Friedrich-Alexander-Universität
Erlangen-Nürnberg

Module description

for the degree programme

Master of Science Nanotechnology

(Version of examination regulation: 20232)

for the summer term 2025

Table of contents

1	**Module name** 1999	**Master thesis (M.Sc. Nanotechnology 20232)** Master’s thesis	**30 ECTS**
2	Courses / lectures	No courses / lectures available for this module!	
3	Lecturers	No lecturers available since there are no courses / lectures for this module!	

4	**Module coordinator**	
5	**Contents**	Die Masterarbeit dient dazu, die Fähigkeit zu selbstständiger Bearbeitung von wissenschaftlichen Aufgabenstellungen der Nanotechnologie nachzuweisen; sie behandelt in der Regel ein wissenschaftliches Thema aus dem Kernfach. . Die Masterarbeit wird ergänzt durch ein 30 minütiges Referat, in dem die Masterarbeit und deren Ergebnisse vorgestellt werden und eine anschließende Diskussion. :: The master's thesis serves to demonstrate the ability to work independently on scientific tasks in nanotechnology; it usually deals with a scientific topic from the core subject. subject from the core subject. The master's thesis is supplemented by a 30-minute presentation in which the master's thesis and its results are presented. Master's thesis and its results are presented and a subsequent discussion.
6	**Learning objectives and skills**	**Die Studierenden** • erwerben die Fähigkeit, eine wissenschaftliche Fragestellung im Bereich der Nanotechnologie über einen längeren Zeitraum zu verfolgen, das entsprechende Fachgebiet selbstständig und innerhalb einer vorgegebenen Frist zu bearbeiten • entwickeln eigenständige Ideen und Konzepte zur Lösung wissenschaftlicher Probleme aus dem der Nanotechnologie • gehen in vertiefter und kritischer Weise mit Theorien, Terminologien, Besonderheiten, Grenzen und Lehrmeinungen um und reflektieren diese • sind in der Lage, geeignete wissenschaftliche Methoden selbständig anzuwenden und weiterzuentwickeln sowie die Ergebnisse in wissenschaftlich angemessener Form darzustellen • können fachbezogene Inhalte klar und zielgruppengerecht schriftlich und mündlich präsentieren und argumentativ vertreten

		• erweitern ihre Planungs- und Strukturierungsfähigkeit in der Umsetzung eines thematischen Projektes ::: **The students** - acquire the ability to pursue a scientific question in the field of nanotechnology over a longer period of time. over a longer period of time, to work on the corresponding subject area independently and within a given work on the corresponding subject independently and within a given period of time - develop independent ideas and concepts for solving scientific problems in the field of nanotechnology - deal with theories, terminologies, specifics, limitations and opinions in a profound and critical way and reflect on them. and reflect on these theories - are able to independently apply and further develop appropriate scientific methods as well as to present the results in a scientifically appropriate form - are able to present subject-related content clearly and appropriately to the target group, both orally and in writing, and to present them argumentatively - expand their planning and structuring skills in the implementation of a thematic project
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 4
9	**Module compatibility**	Pflichtmodul Master of Science Nanotechnology 20232
10	**Method of examination**	Oral (30 minutes) Written (6 Monate) Die Masterarbeit ist in englischer Sprache abzufassen. In begründeten Ausnahmefällen, bspw. wenn die Wissenschaftssprache im Bereich des Themas der Masterarbeit überwiegend Deutsch ist, kann die Studienkommission auf Antrag die Anfertigung in deutscher Sprache genehmigen. Die Masterarbeit wird ergänzt durch ein ca. 30 Minuten dauerndes Referat, in dem die Masterarbeit und deren Ergebnisse vorgestellt werden und eine daran anschließende Diskussion. Der Termin für den Vortrag wird von der betreuenden Lehrperson spätestens zum Ende der Bearbeitungsfrist der Masterarbeit festgelegt und der bzw. dem Studierenden rechtzeitig bekannt gegeben. The master's thesis must be written in English. In justified exceptional cases, for example if the academic language in the area of the topic of the master's thesis is predominantly German, the study commission can, upon request, approve the preparation in German.

		The master's thesis is supplemented by a presentation lasting approximately 30 minutes in which the master's thesis and its results are presented and a subsequent discussion. The date for the lecture will be set by the supervising teacher no later than the end of the master's thesis processing period and will be announced to the student in good time
11	**Grading procedure**	Oral (10%) Written (90%)
12	**Module frequency**	Every semester
13	**Resit examinations**	The exams of this moduls can only be resit once.
14	**Workload in clock hours**	Contact hours: 75 h Independent study: 825 h
15	**Module duration**	1 semester
16	**Teaching and examination language**	english
17	**Bibliography**	

1	**Module name** 45740	**Nanocharakterisierung** Nano Characterization	**10 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Wolfgang Heiß
5	**Contents**	*Elektronenmikroskopie:* Die Vorlesung gibt eine Einführung in die Grundlagen der Raster- und Transmissionselektronenmikroskopie und hat zum Ziel, den Teilnehmern die weitreichenden Möglichkeiten der Mikroskopie mit schnellen Elektronen für die Strukturuntersuchung von Materialen aufzuzeigen. Im Rahmen der Vorlesung und den vertiefenden Übungen soll ein fundiertes Verständnis für die Wechselwirkung von schnellen Elektronen mit Materie und die daraus resultierenden Kontrastphänomene in elektronenmikroskopischen Abbildungen und Beugungsbildern erarbeitet werden, das Grundvoraussetzung für eine korrekte Interpretation elektronenmikroskopischer Ergebnisse sowie die Nutzung elektronenmikroskopischer Verfahren in eigenen Forschungsarbeiten darstellt. Im Bereich der Transmissionselektronenmikroskopie (TEM), die den Schwerpunkt der Vorlesung bildet, werden neben der Elektronenbeugung vornehmlich die Verfahren der sog. konventionellen TEM behandelt. Hochauflösende Transmissionselektronenmikroskopie (HRTEM) sowie die wichtigsten analytische Verfahren (EDX, EELS) werden in einem nachfolgenden zweiten Teil der Vorlesung (EM II) besprochen. *Nanospektroskopie:* - Die Vorlesung gibt einen Überblick über optische Spektroskopie-Methoden die allgemein für Halbleiterstrukturen und im Speziellen für Nanostrukturen verwendet werde. Im Besonderen wir auf drei Themen eingegangen: Nanocharakterisierung über photothermisch indudzierte Resonanz, Nanospektroskopie mit Röntgenstrahlung und Nanospektroskopie über Plasmonen Verstärkung. Gegebenenfalls wird auch Nanoskopie = Mikroskopie mit Auflösung unter dem Beugungslimit vorgestellt. Neben diesen Nanospektroskopie spezifischen Themen werden auch Grundlagen über Wechselwirkung zwischen Licht und Materie oder auch grundlegende Beschreibungen von Licht besprochen. *Rastersondenmikroskopie:* Experimenteller Aufbau (Rastersondenmikroskop und Sonden) - Rasterkraftmikroskopie (Betriebsmodi)- Rastertunnelmikroskopie (Tunneleffekt und Betriebsprinzip) - Bilddatenverarbeitung *Nanoindentierung:* Grundlagen der Härteprüfung - Experimenteller Aufbau eines Nanoindenters - Grundlagen der Kontaktmechanik (Sneddon, Hertz) - Oliver-Pharr Auswertemethode - Fortgeschrittene Methoden zur Bestimmung lokaler mechanischer Eigenschaften (Dehnratenabhängigkeit, Fließspannung, theoretische Festigkeit, Dynamische Charakterisierung)

6	**Learning objectives and skills**	Die Studierenden • kennen mikroskopische Verfahren zur Untersuchung von Materialien auf kleinen Längenskalen • verstehen die vielfältigen Verfahren der Elektronenmikroskopie und deren Anwendung in den Material- und Nanowissenschaften • haben fundierte Kenntnisse über den Einsatz von Rastersondenverfahren • kennen die verschiedenen Methoden der Nanoindentierung und deren Einsatz zur lokalen Untersuchung von mechanischen Materialeigenschaften • verstehen die Einsatzmöglichkeiten hochaufgelöster mikroskopischer Verfahren zur Untersuchung von Nanomaterialien • verstehen vertiefte Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen • haben fundierter Kenntnisse über die Grundlagen zum Aufbau der verschiedenen Werkstoffklassen • kennen fortgeschrittene Methoden zur lokalen mechanischen Eigenschaft von Werkstoffen • kennen und verstehen grundlegende Konzepte zur Beschreibung von Licht • verstehen grundsätzliche Wechselwirkungen zwischen Materie und Licht • verstehen die besonderen optischen Eigenschaften von Halbleiter-Nanomaterialien • kennen die Grundzüge der Plasmonik • kennen optische Meßmethoden für die spektroskopische Charakterisierung einzelner Nanostrukturen • haben einen Überblick über höchstauflösende optische Mikroskopie • haben einen Überblick über Anwendungen von optisch relevanten Nanomaterialien
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Pflichtmodul Master of Science Nanotechnology 20232
10	**Method of examination**	Oral (30 minutes) mündliche Prüfung (30 Min.) oral exam (30 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 135 h Independent study: 165 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 45750	**Praktikum Synthese / Charakterisierung** Practical course synthesis/ characterization	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	apl. Prof. Dr. Heinz Werner Höppel
5	**Contents**	Ziel dieses Praktikums ist es, das erlernte Wissen aus den früheren Mastervorlesungen der Module M1, M4 und M6 sowie aus dem vorausgegangenen Bachelorstudium in praktischen Versuchen zu vertiefen. Das Praktikum orientiert sich an die Herstellung und Charakterisierung von nanostrukturierten Werkstoffen. Dazu zählen Dünnschichten, Nanopartikeln und ultrafeinkörnige Werkstoffe die durch top-down und bottom-up Verfahren hergestellt werden. Die Charakterisierung erfolgt mittels Indentierung, TEM, REM, UV-Vis und XRD. Im Einzelnen werden derzeit zwei Versuchsreihen angeboten: • Synthese von Nanopartikeln mit verschiedenen Größen • Spektroskopische Untersuchung von Nanopartikeln • Transmissionselektronenmikroskopie von Nanopartikeln • Herstellung und Charakterisierung von CVD-Diamantschichten sowie • Herstellung und Charakterisierung von PED-Ni • Erzeugung und Eigenschaften von ultrafeinkörnigen Blechwerkstoffen • Mikrostrukturcharakterisierung mittels TEM • Herstellung und Charakterisierung von CVD-Diamantschichten Aufgrund der begrenzten Kapazität einzelner Versuche können nicht alle Einteilungswünsche garantiert werden. Es besteht Anwesenheitspflicht bei den Versuchen. Bei jedem Versuch müssen ein Vor- (ehem. Antestat) und Nach-Protokoll (ehem. Protokoll) erfolgreich geleistet werden, was durch Unterschriften der jeweiligen Betreuer auf der Testatkarte bestätigt wird. Das Modul gilt als bestanden, wenn die vollständig ausgefüllte Testatkarte bis zum Beginn des nächstfolgenden Vorlesungszeitraums im Sekretariat des Modulverantwortlichens abgegeben wird.
6	**Learning objectives and skills**	Die Studierenden anwenden: Die Studierenden wenden bei diesem Praktikum das in den VLs erlernte Wissen zur Herstellung und Charakterisierung von nanostrukturierten Werkstoffen an. analysieren und bewerten: Die erzeugten Messwerte werden in Kleingruppen analysiert und bewertet. In Fokus steht dabei auch, werkstoffübergreifende Eigenschaften und Methoden zu vermitteln.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1

9	**Module compatibility**	Pflichtmodul Master of Science Nanotechnology 20232 Praktikumsleistung, vgl. § 6 Abs. 3 Satz 4 ABMPO/TechFak sowie Modulhandbuch Internship performance, see Section 6 Paragraph 3 Sentence 4 ABMPO/TechFak and module handbook
10	**Method of examination**	Practical achievement
11	**Grading procedure**	Practical achievement (pass/fail)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 45761	**Computational Nanoscience**	**5 ECTS**
2	Courses / lectures		
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Dirk Zahn
5	**Contents**	**Computational Nanoscience** • Introduction to Computational Nanoscience • Repetition of the quantum mechanical basics • Introduction to DFT and HF methods • Application examples: electronic properties, • IR spectroscopy • Semi-empirical potentials, force fields • Treatment of long-range interactions • Algorithms for structure optimization • Nudged Elastic Band method • molecular dynamics • Monte Carlo methods **Application examples:** • Determination of the structure and properties of crystal defects • Exercises on electronic structure calculations and molecular dynamics simulations
6	**Learning objectives and skills**	**Professional competence** **The students** • know the theoretical basics of ab-initio and atomistic simulation methods • can evaluate the areas of application and results of various atomistic simulation methods • can apply more professional simulation tools and analysis methods
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2
9	**Module compatibility**	Pflichtmodul Master of Science Nanotechnology 20232 schriftliche Prüfung (Klausur; 45 Min.) written exam (45 min.)
10	**Method of examination**	Written examination (45 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h

