style-type: none"> Lecture: 2 SWS Exercise: 2 SWS <p>Self-study:</p> <ul style="list-style-type: none"> Individual semester assignment that is included in the examination grade.
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturer	Prof. Dr. rer. nat. Michael Scheffler Dr. rer. nat. Ulf Betke

3 Glass

Name of module	Glass
Teaching aims	<p>The participants will acquire a well-grounded understanding of the basics and associated obstacles in glass science. The fundamental processes and technologies of glass manufacturing are introduced as well as the materials properties and design possibilities (structural and chemical). The participants will be enabled to understand and correctly use technical terms related to glass. They will be acquainted with modern functionalities and quality of glass products, e.g. in the area of façade glass or hollowware.</p> <p>During the practical training the participants will experience and feel the material glass, its properties and characteristics in comparison to its crystalline equivalences.</p>
Content of the module	<p>Content:</p> <ul style="list-style-type: none"> • Definition of glass and the glassy state, fundamental aspects • Glass types/glass systems • Glass synthesis: batch chemistry and reactions, fabrication and processing including environmental and energy aspects • Optical, mechanical, chemical properties including respective applications • Crystallization and Glass-Ceramics • Characterization techniques
Type of lecture	Lectures and exercises
Preconditions for attending	Fundamentals in inorganic and physical chemistry, solid state physics as well as mechanics and rheology.
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	<p>Time of attendance:</p> <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 1 SWS • Practical: 1 SWS <p>Self-study:</p> <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every winter term
Duration of module	One semester
Responsible lecturer	Dr.-Ing. Cuong Phan

4 Heat Treatment of Materials

Name of module	Heat Treatment of Materials
Teaching aims	Numerous materials are subjected to thermal or mechanical treatment during or after the primary manufacturing process. The properties of these materials can be modified by a narrow selection of parameters. The learning objective is knowledge of the material- and application-related selection of treatment processes and their integration into the production process.
Content of the module	Content: <ul style="list-style-type: none"> • Theoretical fundamentals of thermal, thermochemical and mechanical processes • Application-related selection of treatment processes • Design of process-integrated technologies
Type of lecture	Lectures and exercises
Preconditions for attending	Understanding of basic mechanisms of heat treatment of metals, hardening mechanisms, phase diagrams (Basics of Materials Technology)
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 2 SWS Self-study: <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturer	Prof. Dr.-Ing. habil. Thorsten Halle

5 Inorganic, Non-Metallic Binders

Name of module	Inorganic, Non-metallic Binders
Teaching aims	<p>The participants will gain experience and acquire knowledge on technological properties of mortar and concrete as well as the underlying chemical reactions and the subsequent built up of microstructure.</p> <p>Methods to design the composition of these materials to meet defined specifications are presented and the participants will be able to apply this knowledge in order to:</p> <ul style="list-style-type: none"> • evaluate the performance of construction materials • design a mortar or concrete composition based on given raw materials to meet required specifications • create a data sheet
Content of the module	<p>Content:</p> <ul style="list-style-type: none"> • Structural and Functional mortars and concrete • Workability, strength and durability • Development of microstructure • Functions of binders, additives and admixtures • OPC based mix design for standard concrete • Insulating and low-density concrete (porous concrete, AAC) • Ultra-high strength concrete - UHPC • Self-Compacting Concrete - SCC • Special mortars for grouting, repair, adhesives, extrusion and 3D printing
Type of lecture	Lectures and exercises
Preconditions for attending	Good skills in mechanics and mathematics
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	<p>Time of attendance:</p> <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 2 SWS <p>Self-study:</p> <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every winter term
Duration of module	One semester
Responsible lecturer	Prof. Dr.-Ing. Thomas A. Bier

6 Materials Characterization

Name of module	Materials Characterization
Teaching aims	<p>Aim and skills of the course:</p> <p>The students will get in touch with the most important characterization techniques for different kinds of materials. This includes the (micro)structural analysis (e. g. electron microscopy, X-ray diffraction and Raman spectroscopy) as well as property-related characterization techniques (e. g. porosity and surface area analysis, thermal properties). The course includes the theoretical background to all methods, as well as some hands-on experience for selected techniques being present at VGU.</p>
Content of the module	<p>Content:</p> <ul style="list-style-type: none"> • structural description of materials (basics in crystallography, symmetry and space group theory); • (powder) X-ray diffraction (theory, accessible information about the sample, diffractometer setups, data evaluation); • microscopic characterization techniques (optical and Raman-microscopy, electron microscopy, elemental analysis by EDS, sample preparation); • thermal analysis (thermogravimetry, differential scanning calorimetry); • porosity and surface area analysis (pycnometry, gas adsorption, Hg intrusion);
Type of lecture	Lectures and exercises
Usability of module	Master programs only
Preconditions for attending	Basic knowledge in materials science and technology; knowledge of material classes or knowledge in basics of chemistry and physics of materials
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP; marks according to study and examination regulations
Efforts	Lecture (2 SWS per semester) Self-study over 94 h
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturers	Prof. Dr. rer. nat. Franziska Scheffler Dr. rer. nat. Ulf Betke