14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Tadmor, Miller: Modeling Materials

1	**Module name** 45770	**Top-Down Nanostrukturierung** Top-Down Nanostructuring	**10 ECTS**
2	Courses / lectures	Vorlesung: Halbleitertechnik IV - Nanoelektronik (2 SWS, SoSe 2025) Vorlesung: Halbleitertechnologie IV - Optical Lithography: Technology, Physical Effects, and Modelling (2 SWS, SoSe 2025) Übung: Übung zu Halbleitertechnologie IV - Optical Lithography (2 SWS, SoSe 2025)	2,5 ECTS - -
3	Lecturers	Dr. Michael Jank PD Dr. Andreas Erdmann	

4	**Module coordinator**	Dr. Michael Jank Prof. Dr.-Ing. Jörg Schulze
5	**Contents**	*Nanoelectronics* 1. Principles of solid-state electronics and device physics 2. Scaling of MOS transistors 3. Short-channel effects 4. Tunneling 5. MOS memory devices 6. Optimization of drain currents 7. New Architectures and Materials for Nano-MOS Devices 8. Nanowires 9. 2D materials for electronics 10. Neuromorphic systems 11. Integrated quantum electronics *Coating Technology* • Basic surface technology processes • Structure of technical surfaces • Properties of the thin-film processes Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD) • State of the art of diamond synthesis (High Pressure High Temperature, Microwave Plasma CVD, Hot-Filament CVD) and applications • Dependence of diamond growth on CVD parameters • Interaction of different substrates (iron, silicon, titanium) with CVD coating conditions • New fields of application *Optical Lithography* This course reviews different types of optical lithographies and compares them to other methods. The advantages, disadvantages, and limitations of lithographic methods are discussed from different perspectives. Important components of lithographic systems, such as masks, projection systems, and photoresist will be described in detail. Physical and chemical effects such as the light diffraction from small features on ad-vanced photomasks, image formation in high numerical

		aper-ture systems, and coupled kinetic/diffusion processes in mod-ern chemical amplified resists will be analysed. The course includes an in-depth introduction to lithography simulation which is used to devise and optimize modern lithographic processes.
6	**Learning objectives and skills**	*Nanoelectronics* The students • explain the structure and function of nanoelectronic devices • describe the manufacturing methods for nanoelectronic devices • analyze the principal problems arising for devices in the nanometer range • discuss different approaches for future devices • evaluate advantages and disadvantages as well as limitations of current trends and developments in the field of nanoelectronic devices *Coating Technology" The students • develop a deep understanding of CVD processes • are able to assiess the relationships between the process and the microstructure or strength of surface-hardened steels • understand the property potential of CVD diamond coatings for innovative application *Optical Lithography* The goals of this lecture are • understand the principles of optical projection lithography • learn how optical resolution enhancements work • get an overview on alternative lithographic techniques • get an introduction to lithography simulation • understand the role of nanoscale light scattering effects
7	**Prerequisites**	*Nanoelectronics* Knowledge from the lectures Semiconductor Devices or Nano IV. *Coating Technology* Basic knowledge of inorganic chemistry, phase diagrams
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Pflichtmodul Master of Science Nanotechnology 20232
10	**Method of examination**	Oral (30 minutes) mündliche Prüfung (30 Min.) oral exam (30 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester

15	**Teaching and examination language**	german or english
16	**Bibliography**	*Nanelectronics* • S. Wolf: Silicon Processing for the VLSI Era: Volume 3 The Submicron MOSFET, Lattice Press, 1995 • S. Wolf: Silicon Processing for the VLSI Era: Volume 4 Deep-Submicron Process Technology, Lattice Press, 2002 • C. Y. Chang, S. M. Sze: ULSI - Technology, MacGraw-Hill, 1996 • K. Goser, P. Glösekötter, J. Dienstuhl: Nanoelectronics ans Nanosystems, Springer-Verlag, 2004 • H. Xiao, Introduction to Semiconductor Manufacturing Technology, Prentice Hall, 2001 • R. Waser (ed.): Nanoelectronics and Information Technology: Materials, Processes, Devices, 2. Auflage, Wiley-VCH, 2005

1	**Module name** 45780	**Bottom-Up Nano-Synthese / Self-Assembly** Bottom-up Nanosynthesis / Self-assembly	**10 ECTS**
2	Courses / lectures	Vorlesung: Molekulare Nanostrukturen (2 SWS, WiSe 2025) Vorlesung mit Übung: Nanotechnology of Disperse Systems (3 SWS, SoSe 2025) Vorlesung: Self-assembly at surface (2 SWS, SoSe 2025)	- 5 ECTS -
3	Lecturers	Prof. Dr. Franziska Gröhn Prof. Dr. Robin Klupp Taylor Dr. Monica Distaso Prof. Dr. Marcus Halik	

4	**Module coordinator**	Prof. Dr. Franziska Gröhn Prof. Dr. Marcus Halik Prof. Dr. Robin Klupp Taylor
5	**Contents**	**Molecular Nanostructures (Prof. Gröhn, Winter Semester Only, 3 ECTS)** • Introduction: Molecules, nanoparticles and molecular nanostructures • Self-assembly of surfactants: interplay of enthalpy and entropy in self-organization, the hydrophobic effect, equilibrium of association, micelle form • Different self-organized nanoparticles from amphiphilic building blocks: ternary systems, block copolymers, more complex amphiphilic building blocks and architectures, use as carriers and confined reaction space • Interaction forces in colloidal systems: various attractive interactions for supramolecular linking, repulsive forces for stabilization, DLVO theory • Diverse and novel supramolecular nanoparticles: through π-π interaction, metal coordination, ionic interaction or their interplay; Responsive and switchable supramolecular particles • Polymers and Polyelectroylets: Characteristics of macromolecules in solution, macromolecular architectures, dendrimers and microgels • Characterization of molecular nanostructures with static and dynamic light scattering; Combination of various structural analytical methods • Functional complex nano-objects in solution for future applications • Understanding and actively apply structure formation principles, experiment design and data analysis. **Nanotechnology of Disperse Systems (Prof. Klupp Taylor, Dr. Distaso, Winter and Summer Semester, 3+1 ECTS)** • Introduction to nanodisperse systems and their broad fields of application and research

		• Optoelectronic properties of nanodisperse systems • Magnetic properties of nanodisperse systems • Ex situ and in situ characterisation of nanoparticles (Optical methods; Electron microscopy; Scanning probe microscopy; Spectroscopy) • Fundamental aspects of the preparation of nanodisperse systems (Thermodynamic fundamentals; Hydrolysis and polycondensation (metal oxides); Redox-reactions (metals); Solvothermal/Hydrothermal synthesis; Control of particle size and morphology) • Synthesis and properties of carbon nanotubes • Industrial methods of nanoparticle synthesis • Exercise sessions: 10 minute critical presentations on recent primary research literature, organised into thematic sessions **Self-organization on Surfaces (Prof. Halik, Winter Semester Only, 3 ECTS)** • Fundamentals: Physisorption and chemisorption, growth modes, anchor group chemistry, analytical methods for characterization, phase separation • Weak surface interaction (van der Waals and dipolar WW), mobility of nanoscale systems on surfaces, 2D vs. 3D assembly • Medium WW (H-bonding, non-covalent systems) self-terminated growth, generation of 2D- superstructures, substrate influence (chemical structure and morphology) • Strong WW (Coulomb, covalent) stability (mechanical, chemical, thermal) exchange reactions on surfaces • Application examples • Hierarchical structure construction (layer-by-layer, complex layer structures, gradients, structured self-organization with lateral resolution on nm scale) • Self-organization on complex inner surfaces (Organization 3.-5. order)
6	**Learning objectives and skills**	**Molecular Nanostructures (Prof. Gröhn, Winter Semester Only, 3 ECTS)** • Acquire factual knowledge about various types of nanoscale molecular structures • Learn how the interplay of different interactions controls the formation of self-organized structures and colloidal systems. • Learn to quantitatively describe molecular nanostructures in solution. • Asses which molecular factors determine the shape, size, and architecture of supramolecular nanoparticles in solution. • Assess which methods are suitable for the structural characterization of supramolecular nanoparticles and layers. • Discover entry-points into the vast research literature covering nanoparticles. • Identify the preferred methods to produce nanoparticles of a specified material, size, shape or properties.

		Nanotechnology of Disperse Systems (Prof. Klupp Taylor, Dr. Distaso, Winter and Summer Semester, 3+1 ECTS) • Identify major applications and research fields of nanodisperse systems • Identify and explain the fundamental theories of nucleation and growth and colloidal stability • Differentiate between different approaches for the preparation of nanodisperse systems • Select metal and metal oxide precursors and oxidizing/ reducing agents according to their thermodynamic properties. • Give examples of means to control nanoparticle size, shape and agglomeration state • Distinguish between different characterization tools according to their advantages and disadvantages for the analysis of nanodisperse systems • Identify the influence of particle size on key physical properties • Match physical properties of nanoparticles to current or emergent applications • Plan a presentation in which they compare and appraise recent research activities from the literature **Self-organization on Surfaces (Prof. Halik, Winter Semester Only, 3 ECTS)** • ...
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2
9	**Module compatibility**	Pflichtmodul Master of Science Nanotechnology 20232
10	**Method of examination**	Oral (30 minutes) mündliche Prüfung (30 Min). oral exam (30 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every second semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	german or english
16	**Bibliography**	**Nanoparticles and nanotechnology in general** • Axelos, M.A. and van de Voorde, M.H. (2017) Nanotechnology in agriculture and food science, Wiley-VCH, Verlag GmbH & Co. KGaA, Weinheim. Full text • Diwald, O. Berger, T. (2021) Metal oxide nanoparticles: Formation, functional properties, and interfaces, Wiley-VCH, Verlag GmbH & Co. KGaA, Weinheim. Full text

- Müller, B. and van de Voorde, M. (2017) Nanoscience and Nanotechnology for Human Health, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany. Full text
- Naitō, M., Yokoyama, T., Hosokawa, K., Nogi, K. (eds) (2018) Nanoparticle technology handbook, Elsevier, Amsterdam. Full text
- Natelson, D. (2015) Nanostructures and Nanotechnology, Cambridge University Press, Cambridge. Full text
- Sánchez-Domínguez, M. and Rodriguez Abreu, C. (2016) Nanocolloids: A meeting point for scientists and technologists, Elsevier, Amsterdam. Full text
- Sharon, M. (ed) (2019) History of nanotechnology: From pre-historic to modern times, Wiley, Hoboken NJ USA. Full text

Optical properties of nanoparticles / nanophotonics

- Bohren, C.F. and Huffman, D.R. (1993 (1998[printing])) Absorption and scattering of light by small particles, Wiley, New York, Chichester. Full text
- Gaponenko, S. V. Introduction to nanophotonics, 2010, (Full text)
- Pelton, M. and Bryant, G.W. (2013) Introduction to metal-nanoparticle plasmonics, Wiley; Science Wise Publishing, Hoboken, New Jersey. Full text
- Quinten, M. (2011) Optical properties of nanoparticle systems: Mie and beyond, Wiley-VCH, Weinheim. Full text

Magnetic nanoparticles

- Gubin, S.P. (2009) Magnetic nanoparticles, Wiley-VCH, Weinheim. Full text
- Katz, E. (ed) (2020) Magnetic Nanoparticles, MDPI, Basel. Full text (open access)
- Rivas, J., Kolen'ko, Y.V., Bañobre-López, M. (2016) Magnetic Nanocolloids, in Nanocolloids, Elsevier, pp. 75–129. Full text

Nanoparticle characterisation

- Unger, W., Hodoroaba, V.-D., Shard, A. (2019) Characterization of nanoparticles: Measurement processes for nanoparticles Elsevier, Amsterdam. Full text

Nanoparticle synthesis

- Haumesser, P.-H. (2016) Nucleation and growth of metals: From thin films to nanoparticles, Elsevier, Amsterdam. Full text
- Mohan, S., Oluwafemi, S.O., Kalarikkal, N., Thomas, S. (2018) Synthesis of inorganic nanomaterials: Advances and key technologies, Woodhead Publishing, Oxford. Full text
- Sau, Tapan K, Rogach, Andrey L. Complex-shaped metal nanoparticles: bottom-up syntheses and applications, 2012 Wiley-VCH Full Text
- Thomas, Sabu et al. Colloidal Metal Oxide Nanoparticles: Synthesis, Characterization and Applications, 2020 Elsevier Full Text
- Thota, S. and Crans, D.C. (2018) Metal nanoparticles: Synthesis and applications in pharmaceutical sciences, Wiley-VCH, Weinheim. Full text

1	**Module name** 45865	**Wissenschaftliches Projekt** Scientific project	**10 ECTS**
2	Courses / lectures	Seminar: Hauptseminar M12-MWT/NT WTM (4 SWS) Masterseminar: Seminar Polymerwerkstoffe-Kernfach - ALTE FPO (2 SWS) Seminar: Literature research and working techniques M12-NT-WW3 (5 SWS) Masterseminar: Hauptseminar M12-NT-WW3 (5 SWS)	5 ECTS 5 ECTS 5 ECTS 5 ECTS
3	Lecturers	Peter Randelzhofer Prof. Dr. Kyle Grant Webber Tobias Fey Prof. Dr. Dominique de Ligny apl. Prof. Dr. Nahum Travitzky PD Dr. Stephan Wolf	

4	**Module coordinator**	Frederik Leikauf
5	**Contents**	In preparation for the master's thesis, the students carry out independent literature research on a relevant topic in the field of nanotechnology. Supervision is organized in the respective chairs. The lecturers issue topics on which the students have to present their research results in writing. Furthermore, the students prepare a lecture in English on the topic. After the lecture (approx. 30 minutes), the speaker will answer questions in a discussion round --- Die Studierenden erarbeiten zur Vorbereitung der Masterarbeit eine eigenständige Literaturrecherche in einem relevanten Thema im Bereich der Nanotechnologie. Die Betreuung wird in den jeweiligen Lehrstühlen organisiert. Von den Dozenten werden Themen ausgegeben, zu welchen die Studierenden ihre Rechercheergebnisse in schriftlicher Form darstellen müssen. Weiterhin erarbeiten die Studierenden zu dem Thema einen Vortrag in englischer Sprache. Im Anschluss an den Vortrag (ca. 30 Minuten) steht der Vortragende Rede und Antwort in einer Diskussionsrunde.
6	**Learning objectives and skills**	Students are able: • explain scientific basics as well as specialized and in-depth knowledge. • independently design, reflect and methodically expand their own learning processes, • work independently on literature research for a specific topic in the field of nanotechnology, • summarize and discuss this topic in writing.

		• give a free lecture on a piece of knowledge compiled from the literature • Apply subject-related basics, terms and formulations in English --- Die Studierenden können: • wissenschaftliche Grundlagen sowie spezialisiertes und vertieftes Fachwissen erläutern. • eigene Lernprozesse selbständig gestalten, reflektieren und methodisch erweitern, • eine Literaturrecherche für ein eingegrenztes Thema im Bereich der Nanotechnologie selbständig bearbeiten, zusammenfassen und dieses Thema in schriftlicher Form diskutieren. • einen freien Vortrag zu einem aus der Literatur erarbeiteten Wissensstoffs halten • fachbezogene Grundlagen, Begriffe und Formulierungsweisen in Englischer Sprache anwenden
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 3
9	**Module compatibility**	Pflichtmodul Master of Science Nanotechnology 20232
10	**Method of examination**	Seminar achievement Seminarleistung, vgl. § 6 Abs. 3 Satz 7 und 8 ABMPO/TechFak sowie Modulhandbuch Seminar performance, see § 6 paragraph 3 sentences 7 and 8 ABMPO/ TechFak and module manual
11	**Grading procedure**	Seminar achievement (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46217	**Softskills** Soft Skills	**5 ECTS**
2	Courses / lectures	Seminar: M13 Softskills (4 SWS)	4 ECTS
3	Lecturers	Rebecca Schuster Susanne Michler Dr.-Ing. Joachim Kaschta Frederik Leikauf	

4	**Module coordinator**	Frederik Leikauf
5	**Contents**	**Präsentationstechnik** In diesem Modul erwerben die Studierenden im ersten Teil zunächst grundlegende Fähigkeiten und Kenntnisse zum wissenschaftlichen Arbeiten. Sie lernen dann im Anschluss, wie sie effektive Präsentationen vorbereiten und gestalten können, wobei Schwerpunkte auf der Entwicklung von Präsentationsfähigkeiten wie Körpersprache und Rhetorik aber auch auf der Foliengestaltung liegen. Darüber hinaus erhalten die Studierenden noch praktische Übungen zur Stimmbildung In diesem Seminar werden an Hand von Vorträgen, die von Studierenden auszuarbeiten und in englischer Sprache vorzutragen sind, die neusten Entwicklungen aus dem Gebiet der Werkstoffwissenschaften vorgestellt. Die Literatur zu einem Thema ist selbständig zu suchen oder wird vom Betreuer ausgegeben. Im Anschluss an den Vortrag (20 Minuten) steht der Vortragende Rede und Antwort in einer Diskussionsrunde (5 Minuten). **Exkursionen** In den Exkursionen werden verschiedene Aspekte der industriellen Umgebung im Bereich der Werkstofftechnologie oder Nanotechnologie kennengelernt. .... **Presentation Technique** In this module, students first acquire basic skills and knowledge of scientific work. They then learn how to prepare and design effective presentations, focusing on the development of presentation skills such as body language and rhetoric, but also on slide design. In addition, the students will receive practical exercises in voice training. In this seminar, the latest developments in the field of materials science are presented by means of lectures to be prepared by students and presented in English. The literature on a topic has to be searched independently or will be handed out by the supervisor. Following the

		lecture (20 minutes), the lecturer will be available to answer questions in a discussion session (5 minutes). **Excursions** In the excursions different aspects of the industrial environment in the field of materials technology or nanotechnology are learned.
6	**Learning objectives and skills**	Die Studierenden werden befähigt, wissenschaftliche Informationen klar und überzeugend zu kommunizieren und sind am Ende des Moduls in der Lage, selbstbewusst und kompetent vor anderen zu präsentieren. Dafür erarbeiten die Studierenden selbständig ein wissenschaftliches Referat in englischer Sprache zu einem vorgegebenen Thema. Sie erwerben Erfahrungen im möglichst freien Vortrag eines aus der Literatur erarbeiteten Wissensstoffs. Die Studierenden • können selbständig aktuelle wissenschaftliche Ergebnisse und Erkenntnisse in einer Thematik des Masterstudiums (im Bereich der Materialwissenschaft oder im Bereich der Nanotechnologie) präsentieren und in der Gruppe diskutieren; • können freie Vorträge über aus der Literatur erarbeiteten Wissensstoff halten; • stärken ihre Selbst- und Sozialkompetenz, indem einerseits ein Fachthema für ein Fachpublikum auf Masterniveau aufbereitet, dargestellt und zielgruppenadäquat präsentiert wird und andererseits in einer Gruppe gemeinsam und unter Anleitung fachnahe Anwendungen sowie Realisierungsmöglichkeiten diskutiert werden; • schärfen durch die Wahlfreiheit der Exkursionen ihr Profil im Hinblick auf ihr angestrebtes zukünftiges Berufsfeld und/oder ihre Persönlichkeit .... Students will be enabled to communicate scientific information clearly and convincingly and will be able to present confidently and competently in front of others at the end of the module. For this purpose, students independently develop a scientific presentation in English on a given topic. They will gain experience in giving as free a presentation as possible of a body of knowledge acquired from the literature. **The students** • can independently present current scientific results and findings in a topic of the Master's program (in the field of materials science or in the field of nanotechnology) and discuss them in the group;

		• can give free lectures on knowledge material acquired from the literature; • strengthen their self- and social competence by preparing, presenting and presenting a specialized topic for a specialized audience at Master's level in a way appropriate to the target group on the one hand, and by discussing specialized applications as well as realization possibilities in a group together and under guidance on the other hand; • sharpen their profile with regard to their desired future professional field and/or their personality through the freedom of choice of the excursions.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 3
9	**Module compatibility**	Pflichtmodul Master of Science Nanotechnology 20232
10	**Method of examination**	Seminar achievement Organisatorisches: Exkursionen werden entweder auf den Homepages oder durch Aushänge der Lehrstühle des Departments Werkstoffwissenschaften angekündigt. **Ergänzende Informationen zu Studien- und Prüfungsleistungen:** Präsentationstechnik: **ein Vortrag (20 Min.)** 1 Exkursion: **Die Nachweise der Exkursionen müssen im SSC des Dep. WW abgegeben werden.** …… **Organizational Information:** Excursions are announced either on the department's websites or on bulletin boards of the Materials Science department chairs. **Additional Information on Study and Examination Requirements:** Presentation techniques: one presentation (20 min.) 1 excursion: Proof of excursion attendance must be submitted to the SSC of the Materials Science department.
11	**Grading procedure**	Seminar achievement (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

General Materials Properties

1	**Module name** 46301	**Structural Materials**	**10 ECTS**
2	Courses / lectures	Vorlesung: Structural Materials 2 (2 SWS, SoSe 2025) Übung: Structural Materials 2 - Excercises (2 SWS, SoSe 2025)	3 ECTS 2 ECTS
3	Lecturers	Steffen Neumeier Prof. Dr. Mathias Göken Dr. Michael Wurmshuber	

4	**Module coordinator**	Prof. Dr. Mathias Göken
5	**Contents**	*Angewandte Grundlagen I+II, V, 2x2 SWS, 5 ECTS* Blickpunkt steht die Beziehung zwischen Mikrostruktur / Aufbau der Werkstoffe und ihren mechanischen Eigenschaf-ten. Hierzu werden grundlegende Verformungs- und Schädigungsmechanismen besprochen und auf technisch relevante Legierungen übertragen. Die Inhalte im Einzelnen: • Mechanische Eigenschaften (Ein- und Vielkristallverformung, Verformungsmechanismen) • Bruchmechanik (Grundlagen, Anwendungen) • mikrostruktureller und atomarer Aufbau auf unterschiedlichen Längenskalen sowie die daraus ableitbare Eigenschaften) • Verbundwerkstoffe • Simulationstechniken und deren Anwendung • Phasenumwandlungen und Ausscheidungskinetik *Übungen zu Angewandten Grundlagen I+II, 2x2 SWS, 5 ECTS* Anhand von Übungsaufgaben werden die Vorlesungsinhalte der VL Angewandte Grundlagen vertieft. Themenschwerpunkte: • Simulationstechniken • Verformungsmodelle • Ausscheidungskinetik • Experimentelle Techniken • Bruchmechanik Structural Materials (Applied Fundamentals) I+II, V, 2x2 SWS, 5 ECTS The focus is on the relationship between microstructure / structure of materials and their mechanical properties. Basic deformation and damage mechanisms are discussed and applied to technically relevant alloys. The contents in detail: • Mechanical properties (single and multi-crystal deformation, deformation mechanisms) • Fracture mechanics (fundamentals, applications) • microstructural and atomic structure on different length scales and the properties that can be derived from them) • composite materials • simulation techniques and their application • phase transformations and precipitation kinetics Exercises on Structural Materials (Applied Fundamentals) I+II, 2x2 SWS, 5 ECTS