7 Materials Science I – Metals

Name of module	Metals
Teaching aims	Acquisition of an in-depth understanding of the material-physical and mechanical phenomena in metals; Acquisition of in-depth knowledge of material behavior at high temperatures and high strain rates; Ability to correlate microstructural properties of constituents of alloys with macroscopic material behavior and to interpret the mechanisms.
Content of the module	Content: <ul style="list-style-type: none"> • Crystal symmetries and symmetry classes • Dislocations in metals • Movement and interactions of dislocations • Physical mechanisms at interfaces, description of interfaces • Elastic and plastic material behavior as a function of the crystal structure • Crystal structure, temperature and strain rate • Phase transitions and phase transformations in solids • Strengthening mechanisms in complex material systems
Type of lecture	Lectures and exercises
Preconditions for attending	Understanding of basic mechanisms and microstructure-properties correlations of technical materials (Basics of Materials Technology)
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 2 SWS Self-study: <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturers	Prof. Dr.-Ing. Manja Krüger Dr.-Ing. Georg Hasemann

8 Mechanics of Materials and Fracture Mechanics

Name of module	Mechanics of Materials and Fracture Mechanics
Teaching aims	Analysis and design of structures requires accurate description of materials behavior for complex loading and temperature conditions. The objective of the course is to give an introduction to constitutive modeling, identification of material parameters and application to the finite element analysis of components. The students experience in basics of mechanical behavior of materials including elasticity, plasticity, creep, damage and fracture. The students will be taught in the development, calibration and numerical implementation of advanced constitutive models for multi-axial stress states.
Content of the module	Content: <ul style="list-style-type: none"> • Elasticity • Plasticity • Creep • Rheological models • Yield and Failure Criteria • Stress fields around notches and crack tips • Stress intensity factors • Criteria for crack propagation
Type of lecture	Lectures and exercises
Preconditions for attending	Good skills in mechanics and mathematics
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 2 SWS Self-study: <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturer	Prof. Dr.-Ing. habil. Holm Altenbach

9 Micro-Nano Fabrication Technology

Name of module	Micro-Nano Fabrication Technology
Teaching aims	The participants will acquire a well-grounded understanding of the fundamental aspects and techniques in micro and nanofabrication technology. The processes for basic and several advanced micro/nanodevices are introduced. Typical applications of the micro/nano materials and devices are discussed with considerable attention for ones that can be realized at VGU then applied quickly to solve the local demands in healthcare and environment. During the practical training the participants will realize and characterize the assigned devices by using recently invested equipment at the VGU laboratories for Materials Science.
Content of the module	Content: <ul style="list-style-type: none"> • Introduction of micro/nanotechnology • Micro-nano lithography • Thin-film deposition (chemical and physical depositions) • Etching (isotropic and anisotropic etchings; wet and dried etching) • Supported fabrication techniques (wafer bonding, dicing ...) • Characterization techniques • Micro - nano membranes • Practical work: realization of micro-nano silicon nitride (SiN) membranes at VGU Labs (hand on training on micro-nanolithography, thin-film deposition, dried and wet etching...) • Morphology, dimension and mechanical characterization of the realized SiN membranes (optical microscopy, SEM, ...)
Type of lecture	Lectures, exercises, practical
Preconditions for attending	Fundamentals in Materials Science, Physics and Chemistry.
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 1 SWS • Practical: 1 SWS Self-study: <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturer	Dr.-Ing. Hien Duy Tong

10 Polymers

Name of module	Polymers
Teaching aims	Students can use the knowledge of plastics and define the necessary testing and analysis. They can explain the complex relationships, like structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).
Content of the module	Content: <ul style="list-style-type: none"> • Structure and properties of polymers • Structure of macromolecules • Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weight distribution • Morphology (amorph, crystalline, blends) • Mechanical properties (elasticity, plasticity, viscoelasticity) • Thermal properties • Electrical properties • Theoretical modelling • Applications
Type of lecture	Lectures and exercises
Preconditions for attending	Understanding of basic mechanisms and microstructure-properties correlations of technical materials (Basics of Materials Technology)
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 2 SWS Self-study: <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturer	Dr. rer. nat. Sven Henning