		• The lecture contents of the lecture Applied Fundamentals are deepened by means of exercises. Main topics: • Simulation techniques • deformation models • Precipitation kinetics • Experimental techniques • Fracture mechanics
6	**Learning objectives and skills**	*Fachkompetenz* Evaluieren (Beurteilen) Die Studierenden • vertiefen ihr Wissen über die vielfältigen strukturellen Aufbauten der Werkstoffe und können diese beurteilen • vertiefen das Verständnis über die Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen • können Legierungsthermodynamik anwenden und Zustandsdiagrammen analysieren • vertiefen das Wissens zu den mechanischen Eigenschaften und Härtungsmechanismen • können Struktur-Eigenschaftskorrelationen erschließen und überprüfen • beurteilen eigenständig Struktur-Eigenschaftsbeziehungen an Beispielen • verstehen die Vorgänge und Eigenschaften von Werkstoffen auf verschiedenen Größenskalen • erwerben fundierter Kenntnisse über die Grundlagen zum Aufbau der verschiedenen Werkstoffklassen, Charakterisieren unterschiedlicher Strukturen • vertiefen ihr Verständnis der Zusammenhänge zwischen Aufbau, thermomechanischer Vorgeschichte und Eigenschaften der Werkstoffe und können diese erklären • wenden und beurteilen Simulationsmethoden und können diese klassifizieren • vertiefen die erlernten Inhalte durch Übungen und Praktikum • erlernen und wenden neuen Methoden an • deepen their knowledge of the various structural compositions of materials and are able to evaluate them • deepen their understanding of the relationships between the chemical composition, structure and properties of materials • can apply alloy thermodynamics and analyze state diagrams • deepen knowledge of mechanical properties and hardening mechanisms • can develop and verify structure-property correlations • independently evaluate structure-property relationships using examples • understand the processes and properties of materials on different size scales

		• acquire a sound knowledge of the fundamentals of the structure of the various classes of materials, characterize different structures • deepen their understanding of the relationships between structure, thermomechanical history and properties of materials and can explain them • apply and evaluate simulation methods and can classify them • deepen the learned contents by exercises and practical training • learn and apply new methods • *Lern- bzw. Methodenkompetenz* Neue Methodenkompetenzen, die erworben werden können: • Simulationstechniken • Materialwissenschaftliche Lösungsstrategien Learning or methodological competencies New methodological competencies that can be acquired: • Simulation techniques • Material science solution strategies
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Variable mündliche Prüfung (30 min.) oral exam (30 minutes)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46292	**Macroscopic mechanical properties**	**5 ECTS**
2	Courses / lectures	Vorlesung: Ermüdungsverhalten von Metallen und Legierungen (1 SWS, SoSe 2025) Sonstige Lehrveranstaltung: Lecture Briefing MSE I (0 SWS, SoSe 2025) Sonstige Lehrveranstaltung: Vorbesprechung Praktika in Mastermodulen WW 1 inkl. Sicherheitsbelehrung (0 SWS, SoSe 2025) Vorlesung mit Übung: High-Temperature Materials and Intermetallics (2 SWS, SoSe 2025) Einführungskurs: Lab-course briefing & Security Instruction Part II (SoSe 2025)	1,5 ECTS - - 2 ECTS -
3	Lecturers	apl. Prof. Dr. Heinz Werner Höppel Prof. Dr. Peter Felfer Steffen Neumeier Prof. Dr. Mathias Göken Dr. Michael Wurmshuber	

4	**Module coordinator**	apl. Prof. Dr. Heinz Werner Höppel
5	**Contents**	***Atomsondentomography with exercise*** • Introduction to Atomic Probe Tomography • Physical basics of APT • Principle and instrument limitations • Evaluation methods • practical implementation *** fatigue behavior of metals and alloys, V, 1 SWS, 1 ECTS*** • fundamentals of alternating deformation and fatigue strength of metallic materials • importance in practice • performance of fatigue tests • cyclic deformation and saturation behavior, cyclic sliding behavior, fatigue-induced microstructural changes • fatigue crack formation and propagation, • fatigue life • multiamplitude loading • other special fatigue topics ***Practical course on fatigue behavior and fracture mechanics, 1 SWS, 1 ECTS** Experiments on cyclic deformation behavior Fracture mechanics behavior of materials ***Practical seminar: Experimental methods, SWS, 1 ECTS*** • different experimental methods • Temperature measurement • Force-strain measurement

		• Vacuum technology • PID controller
6	**Learning objectives and skills**	**The students** • deepen their knowledge of the diverse structural compositions of materials and are able to evaluate them • deepen their understanding of the relationships between the chemical composition, structure and properties of materials • deepen their knowledge of mechanical properties and hardening mechanisms • deepen their knowledge of structure-property correlations • independently assess structure-property relationships using examples • understand the processes and properties of materials on different size scales • deepen their knowledge through exercises and practical training • learn and apply new methods • learn, apply and evaluate processes during cyclic deformation • learn, deepen and assess fracture mechanics processes • understand the basics of biomechanics, apply their knowledge and assess using appropriate practical examples
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Practical achievement Oral (15 minutes) in the moment an oral exam (xy minutes)
11	**Grading procedure**	Practical achievement (pass/fail) Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46207	**Materialcharakterisierung** Material characterization	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Atomsondenmikroskopie_School (1 SWS, SoSe 2025) Sonstige Lehrveranstaltung: Lecture Briefing MSE I (0 SWS, SoSe 2025) Sonstige Lehrveranstaltung: Vorbesprechung Praktika in Mastermodulen WW 1 inkl. Sicherheitsbelehrung (0 SWS, SoSe 2025)	1 ECTS - -
3	Lecturers	Prof. Dr. Peter Felfer apl. Prof. Dr. Heinz Werner Höppel Steffen Neumeier Prof. Dr. Mathias Göken Dr. Michael Wurmshuber	

4	**Module coordinator**	Steffen Neumeier
5	**Contents**	Quantitative Gefügeanalyse, V+Ü, 1 SWS, 1 ECTS • Einführung in die Quantitative Gefügeanalyse und die dazugehörigen Meßmethoden • Auswertemethoden • Grundlagen der Statistik • Praktische Anwendung von Image C Röntgenmethoden in der Materialanalyse, V, 1 SWS, 1 ECTS • Grundlagen der Röntgen-/Synchrotron-/Neutronenbeugung • Experimentelle Methoden • Anwendung in der Materialanalyse (Gitterkonstantenbestimmung, Spannungsanalyse, Texturanalyse,) Anforderungen der Industrie an einen Werkstoffingenieur: • Grundlagen industrieller Planungen im Werkstoffumfeld • Industrielle Lösungsstrategien bei Werkstofffragestellungen • Industrielle Charakterisierungsverfahren Quantitative Microstructural Analysis, V+Ü, 1 SWS, 1 ECTS • Introduction to quantitative microstructure analysis and the corresponding measuring methods • Evaluation methods • Basics of statistics • Practical application of Image C X-ray methods in materials analysis, V, 1 SWS, 1 ECTS • Basics of X-ray/synchrotron/neutron diffraction • Experimental methods • Application in material analysis (determination of lattice constants, stress analysis, texture analysis,...) Fundamentals of Failure Analysis, V+Ü+P 0.5+1+0.5 SWS, 0.5+1+0.5 ECTS • Basic procedure of damage analysis • Damage hypotheses • Case studies from practice

		• Practical test to deepen the contents
6	**Learning objectives and skills**	Fachkompetenz Evaluieren (Beurteilen) Die Studierenden • vertiefen ihr Wissen über die vielfältigen strukturellen Aufbauten der Werkstoffe und können diese beurteilen • vertiefen das Verständnis über die Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen • beurteilen eigenständig Struktur-Eigenschaftsbeziehungen an Beispielen • erwerben fundierter Kenntnisse über die Grundlagen zum Aufbau der verschiedenen Werkstoffklassen, Charakterisieren unterschiedlicher Strukutren • vertiefen die erlernten Inhalte durch Übungen und Praktikum • erlernen und wenden neuen Methoden an • erlernen Grundlagen der Schadensanalyse, wenden diese an Beispielfällen an und stellen Schadenshypothesen auf Lern- bzw. Methodenkompetenz Neue Methodenkompetenzen, die erworben werden können: • Grundlegende Experimentiertechniken • Quantitative Gefügeanalyse • Grundlegende Methoden der Röntgenbeugung Technical competence Evaluating (assessing) Students will • deepen their knowledge of the various structural compositions of materials and are able to evaluate them • deepen their understanding of the relationships between the chemical composition, structure and properties of materials • independently assess structure-property relationships using examples • acquire a sound knowledge of the fundamentals of the structure of the various classes of materials and characterize different structures • deepen the learned contents by exercises and practical training • learn and apply new methods • learn the basics of damage analysis, apply them to example cases and establish damage hypotheses Learning or methodological competencies New methodological competencies that can be acquired: • Basic experimental techniques • Quantitative microstructure analysis • Basic methods of X-ray diffraction
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232

		General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Variable (100%) mündliche Prüfung (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46203	**Hochtemperaturwerkstoffe** High-temperature materials	**5 ECTS**
2	Courses / lectures	Praktikum: Labwork: High-Temperature Materials (3 SWS) Vorlesung mit Übung: High-Temperature Materials and Intermetallics (2 SWS) Einführungskurs: Lab-course briefing & Security Instruction Part II	3 ECTS 2 ECTS -
3	Lecturers	apl. Prof. Dr. Heinz Werner Höppel Steffen Neumeier	

4	**Module coordinator**	Steffen Neumeier
5	**Contents**	*Hochtemperaturwerkstoffe und Intermetallische Phasen, V, 2 SWS, 2 ECTS* • Grundlagen der Hochtemperaturverformung • Struktur und Eigenschaften Intermetallischer Phasen • Vorstellung unterschiedlicher Werkstoffgruppen (Nickel- und Cobaltbasis-Superlegierungen, TiAl, FeAl, Oxidationsschutzschichten, Hochtemperaturstähle) mit ihren jeweiligen Eigenschaften und Anwendungen • aktuelle Entwicklungen in diesem Gebiet *Praktikum, 3 SWS, 3 ECTS* • Ausscheidungsvorgänge in Metallen • Diffusionsvorgänge Content: • High temperature materials and intermetallic phases, V, 2 SWS, 2 ECTS • Fundamentals of high temperature deformation • Structure and properties of intermetallic phases • Presentation of different material groups (nickel and cobalt based superalloys, TiAl, FeAl, oxidation protection coatings, high temperature steels...) with their respective properties and applications • current developments in this field practical course, 3 SWS, 3 ECTS • Precipitation processes in metals • Diffusion processes
6	**Learning objectives and skills**	*Fachkompetenz Evaluieren (Beurteilen)* Die Studierenden • vertiefen ihr Wissen über die vielfältigen strukturellen Aufbauten der Werkstoffe und können diese beurteilen • vertiefen das Verständnis über die Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen • vertiefen das Wissens zu den mechanischen Eigenschaften und dem Werkstoffverhalten bei hohen Temperaturen

		• vertiefen ihr Verständnis der Zusammenhänge zwischen Aufbau, thermomechanischer Vorgeschichte und Eigenschaften der Werkstoffe und können diese erklären • vertiefen die erlernten Inhalte durch Übungen und Praktikum • erlernen und wenden neuen Methoden an • erlernen und verstehen Vorgänge bei Hochtemperaturbelastung und evaluieren Kriterien zur Auswahl von Werkstoffen und Beschichtungen für HT-Anwendungen Lern- bzw. Methodenkompetenz Neue Methodenkompetenzen, die erworben werden können: • Grundlegende Experimentiertechniken • Grundlegende Mikroskopiertechniken Learning objectives and competences: • Technical competence Evaluate (judge) The students • deepen their knowledge of the various structural compositions of materials and are able to evaluate them • deepen their understanding of the relationships between the chemical composition, structure and properties of materials • deepen their knowledge of mechanical properties and material behavior at high temperatures • deepen their understanding of the relationships between structure, thermomechanical history and properties of materials and are able to explain them • deepen their knowledge through exercises and practical training • learn and apply new methods • learn and understand processes at high temperatures and evaluate criteria for the selection of materials and coatings for HT applications Learning or methodological competencies New methodological competencies that can be acquired: • Basic experimental techniques • Basic microscopy techniques
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46248	**Tribologie und Oberflächentechnik und Schadensanalyse** Tribiology, surface finishing and damage analysis	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Werkstoffe: Tribologie und Oberflächentechnik (2 SWS) Praktikum: Praktikum: Tribologie (2 SWS) Praktikum: Labwork Failure Analysis (0 SWS) Vorlesung mit Übung: Grundlagen der Schadensanalyse an Bauteilen (2 SWS)	2 ECTS 3 ECTS - 3 ECTS
3	Lecturers	apl. Prof. Dr. Heinz Werner Höppel Christina Hasenest Prof. Dr. Peter Weidinger	

4	**Module coordinator**	apl. Prof. Dr. Heinz Werner Höppel
5	**Contents**	*Tribologie und Oberflächentechnik, V, 2 SWS, 2 ECTS* • Beschichtungstechnologien • Grundlagen der Tribologie • Verschleißmechanismen • Einführung in die Oberflächentechnik *Schadensanalyse metallischer Werkstoffe, V, 2 SWS, 2 ECTS * Praktikum:Tribologie, 1 SWS, 1 ECTS* *Grundlagen der Schadensanalyse mit Praktikum, 1 SWS, 1 ECTS* • Grundlegendes Vorgehen bei der Schadensanalyse • Schadenshypothesen • Schadensabhilfemaßnahmen • praktische Fallbeispiele Courses: Lectures: 1) Materials: Tribology and Surface Engineering (Lecture with exercise, 2 SWS) Failure analysis of metallic materials Lecture with exercise, 2 SWS) Practical Courses: 1) Tribology: Practical Course, 1 SWS expected start 2nd half of the semester! 2) Failure analysis of metallic materials Practical course, 1 SWS, block course Content: • Tribology and Surface Technology, • Coating Technologies • Basics of tribology • Wear mechanisms • Introduction to surface technology

		• Failure Analysis • Practical course: Tribology • Practical Course: Failure Analysis
6	**Learning objectives and skills**	*Fachkompetenz Evaluieren (Beurteilen)* Die Studierenden • vertiefen ihr Wissen über die vielfältigen strukturellen Aufbauten der Werkstoffe und können diese beurteilen • vertiefen das Verständnis über die Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen und über tribologische Vorgänge • vertiefen ihr Wissen zu Beschichtungstechnologien und Schichteigenschaften • vertiefen ihr Verständnis der Zusammenhänge zwischen Aufbau, thermomechanischer Vorgeschichte und Eigenschaften der Werkstoffe und können diese eklären • vertiefen die erlernten Inhalte durch Praktikum • erlernen und wenden neuen Methoden an • erlernen und verstehen tribologische Vorgänge und evaluieren Kriterien zur Auswahl von Werkstoffen und Beschichtungen für tribologische Anwendungen Technical competence Evaluating (assessing) Students will • deepen their knowledge about the various structural compositions of materials and are able to evaluate the • deepen their understanding of the relationships between the chemical composition, structure and properties of materials and of tribological processes • deepen their knowledge of coating technologies and coating properties • deepen their understanding of the relationships between structure, thermomechanical history and properties of materials and are able to clarify these relationships • deepen their knowledge through practical training • learn and apply new methods • learn and understand tribological processes and evaluate criteria for selecting materials and coatings for tribological applications • learn and understand failure analysis methods • apply learned methods and strategies in case studies
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Variable

		derzeit mündliche Prüfung (15 Min.) currently oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46308	**Iron and Steel**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Iron and steel II (2 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Prof. Dr. Peter Felfer	

4	**Module coordinator**	Prof. Dr. Peter Felfer
5	**Contents**	Eisen- und Stahlwerkstoffe I+II , V+Ü, 2+3 SWS, 2+3 ECTS • Grundlagen der Stahlherstellung • Grundlagen der Wärmebehandlungen • Eigenschaften und Anwendung der verschiedenen Stahlklassen • Schweißmetallurgie • Eigenschaften und Anwendungen von Eisengusswerkstoffen Content: Iron and steel materials I+II , V+Ü, 2+3 SWS, 2+3 ECTS • Basics of steel production • Basics of heat treatments • Properties and application of the different steel classes • Welding metallurgy • Properties and applications of iron casting materials
6	**Learning objectives and skills**	*Fachkompetenz Evaluieren (Beurteilen)* Die Studierenden • vertiefen ihr Wissen über die vielfältigen strukturellen Aufbauten der Werkstoffe Eisen und Stahl und können diese beurteilen • vertiefen das Verständnis über die Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen • können Legierungsthermodynamik anwenden und Zustandsdiagrammen analysieren • vertiefen das Wissens zu den mechanischen Eigenschaften und Härtungsmechanismen bei Stählen • können Struktur-Eigenschaftskorrelationen erschließen und überprüfen bei Stählen • beurteilen eigenständig Struktur-Eigenschaftsbeziehungen an Beispielen • vertiefen ihr Verständnis der Zusammenhänge zwischen Aufbau, thermomechanischer Vorgeschichte und Eigenschaften der Werkstoffe und können diese erklären *Lern- bzw. Methodenkompetenz* Neue Methodenkompetenzen, die erworben werden können: • o deepen their knowledge of the diverse structural compositions of iron and steel materials and are able to evaluate them

		◦ deepen their understanding of the relationships between the chemical composition, structure and properties of materials ◦ can apply alloy thermodynamics and analyze state diagrams ◦ deepen knowledge of mechanical properties and hardening mechanisms of steels ◦ can develop and check structure-property correlations for steels ◦ independently assess structure-property relationships using examples ◦ deepen their understanding of the relationships between structure, thermomechanical history and properties of materials and are able to explain these relationships. ◦ Basic experimental techniques
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Variable mündliche Prüfung (15 Min.) oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Materials Science and Engineering for Metals

1	**Module name** 46211	**Metallische Werkstoffe: Grundlagen und Technologien** Metallic Materials: Fundamentals and Technologies	**10 ECTS**
2	Courses / lectures	Übung: Tutorial Metallic Materials 2 (2 SWS, SoSe 2025) Vorlesung: Lecture Metallic Materials: Technologies & Application (2 SWS, SoSe 2025)	2,5 ECTS 2,5 ECTS
3	Lecturers	Dr.-Ing. Christopher Zenk Dr.-Ing. Matthias Markl Prof. Dr.-Ing. Carolin Körner	

4	**Module coordinator**	Prof. Dr.-Ing. Carolin Körner
5	**Contents**	• Grundlagen der Phasen- und Gefügeumwandlung • Zusammenhang zwischen Prozess und Gefügeausbildung • Einführung in die Simulation von Thermodynamik, Kinetik und Formfüllung, ergänzt durch eigene Programmierarbeiten • Einführung in wichtige Verfahrenstechnologien (Gießen, Umformen, Pulvermetallurgie und Fügen) • Vorstellung der Werkstoffgruppen Titan-, Nickelbasis- und Kupferlegierungen, intermetallische Phasen, Formgedächtnislegierungen, Lager- und Kontaktwerkstoffe (Erzeugung, Verarbeitung, wichtige Legierungen, Anwendung und neue Entwicklungen); bei Vorgängen von besonderer praktischer Bedeutung Verknüpfung mit den metallphysikalischen Grundlagen. • Werkstoffeigenschaften und -prüfung **English** • Fundamentals of phase and microstructure transformation • Relationship between process and microstructure formation • Introduction to simulation of thermodynamics, kinetics and mold filling, supplemented by own programming work • Introduction to important process technologies (casting, forming, powder metallurgy and joining) • Presentation of the material groups titanium, nickel-based and copper alloys, intermetallic phases, shape memory alloys, bearing and contact materials (production, processing, important alloys, application and new developments); for processes of particular practical importance, linking with the fundamentals of metal physics. • Material properties and testing
6	**Learning objectives and skills**	Die Studierenden: • erwerben ein Verständnis für industrierelevante Arbeitsmethoden • können wesentliche Entwicklungsfelder metallischer Werkstoffe einordnen

		• erwerben ein tiefes Grundlagenverständnis und können Struktur-Eigenschaftsbeziehungen auf allen Größenskalen klassifizieren • lernen wesentliche Herstellungs- und Verarbeitungsprozesse kennen und können diese differenzieren • erhalten einen tiefgehenden Einblick in alle relevanten Legierungsgruppen und metallische Werkstoffsysteme und sind in der Lage, vor dem Hintergrund von Anwendungsprofilen eine Werkstoffauswahl zu treffen • lernen wesentliche Methoden der Werkstoffcharakterisierung bzw. -prüfung kennen und sind fähig, geeignete Prüfverfahren auszuwählen und die Qualität von Messergebnissen zu hinterfragen • kennen verschiedenen Simulationstools und können die Einsatzmöglichkeiten von Prozess- und Werkstoffsimulation beurteilen • sind in der Lage, Zusammenhänge zwischen Herstellung und Mikrostruktur bzw. Eigenschaften metallischer Werkstoffe zu beurteilen **English** Students will: • acquire an understanding of industry-relevant working methods • can classify essential development fields of metallic materials • acquire a deep basic understanding and can classify structure-property relationships on all size scales • get to know essential manufacturing and processing procedures and can differentiate between them • gain an in-depth insight into all relevant alloy groups and metallic material systems and are able to make a material selection against the background of application profiles • get to know essential methods of material characterization and testing and are able to select suitable test methods and to question the quality of measurement results • are familiar with various simulation tools and are able to assess the possible applications of process and material simulation • are able to assess relationships between manufacturing and microstructure or properties of metallic materials
7	**Prerequisites**	Vorlesung Werkstoffkunde und Technologie der Metalle aus dem 5. Semester B.Sc **English** Lecture Materials Science and Technology of Metals from 5th semester B.Sc
8	**Integration in curriculum**	semester: 1

9	**Module compatibility**	Materials Science and Engineering for Metals Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (30 min.) oral exam (30 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	van Vlack: Materials Science for Engineers Dieter: Mechanical Metallurgy Kurz/Fisher: Fundamentals of Solidification

1	**Module name** 46212	**Metallische Werkstoffe: Neue Prozesse, Technologien und Werkstoffe** Metallic Materials: New Processes, Technologies and Materials	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Lecture Metallic Materials: Technology 2 (2 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	apl. Prof. Dr. Stefan Rosiwal	

4	**Module coordinator**	Prof. Dr.-Ing. Carolin Körner
5	**Contents**	• Beziehung zwischen Prozess und Mikrostrukturbildung • Überblick über die Grundlagen der Stähle und Vorstellung neuer hochfester Stahlsorten und des Stahlleichtbaus • Einführung in spezielle Verfahrenstechniken • Darstellung der Werkstoffgruppen Refraktärmetalle, metallische Gläser, Verbundwerkstoffe, zellulare Werkstoffe (Herstellung, Verarbeitung, wichtige Legierungen, Anwendung und Neuentwicklungen); bei Verfahren von besonderer praktischer Bedeutung Verknüpfung mit den Grundlagen der Metallphysik. **English** • Relationship between process and microstructure formation • Overview of the fundamentals of steels and presentation of new high-strength steel grades and lightweight steel construction • Introduction to special process technologies • Presentation of the material groups refractory metals, metallic glasses, composites, cellular materials (production, processing, important alloys, application and new developments); for processes of particular practical importance, link with the fundamentals of metal physics.
6	**Learning objectives and skills**	**Die Studierenden:** • erwerben ein Verständnis für industrierelevante Arbeitsmethoden. • können Entwicklungsfelder spezieller metallischer Werkstoffe einordnen. • erwerben ein tiefes Grundlagenverständnis und können Struktur-Eigenschaftsbeziehungen auf allen Größenskalen klassifizieren. • lernen spezielle Herstellungs- und Verarbeitungsprozesse kennen und können diese differenzieren. • erhalten einen tiefgehenden Einblick in spezielle metallische Werkstoffsysteme und sind in der Lage, vor dem Hintergrund von Anwendungsprofilen eine Werkstoffauswahl zu treffen. • sind in der Lage, Zusammenhänge zwischen Herstellung und Mikrostruktur bzw. Eigenschaften metallischer Werkstoffe zu beurteilen. **English** Students will:

		• acquire an understanding of industry-relevant working methods. • can classify development fields of special metallic materials. • acquire a deep understanding of fundamentals and can classify structure-property relationships on all size scales. • get to know special manufacturing and processing procedures and can differentiate between them. • gain an in-depth insight into special metallic material systems and are able to make a material selection against the background of application profiles. • are able to assess relationships between manufacturing and microstructure or properties of metallic materials.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Materials Science and Engineering for Metals Master of Science Nanotechnology 20232
10	**Method of examination**	Variable schriftliche Prüfung (60 Min.) written exam (60 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46213	**Additive Fertigung** Additive Manufacturing	**5 ECTS**
2	Courses / lectures	Praktikum: Lab course Additive Manufacturing (2,5 SWS) Vorlesung: Lecture Additive Manufacturing (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Peter Randelzhofer Prof. Dr.-Ing. Carolin Körner	