11 Powder Metallurgy and Sintered Materials

Name of module	Powder Metallurgy and Sintered Materials
Teaching aims	The participants will gain experience in the processing of elemental and alloyed powders, specific analyzing techniques and various methods to consolidate powders for the production of porous or bulk materials. The students will be taught in tailored powder processes, e.g. sintering and additive manufacturing techniques, for metallic and ceramic powder materials for various engineering applications.
Content of the module	Content: <ul style="list-style-type: none"> • Fundamentals of basic mechanisms and processing technologies of elemental powders and alloyed powders • Specific analyzing methods for powder materials • Mechanical alloying and considerations of the energy transfer into powders to evolve solid solutions • Influence of porosity on physical and mechanical properties of sintered materials • Additive manufacturing methods • Examples of powder metallurgical products and parts in engineering and biomedical applications
Type of lecture	Lectures and exercises
Preconditions for attending	Understanding of basic mechanisms and microstructure-properties correlations of technical materials (Basics of Materials Technology)
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: <ul style="list-style-type: none"> • Lecture: 2 SWS • Exercise: 2 SWS Self-study: <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturer	Prof. Dr.-Ing. habil. Manja Krüger Dr.-Ing. Georg Hasemann

12 Research Lab – Properties, Testing and Analytics

Name of module	Research Lab - Properties, testing and analytics
Teaching aims	The course takes place in different laboratories of the VGU. On the basis of practical tasks, special knowledge is imparted on the following focal points: Property changes of metals by heat treatment; Destructive and non-destructive testing methods for material characterization; Metallography and microstructure; etc.
Content of the module	Content: <ul style="list-style-type: none"> • Introduction to different materials labs e.g. • Laboratory for hardening of steel and metals • Laboratory for physical simulation of thermal and thermo-mechanical processes • Laboratory for powder metallurgy • Laboratory for ceramic structures • Laboratory for non-destructive testing • Laboratory for mechanical testing • Laboratory for corrosion testing
Type of lecture	Lectures and exercises
Preconditions for attending	Understanding of basic mechanisms for measure properties, testing and analytics
Usability of module	Master program
Prerequisites for the provision of ECTS	Research laboratory report as a scientific paper
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: <ul style="list-style-type: none"> • Laboratory exercises during the semester Self-study: <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every summer term
Duration of module	One semester
Responsible lecturer	Prof. Dr.-Ing. habil. Thorsten Halle Prof. Dr.-Ing. habil. Manja Krüger Prof. Dr.-Ing. Michael Scheffler Dr.-Ing. Hien Duy Tong

13 Solid-State Physics

Name of module	Solid-State Physics
Teaching aims	The participants will gain experience in the fundamental structural and vibrational aspects of solid-state physics: chemical bonding, structure, diffraction, lattice dynamics, and thermal properties. The students will be trained in exercises by solving extensive series of problems that relate to each chapter of the lecture cycle.
Content of the module	Content: <ul style="list-style-type: none"> • Chemical Bonding in Solids: - Covalent Bonding - Ionic Bonding - Metallic Bonding - The Hydrogen bond - The van der Waals Bond • Structure of Solid Matter: - Crystal Lattice, Point Symmetry, the 32 Crystal Classes (Point Groups) - Simple Crystal Structures - Defects • Diffraction from Periodic Structures: - General Theory of Diffraction - Periodic Structures and Reciprocal Lattice - Braggs Interpretation of the Laue Condition - Brillouin Zones - Structure Factor - Structure Analysis • Dynamics of Atoms in Crystals: - The Potential - Equations of Motion - Diatomic Linear Chain - Scattering by Lattice Vibrations - Phonon Spectroscopy • Thermal Properties: - Density of States - Energy of a Harmonic Oscillator - Specific Heat Capacity - Thermal Expansion - Thermal Conductivity of the Lattice
Type of lecture	Lectures and exercises
Preconditions for attending	Good skills in physics, material science and mathematics
Usability of module	Master program
Prerequisites for the provision of ECTS	Passing the exam
ECTS and marks	5 CP Marks following Study and Examination Regulations
Efforts	Time of attendance: <ul style="list-style-type: none"> • Lecture: 3 SWS • Exercise: 1 SWS Self-study: <ul style="list-style-type: none"> • Individual semester assignment that is included in the examination grade.
Frequency of provision	Every winter term
Duration of module	One semester
Responsible lecturer	Prof. Dr. rer. nat. Jürgen Christen Prof. Dr. rer. nat. Frank Bertram