4	**Module coordinator**	Prof. Dr.-Ing. Carolin Körner
5	**Contents**	• basis of additive manufacturing • methods of additive manufacturing • material phenomena in additive manufaturing • epitaxiale solidification • cracking • characterization of additively manufactured components • alloy development for additive manufacturing • practical work in the field of additive manufacturing
6	**Learning objectives and skills**	The students: • are able to classify the different methods of additive manufacturing • recognize the technical challenges in additive manufacturing and investment casting • recognize the special features of additive manufacturing in terms of microstructure and component properties • penetrate the solidification processes in additive manufacturing • learn to work together with others in a goal-oriented mann in practical group work
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Science and Engineering for Metals Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit Klausur (45 min) currently taking an written exam (45 minutes) Zwei Laborberichte, je ca. 15 Seiten two lab reports, 15 pages each
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 66 h Independent study: 84 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46214	**Metallische Werkstoffe im Automobilbau** Metallic Materials in Automotive Engineering	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr.-Ing. Carolin Körner
5	**Contents**	• Herausforderungen für die Automobilindustrie • Fahrzeugentstehungsprozess • Anforderungen, Werkstoffe und besondere Lösungen für Karrosserie, Fahrwerk und Motoren • Strategie der Werkstoffauswahl • Druckgießen als typisches Fertigungsverfahren (Druckgussmaschine, Druckgusslegierungen, Herausforderungen) • praktische Arbeiten zum Thema Druckgießen • Simulation der Formfüllung **English** • Challenges for the automotive industry • Vehicle development process • Requirements, materials and special solutions for body, chassis and engines • Material selection strategy • Die casting as a typical manufacturing process (die casting machine, die casting alloys, challenges) • practical work on die casting • simulation of mold filling
6	**Learning objectives and skills**	Die Studierenden: • erwerben ein Verständnis für relevante Arbeitsmethoden der Automobilindustrie • können die Auswahl geeigneter Werkstoffe für bestimmte Anwendungen erklären • sind in der Lage, Zusammenhänge zwischen Prozess bzw. Prozessparameter und Mikrostruktur bzw. Eigenschaften metallischer Gussteile zu beurteilen. • können die Ergebnisse von numerischen Simulationen bewerten. • lernen in praktischer Gruppenarbeit zielorientiert mit anderen zusammenzuarbeiten. **English** Students will: • acquire an understanding of relevant working methods in the automotive industry • are able to explain the selection of suitable materials for specific applications

		• are able to evaluate relationships between process or process parameters and microstructure or properties of metallic castings. • are able to evaluate the results of numerical simulations. • learn to cooperate with others in a goal-oriented manner in practical group work.
7	**Prerequisites**	Tiefgehende Kenntnisse der Metallkunde und Technologie der Metalle. Die Anzahl der Praktikumsplätze ist auf 36 Studierende begrenzt. Es wird zu Semesterbeginn ein geeignetes Auswahlverfahren gestartet. **English** In-depth knowledge of metallurgy and metal technology. The number of participants in the lab course is limited to 36! A suitable selection procedure will be launched at the beginning of the semester.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Science and Engineering for Metals Master of Science Nanotechnology 20232
10	**Method of examination**	Variable schriftliche Prüfung (45 Min.) written exam (45 min) Zwei Laborberichte, je ca. 15 Seiten two lab reports, 15 pages each
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 66 h Independent study: 84 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46216	**Pulvermetallurgie** Powder Metallurgy	**5 ECTS**
2	Courses / lectures	Praktikum: Lab course Powder Metallurgy (2,5 SWS) Vorlesung: Lecture Powder Metallurgy (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Peter Randelzhofer Heinrich Kestler	

4	**Module coordinator**	Prof. Dr.-Ing. Carolin Körner
5	**Contents**	• Pulverherstellung • Pulvercharakterisierung • Pressen und Sintern • spezielle Sintermethoden und alternative Konsolidierungsmethoden (Additive Fertigung, PM-Spritzguss) • Anwendungen (Hartmetalle und Beschichtungen) • praktische Arbeiten zum Thema Pulvermetallurgie und Schäumen von Metallen **English** • Powder production • Powder characterization • pressing and sintering • Special sintering methods and alternative consolidation methods (additive manufacturing, PM injection molding) • applications (hard metals and coatings) • practical work on powder metallurgy and foaming of metals
6	**Learning objectives and skills**	**Die Studierenden**: • erwerben ein Verständnis für industrielle Arbeitsmethoden. • können die unterschiedlichen Prozessschritte der Pulvermetallurgie einordnen. • durchdringen den Zusammenhang zwischen Prozessparametern und Eigenschaften von gesinterten Bauteilen. • lernen in praktischer Gruppenarbeit zielorientiert mit anderen zusammenzuarbeiten. **English** Students will: • acquire an understanding of industrial working methods. • can classify the different process steps of powder metallurgy. • understand the relationship between process parameters and the properties of sintered components. • learn to cooperate with others in a goal-oriented manner in practical group work.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232

		Materials Science and Engineering for Metals Master of Science Nanotechnology 20232
10	**Method of examination**	Variable schriftliche Prüfung (45 Min.) written exam (45 min.) Zwei Laborberichte, je ca. 15 Seiten two lab reports, 15 pages each
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 66 h Independent study: 84 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1st and 2nd Scientific-technical elective module

1	**Module name** 46207	**Materialcharakterisierung** Material characterization	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Atomsondenmikroskopie_School (1 SWS, SoSe 2025) Sonstige Lehrveranstaltung: Lecture Briefing MSE I (0 SWS, SoSe 2025) Sonstige Lehrveranstaltung: Vorbesprechung Praktika in Mastermodulen WW 1 inkl. Sicherheitsbelehrung (0 SWS, SoSe 2025)	1 ECTS - -
3	Lecturers	Prof. Dr. Peter Felfer apl. Prof. Dr. Heinz Werner Höppel Steffen Neumeier Prof. Dr. Mathias Göken Dr. Michael Wurmshuber	

4	**Module coordinator**	Steffen Neumeier
5	**Contents**	Quantitative Gefügeanalyse, V+Ü, 1 SWS, 1 ECTS • Einführung in die Quantitative Gefügeanalyse und die dazugehörigen Meßmethoden • Auswertemethoden • Grundlagen der Statistik • Praktische Anwendung von Image C Röntgenmethoden in der Materialanalyse, V, 1 SWS, 1 ECTS • Grundlagen der Röntgen-/Synchrotron-/Neutronenbeugung • Experimentelle Methoden • Anwendung in der Materialanalyse (Gitterkonstantenbestimmung, Spannungsanalyse, Texturanalyse,) Anforderungen der Industrie an einen Werkstoffingenieur: • Grundlagen industrieller Planungen im Werkstoffumfeld • Industrielle Lösungsstrategien bei Werkstofffragestellungen • Industrielle Charakterisierungsverfahren Quantitative Microstructural Analysis, V+Ü, 1 SWS, 1 ECTS • Introduction to quantitative microstructure analysis and the corresponding measuring methods • Evaluation methods • Basics of statistics • Practical application of Image C X-ray methods in materials analysis, V, 1 SWS, 1 ECTS • Basics of X-ray/synchrotron/neutron diffraction • Experimental methods • Application in material analysis (determination of lattice constants, stress analysis, texture analysis,...) Fundamentals of Failure Analysis, V+Ü+P 0.5+1+0.5 SWS, 0.5+1+0.5 ECTS • Basic procedure of damage analysis • Damage hypotheses • Case studies from practice

		• Practical test to deepen the contents
6	**Learning objectives and skills**	Fachkompetenz Evaluieren (Beurteilen) Die Studierenden • vertiefen ihr Wissen über die vielfältigen strukturellen Aufbauten der Werkstoffe und können diese beurteilen • vertiefen das Verständnis über die Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen • beurteilen eigenständig Struktur-Eigenschaftsbeziehungen an Beispielen • erwerben fundierter Kenntnisse über die Grundlagen zum Aufbau der verschiedenen Werkstoffklassen, Charakterisieren unterschiedlicher Strukutren • vertiefen die erlernten Inhalte durch Übungen und Praktikum • erlernen und wenden neuen Methoden an • erlernen Grundlagen der Schadensanalyse, wenden diese an Beispielfällen an und stellen Schadenshypothesen auf Lern- bzw. Methodenkompetenz Neue Methodenkompetenzen, die erworben werden können: • Grundlegende Experimentiertechniken • Quantitative Gefügeanalyse • Grundlegende Methoden der Röntgenbeugung Technical competence Evaluating (assessing) Students will • deepen their knowledge of the various structural compositions of materials and are able to evaluate them • deepen their understanding of the relationships between the chemical composition, structure and properties of materials • independently assess structure-property relationships using examples • acquire a sound knowledge of the fundamentals of the structure of the various classes of materials and characterize different structures • deepen the learned contents by exercises and practical training • learn and apply new methods • learn the basics of damage analysis, apply them to example cases and establish damage hypotheses Learning or methodological competencies New methodological competencies that can be acquired: • Basic experimental techniques • Quantitative microstructure analysis • Basic methods of X-ray diffraction
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232

		General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Variable (100%) mündliche Prüfung (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46213	**Additive Fertigung** Additive Manufacturing	**5 ECTS**
2	Courses / lectures	Praktikum: Lab course Additive Manufacturing (2,5 SWS) Vorlesung: Lecture Additive Manufacturing (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Peter Randelzhofer Prof. Dr.-Ing. Carolin Körner	

4	**Module coordinator**	Prof. Dr.-Ing. Carolin Körner
5	**Contents**	• basis of additive manufacturing • methods of additive manufacturing • material phenomena in additive manufaturing • epitaxiale solidification • cracking • characterization of additively manufactured components • alloy development for additive manufacturing • practical work in the field of additive manufacturing
6	**Learning objectives and skills**	The students: • are able to classify the different methods of additive manufacturing • recognize the technical challenges in additive manufacturing and investment casting • recognize the special features of additive manufacturing in terms of microstructure and component properties • penetrate the solidification processes in additive manufacturing • learn to work together with others in a goal-oriented mann in practical group work
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Science and Engineering for Metals Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit Klausur (45 min) currently taking an written exam (45 minutes) Zwei Laborberichte, je ca. 15 Seiten two lab reports, 15 pages each
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 66 h Independent study: 84 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46214	**Metallische Werkstoffe im Automobilbau** Metallic Materials in Automotive Engineering	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr.-Ing. Carolin Körner
5	**Contents**	• Herausforderungen für die Automobilindustrie • Fahrzeugentstehungsprozess • Anforderungen, Werkstoffe und besondere Lösungen für Karrosserie, Fahrwerk und Motoren • Strategie der Werkstoffauswahl • Druckgießen als typisches Fertigungsverfahren (Druckgussmaschine, Druckgusslegierungen, Herausforderungen) • praktische Arbeiten zum Thema Druckgießen • Simulation der Formfüllung **English** • Challenges for the automotive industry • Vehicle development process • Requirements, materials and special solutions for body, chassis and engines • Material selection strategy • Die casting as a typical manufacturing process (die casting machine, die casting alloys, challenges) • practical work on die casting • simulation of mold filling
6	**Learning objectives and skills**	Die Studierenden: • erwerben ein Verständnis für relevante Arbeitsmethoden der Automobilindustrie • können die Auswahl geeigneter Werkstoffe für bestimmte Anwendungen erklären • sind in der Lage, Zusammenhänge zwischen Prozess bzw. Prozessparameter und Mikrostruktur bzw. Eigenschaften metallischer Gussteile zu beurteilen. • können die Ergebnisse von numerischen Simulationen bewerten. • lernen in praktischer Gruppenarbeit zielorientiert mit anderen zusammenzuarbeiten. **English** Students will: • acquire an understanding of relevant working methods in the automotive industry • are able to explain the selection of suitable materials for specific applications

		• are able to evaluate relationships between process or process parameters and microstructure or properties of metallic castings. • are able to evaluate the results of numerical simulations. • learn to cooperate with others in a goal-oriented manner in practical group work.
7	**Prerequisites**	Tiefgehende Kenntnisse der Metallkunde und Technologie der Metalle. Die Anzahl der Praktikumsplätze ist auf 36 Studierende begrenzt. Es wird zu Semesterbeginn ein geeignetes Auswahlverfahren gestartet. **English** In-depth knowledge of metallurgy and metal technology. The number of participants in the lab course is limited to 36! A suitable selection procedure will be launched at the beginning of the semester.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Science and Engineering for Metals Master of Science Nanotechnology 20232
10	**Method of examination**	Variable schriftliche Prüfung (45 Min.) written exam (45 min) Zwei Laborberichte, je ca. 15 Seiten two lab reports, 15 pages each
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 66 h Independent study: 84 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46216	**Pulvermetallurgie** Powder Metallurgy	**5 ECTS**
2	Courses / lectures	Praktikum: Lab course Powder Metallurgy (2,5 SWS) Vorlesung: Lecture Powder Metallurgy (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Peter Randelzhofer Heinrich Kestler	

4	**Module coordinator**	Prof. Dr.-Ing. Carolin Körner
5	**Contents**	• Pulverherstellung • Pulvercharakterisierung • Pressen und Sintern • spezielle Sintermethoden und alternative Konsolidierungsmethoden (Additive Fertigung, PM-Spritzguss) • Anwendungen (Hartmetalle und Beschichtungen) • praktische Arbeiten zum Thema Pulvermetallurgie und Schäumen von Metallen **English** • Powder production • Powder characterization • pressing and sintering • Special sintering methods and alternative consolidation methods (additive manufacturing, PM injection molding) • applications (hard metals and coatings) • practical work on powder metallurgy and foaming of metals
6	**Learning objectives and skills**	**Die Studierenden**: • erwerben ein Verständnis für industrielle Arbeitsmethoden. • können die unterschiedlichen Prozessschritte der Pulvermetallurgie einordnen. • durchdringen den Zusammenhang zwischen Prozessparametern und Eigenschaften von gesinterten Bauteilen. • lernen in praktischer Gruppenarbeit zielorientiert mit anderen zusammenzuarbeiten. **English** Students will: • acquire an understanding of industrial working methods. • can classify the different process steps of powder metallurgy. • understand the relationship between process parameters and the properties of sintered components. • learn to cooperate with others in a goal-oriented manner in practical group work.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232

		Materials Science and Engineering for Metals Master of Science Nanotechnology 20232
10	**Method of examination**	Variable schriftliche Prüfung (45 Min.) written exam (45 min.) Zwei Laborberichte, je ca. 15 Seiten two lab reports, 15 pages each
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 66 h Independent study: 84 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46223	**Funktionskeramiken I** Functional ceramics I	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey Prof. Dr. Kyle Grant Webber
5	**Contents**	|Funktionskeramik | Dieser Kurs bietet eine Einführung in die Funktionskeramik, einschließlich Abschnitten über dielektrische, piezoelektrische, ferroelektrische und ferroelastische Eigenschaften der Elektrokeramik. Die Konzepte werden mit makroskopischen Materialeigenschaften dargestellt und in Verbindung mit den mikrostrukturellen Ursprüngen diskutiert. |Übung für Funktionskeramik I: Elektrische Eigenschaften | In diesem Laborkurs werden die Teilnehmer in die Messung dielektrischer Eigenschaften mit einem LCR-Meter und einem Impedanzspektrometer eingeführt. Es wird ein Equivalent-Circuit aufgebaut, um die Fähigkeit der Impedanzspektroskopie zu demonstrieren, verschiedene zeitabhängige Prozesse z.B. am Kristallgitter und an der Korngrenze zu trennen. *English* |Functional Ceramics I | This course provides an introduction to functional ceramics, including sections on dielectric, piezoelectric, ferroelectric, and ferroelastic properties of electroceramics. Concepts are presented with macroscopic material properties and discussed in conjunction with microstructural origins. |Exercise for Functional Ceramics I: Electrical Properties | In this laboratory course, students will be introduced to the measurement of dielectric properties using an LCR meter and an impedance spectrometer. An equivalent circuit will be set up to demonstrate the ability of impedance spectroscopy to separate different time-dependent processes, e.g., at the crystal lattice and at the grain boundary.
6	**Learning objectives and skills**	Die Studierenden • kennen den Aufbau, die Herstellung, die Eigenschaften von Funktionskeramiken • können diese carakterisieren • kennen deren Anwendung für Tätigkeiten im institutionellen und industriellen Umfeld mit diesem Werkstoffschwerpunkt . • haben ein vertieftes Verständnis folgender Eigenschaften von Keramik: elektrische und mechanische Eigenschaften • haben vertiefte Kenntnisse in den Prozessen zur Herstellung von Keramiken sowie der Methoden zur Bestimmung wichtiger

		Eigenschaften, Erklärung der Zusammenhänge zwischen Zusammensetzung, Gefüge, Eigenschaften *English* The students • know the structure, the production, the properties of functional ceramics • can characterize them • know their application for activities in the institutional and industrial environment with this material focus . • have an in-depth understanding of the following properties of ceramics: electrical and mechanical properties
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46224	**Funktionskeramiken II** Functional ceramics II	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey Prof. Dr. Kyle Grant Webber
5	**Contents**	**Structural analysis of functional ceramics using advanced diffraction techniques** This course will cover basic crystallography, advanced diffraction techniques (e.g., x-ray, neutron and electron) including instrumentation, strategies to collect diffraction data (ex situ and in situ) and different data analysis methods. The course has been designed in such a way that, in addition to the development of theoretical background, students can have hands-on experience with different data analysis methods and software. At the initial stage we will cover basics of crystallography and principle of diffraction technique. An in-depth discussion on different (e.g., x-ray, 2D x-ray, neutron and electron) diffraction techniques and their use in the field of materials science and engineering will then be presented. In the next step we will discuss ferroelectric/ferroelastic materials and how diffraction technique can be used to investigate microscopic origin of macroscopic functional properties. **Exercises for functional ceramics II: Structural Analysis** Students will learn how to extract various structural parameters using different data analysis (e.g. Selected peak-fitting, Le Bail fitting and Rietveld structural refinement) techniques and how these structural parameters can be correlated with different macroscopic properties. A brief overview of the recent developments and future scopes in the field of structural analysis (e.g., 3D- XRD, diffuse scattering) using diffraction technique will be highlighted to conclude the course
6	**Learning objectives and skills**	**The students** • know the necessary scientific and practical knowledge for the microstructural characterization of ceramics using diffraction methods. • have an in-depth understanding of the following properties of ceramics: electrical, thermal and mechanical properties • understand the influences of structure and microstructure on electromechanical properties • know and understand how diffraction techniques work and what basic models are available for analysis • can use the appropriate software.

7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Irregular
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46225	**Funktionskeramiken III** Functional ceramics III	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey Prof. Dr. Kyle Grant Webber
5	**Contents**	|Mechanical Properties and Fracture of Ceramics | • ◦ Das Laborpraktikum vermittelt praktische Erfahrungen in der makroskopischen mechanischen Charakterisierung von keramischen Werkstoffen, wobei speziell linear elastische und ferroelastische Werkstoffe untersucht werden. *English* |Mechanical Properties and Fracture of Ceramics | This course will introduce participants to the origins of the mechanical behavior of ceramic materials through discussions of atomic structure and microstructure. Here, participants will be introduced to linear elastic fracture mechanics and some concepts related to nonlinear fracture mechanics. Then, various toughness mechanisms will be presented and discussed, including phase transforamtion, ferroelasticity, and crack bridging. In the final section of the lecture, fractographic techniques for the analysis of fracture surfaces as well as subcritical crack growth will be presented. |Exercise for Functional Ceramics III: Mechanical Properties | This laboratory practical course provides hands-on experience in the macroscopic mechanical characterization of ceramic materials, specifically studying linear elastic and ferroelastic materials.
6	**Learning objectives and skills**	Die Studierenden • lernen die Ursprünge der mechanischen Eigenschaften von Keramiken kennen • verstehen, wie sich keramische Werkstoffe nichtlinear, hysteretisch oder plastisch verformen können und wie dies das Bruchverhalten beeinflussen kann • erlernen der Grundlagen der linear-elastischen Bruchmechanik, insbesondere der Hintergründe der Energiefreisetzungsrate und des Spannungsintensitätsfaktors • verstehen Bruchflächen zur Analyse der Bruchentstehung genutzt werden können • verstehen, woe Risse unterkritisch wachsen können und können diese charakterisieren *English* The students • learn the origins of the mechanical properties of ceramics

		• understand how ceramic materials can deform nonlinearly, hysteretically, or plastically and how this can affect fracture behavior • learn the fundamentals of linear elastic fracture mechanics, especially the background of the energy release rate and stress intensity factor • understand fracture surfaces can be used to analyze fracture initiation • understand where cracks can grow subcritically and be able to characterize them
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46226	**Porous and cellular Ceramics I** Porous and cellular ceramics I	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey
5	**Contents**	|Microstructural characterization | • Strukturelle Charakterisierung poröser und zellularer Keramiken durch den Einsatz gängiger Methoden wie He-Pyk, Hg-Porosimetrie, µCT, SEM, Permeabilität • Einsatz von Bildanalyse und Simulationen zur Strukturparameterberechnung wie Zellgröße, Stegbreite, Anisotropie, Interkonnektivität und Tortuosität • Strukturelle Besonderheiten poröser Werkstoffe |Thermal and mechanical characterisation | • Bestimmung thermischer / mechanischer Eigenschaften an porösen und zellularen Werkstoffen • Bestimmung des Einflusses der Porosität, Porenform und Porenform auf die physikalischen Eigenschaften *English* |Microstructural characterization| • Structural characterization of porous and cellular ceramics by using common methods such as He-Pyk, Hg-porosimetry, µCT, SEM, permeability • Use of image analysis and simulations to calculate structural parameters such as cell size, web width, anisotropy, interconnectivity and tortuosity • Structural features of porous materials |Thermal and mechanical characterization| • Determination of thermal / mechanical properties of porous and cellular materials • Determination of the influence of porosity, pore shape and pore form on physical properties
6	**Learning objectives and skills**	Die Studierenden • Erlernen die Auswahl von Charakterisierungsmethoden und deren Einsatz sowie Grenzen der Anwendbarkeit der Untersuchungsmethoden und Algorithmen • Entscheiden die Auswahl der Charakterisierungsmethodik vor dem Hintergrund der Einsatzgrenzen • Vermittlen der notwendigen wissenschaftlichen und praktischen Kenntnisse zur Charakterisierung von porösen und Keramiken für Tätigkeiten im institutionellen und industriellen Umfeld mit diesem Werkstoffschwerpunkt. • Vertiefen das Verständnis über die Mikrostruktur poröser und zellularer keramischer Werkstoffe und deren Auswirkung auf die physikalischen Eigenschaften

		English Students will • Learn the selection of characterization methods and their use as well as limits of applicability of the investigation methods and algorithms • Decide the choice of characterization methodology in the light of the limits of application • Provide the necessary scientific and practical knowledge to characterize porous and ceramics for activities in institutional and industrial settings with this material focus. • Deepen understanding of the microstructure of porous and cellular ceramic materials and its effect on physical properties.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232 mündliche Prüfung (15 Min.) oral exam (15 min.)
10	**Method of examination**	Oral
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46227	**Porous and cellular Ceramics II** Porous and cellular ceramics II	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Porous and cellular Ceramics for engineers (2 SWS) Vorlesung mit Übung: Porous and cellular applications (2 SWS)	3 ECTS -
3	Lecturers	Tobias Fey	

4	**Module coordinator**	Tobias Fey
5	**Contents**	**Porous and cellular Ceramics for engineers** • Architecture and structure of porous and cellular ceramics over different length scales • manufacturing processes of porous and cellular ceramics from conventional to additive processes • physical properties depending on the porosity, pore shape and pore type • areas of applications of porous and cellular structures in particular a) light weight constructions b) catalysis c) energy and d) scaffolds **Porous and cellular applications** • Practical production of ceramic porous scaffolds using different methods discussed in the lecture • Variation of the manufacturing parameters to modify the microstructure and pore shape and type for the respective application (open / closed cell) • Implementation of application-oriented studies
6	**Learning objectives and skills**	**The students** • learn the necessary scientific basics for the structure and composition as well as the production and application of porous and cellular ceramics • intensify your knowledge of the production of porous and cellular ceramic materials and their effect on structural and physical properties • learn how to select materials and processes against the background of application profiles using examples • deepen the scientific basics in application-oriented studies
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (15 Min.)

		oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46228	**Glas I** Glass I	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Dominique Ligny
5	**Contents**	|Optical properties of glasses| • Fundamental concepts: The electromagnetic spectrum and units, Absorption, Luminescence, Scattering • Optical transparency of solids: Optical magnitudes and the dielectric constant, The Lorentz Oscillator, Metals, Semiconductors and insulators, Excitons, Reflection and polarization • Optical glasses: Optical aberration and solutions, Dispersion properties and composition • Colors in glasses: The eye, Optically Active Centers, Transition metals in glasses, Metallic and Chalcogenide nanoparticles • Chromism: Thermochromism, Photochromism, Gasochromism, Electrochromism • IR glasses: Chalcogenide, Fluorite glasses • Optical Fibers: Principle, Manufacturing, Applications, Photonic fibers |Vibrational spectroscopies, from theory to practice | • Nature of vibrations inside matter • Interaction light matter • Instrumentation • Raman application • Infrared Spectroscopy • Advanced technics
6	**Learning objectives and skills**	|Spectroscopy techniques applied to amorphous materials | The students will • Understand the solid state physic background link to the optical properties of all type of materials • Be able to explain the different ways to create colors • Choose the appropriate glass compositions to realize optical device in the infrared region • Have an overview of the different technologies link to light management • Know the different parameters that define an Optical glass fiber and choose them in regard of the attended application |Vibrational spectroscopies, from theory to practice| The student will • Understand in a comprehensive way the solid state physic background link to these spectroscopies

		• Know the different parts of a spectrometer and their characteristic parameter • Exercise himself to set the parameters of an observation and run the measurements • Treat the data by applying the needed corrections • Evaluate the data using peak fitting, momentum calculations and Principal Component Analysis • Deduce information on the structure of common glasses
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46229	**Glas II** Glass II	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Glass formulation using project management (2 SWS) Vorlesung mit Übung: Glass and Ceramic for Energy-Technology (2 SWS)	- -
3	Lecturers		

4	**Module coordinator**	Prof. Dr. Dominique Ligny
5	**Contents**	Glass formulation using project management: Intensive exercise of 6 half days at the end of the semester. The teaching follows an "on time approach. After presentation of the case study, an introduction to the project management is given. Analytical tools are given to the students than can use them directly on the case study. The project is then defined through brainstorming followed by Solution analysis and quotation. The rules for scheduling, monitoring and controlling a project are introduced before the case study is started to be solved. An emphasis is given on reporting by quick presentation at the end of each half day by the project team. In conclusion a last time is taken to analyze the personal issues encounter during these six half days. That help the students to have a pragmatic thinking about what could have been a better project team and the need of a leader. Glass and Ceramic for Energy-technology: • Materials and energy • Solar Energy • Solar Thermal • Photovoltaic Energy • Insulation • Wind Energy • Nuclear waste glass storage • Energy in glass processing • Fuel Cell and Ion conductivity • Lighting LED and LASER REE technology
6	**Learning objectives and skills**	Glass formulation using project management The student will • Learn the different concept used in project management as well as its specific vocabulary • Practice the project management in a small team • Use the different tools of project management • Go from an application to the conception of a product Glass and Ceramic for Energy-technology The student will • Understand the global environmental issues related to the use of glasses for: • Nonrenewable energy sources • Renewable energy sources • Energy efficiency

		• Energy storage • Know the improvement needed in the future • Look for solution by linking the expected performance to the glass properties • Be able to choose the good glass composition, production and shaping processes
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46233	**Seminar modul** Seminar module	**5 ECTS**
2	Courses / lectures		
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey Prof. Dr. Dominique Ligny Prof. Dr. Kyle Grant Webber PD Dr. Stephan Wolf
5	**Contents**	**Science Seminar with reports on scientific projects** • o Vortragende aus der Industrie berichten aktuelle wissenschaftliche Themen und Projekte Literature seminar Zusammenfassung eines wissenschaftlichen Papers in Form eines Vortrages und eines Posters Science Seminar with reports on scientific projects • Summary of a scientific project that comes from the current research environment • Industry report seminar • Lecturers from industry report on current scientific topics and projects Literature seminar Summary of a scientific paper in the form of a lecture and a poster
6	**Learning objectives and skills**	**Die Studierenden** • vertiefen Ihre Kenntnisse über Präsentationstechniken • erlernen die Recherche von Literatur durch den Einsatz von Datenbanken • verstehen den inhaltlichen Aufbau von wissenschaftlichen Vorträgen und Berichten und können dies umsetzten • erlernen die Erstellung von wissenschaftlichen Postern und Berichten **The students** • deepen your knowledge of presentation techniques • learn how to research literature using databases • understand the structure of the content of scientific lectures and reports and can implement this • learn how to create scientific posters and reports
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Achievement credit Leistungsschein

		Performance certificate
11	**Grading procedure**	Achievement credit (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 105 h Independent study: 45 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46237	**Oberflächenanalyse I** Surface analysis I	**5 ECTS**
2	Courses / lectures	Seminar: Seminar Surface Science and Corrosion (2 SWS)	1 ECTS
3	Lecturers	Prof. Dr. Patrik Schmuki	

4	**Module coordinator**	Prof. Dr. Patrik Schmuki
5	**Contents**	*Surface Analysis I + II (Vl+Ü)* The generation of nanostructured materials gained relevance in the recent years and efficient characterization methods were developed, permitting insight into the topographical and chemical nanostructure of materials. The scope of this course covers a range of surface analytical instruments, discussing their principle mode of operation, application and data interpretation. All discussed instruments are also available at the chair and tutorials at the machines are a part of the lecture. The fabrication of nanostructured materials from particles to complex 3 dimensional structures is the topic of the second part of this lecture. Die Strukturierung von Werkstoffoberflächen auf der Nanoskala erlangte in jüngster Vergangenheit große Bedeutung was nicht zuletzt auf der Entwicklung hocheffizienter Charakterisierungsmethoden fußt. Diese erlauben eine hochauflösende Analyse der topografischen sowie chemischen Natur der Oberfläche. Im Zuge dieser Lehrveranstaltung (Teil I) werden eine Vielzahl Oberflächenanalytischer Verfahren und Instrumente erläutert und deren Funktionsprinzip und etwaige Betriebsmodi besprochen, wobei auch auf die Messdateninterpretation Wert gelegt wird. Für die am LS vorhandenen Verfahren erfolgt außerdem eine Begehung der Labore wobei die Studierenden einen konkreten Eindruck der diversen Techniken erhalten können. Im zweiten Teil der Lehrveranstaltung (Teil II) wird die Darstellung nanostrukturierter Werkstoffe besprochen. Hierbei wird auf Partikel bis hin zu komplexen dreidimensionalen Strukturen eine große Bandbreite der Oberflächenmodifikation abgedeckt. *Seminar Surface Science and Corrosion* Das Seminar Surface Science and Corrosion bietet die Gelegenheit Einblicke in den aktuellen Stand der Forschungsfelder des Lehrstuhls zu erlangen. Hierbei werden Fallbeispiele präsentiert und diskutiert und so ein tiefgehendes Verständnis der Messmethoden, welche in der VL Surface Analysis vermittelt werden, ermöglicht. Neben dieser inhaltlichen Komponente der Art eines Frontalunterrichtes, ist es möglich und sehr erwünscht die Thematiken zu diskutieren. Den Studierenden ist es hierbei neben dem Erwerb von Fachwissen möglich, einen ersten Eindruck vom Ablauf wissenschaftlicher Konferenzen bzw. Tagungen zu erhalten. The seminar Surface science and Corrosion offers the opportunity to gather insights into the current research areas of the chair. In the course of the seminar results are presented and discussed what enables a profound understanding of the techniques that are taught within the lecture Surface Analysis. Besides this factual part, the students have furthermore the chance (and are supposed) to ask questions to

		the speakers. This is an important insight into the academic working environment that might be especially relevant for prospective PhD-students.
6	**Learning objectives and skills**	Surface Analysis I + II (Vl+Ü): **Die Studierenden** • verstehen fundamentaler Konzepte im Bereich Kristallographie • können Vor- und Nachteile verschiedener Verfahren der Oberflächencharakterisierung kritisch diskutieren • verstehen die theoretischen Grundlagen von STM/AFM, SEM/EDX, XPS/Auger, XRD, ToF-SIMS • kennen verschiedener Herstellungsmethoden für Nanostrukturen und Anwendung von CVD. • verstehen das Prinzip des Sol-Gel Prozesses • kennen die Anwendungen nanostrukturierter Oberflächen • kennen und verstehen Verfahren zur Oberflächenanalyse bei Nanomaterialien **The students:** • Describing of basic concepts in crystallography. • Evaluating different kinds of surface characterization techniques (pros and cons). • Elucidating the theoretical background of STM/AFM, SEM/EDX, XPS/Auger, XRD, ToF-SIMS. • Defining fabrication methods of nanostructures and elucidation of nanostructured CVD. • Describing the sol-gel process. • Reporting applications of nanostructured surfaces. • Elucidation of surface analytical techniques for nanomaterial characterization. **Seminar Surface Science and Corrosion** **Die Studierenden** • wenden wissenschaftlicher Verfahren und Techniken in der Forschung (Beispiele)an • haben Erfahrung bezüglich des Ablaufs und der Gepflogenheiten im wissenschaftlichen Arbeitsumfeld durch aktive Teilnahme an Diskussionen. • besitzen Softskills als Vorbereitung auf eine wissenschaftliche Karriere **The students** • Appliance of scientific techniques in research (discussion of examples). • Generating experience in scientific community. • Participation in scientific discussions. • Acquiring of soft-skills for futural scientific careers.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232

		Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination schriftliche Prüfung (45 Min.) written exam (45 min.)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Vorbereitende LiteraturWird im Zuge der Lehrveranstaltung bekannt gegeben.

1	**Module name** 97246	**Qualitätsmanagement** Quality management	**5 ECTS**
2	Courses / lectures	Vorlesung: Qualitätstechniken - QTeK - vhb (2 SWS) Vorlesung: Qualitätsmanagement QMaK (2 SWS)	- -
3	Lecturers		

4	**Module coordinator**	Prof. Dr.-Ing. Tino Hausotte
5	**Contents**	*Qualitätsmanagement I - Qualitätstechniken für die Produktentstehung [QM I]* • Einführung und Begriffe • Grundwerkzeuge des Qualitätsmanagements • Erweiterte Werkzeuge des Qualitätsmanagements • Qualitätsmanagement in der Produktplanung (QFD) • Qualitätsmanagement in der Entwicklung und Konstruktion (DR, FTA, ETA, FMEA) • Versuchsmethodik • Maschinen- und Prozessfähigkeit, Qualitätsregelkarten • Zuverlässigkeitstechniken • Qualitätsmanagementsystem - Aufbau und Einführung • |Grundwerkzeuge des QM (Einsendeaufgabe)| • |QFD und FMEA (Einsendeaufgabe)| • |Versuchsmethodik (Einsendeaufgabe)| • |SPC (Einsendeaufgabe)| *Qualitätsmanagement II - Phasenübergreifendes Qualitätsmanagement [QM II]* • Qualitätsmanagementsystem - Auditierung und Zertifizierung • Total Quality Management und EFQM-Modell • Ausbildung und Motivation • Kontinuierliche Verbesserungsprogramme und Benchmarking • Problemlösungstechniken und Qualitätszirkel • Qualitätsbewertung • Qualität und Wirtschaftlichkeit • Six Sigma • Qualitätsmanagement bei Medizinprodukten • |Qualitätsbewertung (Übung)| • |Qualitätsbezogene und Wirtschaftlichkeit (Übung)|

6	**Learning objectives and skills**	Nach dem Besuch des Moduls sind die Teilnehmenden in der Lage, Wissen:
		•
		  ◦ die Werkzeuge, Techniken und Methoden des Qualitätsmanagements entlang des Produktlebenszyklus darzustellen
		  ◦ die Zuverlässigkeit von Systemen zu beschreiben
		  ◦ Wissen zu Qualitätsmanagement als unternehmens- und produktlebenszyklusübergreifende Strategie zu veranschaulichen

		○ Anforderungen, Aufbau, Einführung sowie die Auditierung und Zertifizierung von Qualitätsmanagementsystemen darzustellen ○ die grundlegenden Qualitätsmethoden, -techniken und -werkzeuge auf ein anderes Problem zu übertragen ○ Prozesse mit Hilfe der statistischen Prozesslenkung (SPC), Qualitätsregelkarten und Prozessfähigkeitsindizes zu beschreiben ○ Business Excellence anhand Total Quality Management (TQM), Unternehmensbewertungsmodelle wie EFQM und kontinuierlicher Verbesserungsprozesse im Unternehmen auszuführen ○ die Wirtschaftlichkeit von Qualitätsverbesserungsmaßnahmen zu demonstrieren ○ die Methodik Six Sigma" zu beschreiben und dem Kontext der Qualitätsverbesserung zuzuordnen ○ mit Hilfe der Qualitätsmethoden, -techniken und -werkzeugen Probleme zu analysieren ○ statistische Versuchspläne auf praktische Probleme zu übertragen und aus den Ergebnissen die Zusammenhänge und Einflüsse der Faktoren zu interpretieren ○ Handlungsgrundlagen hinsichtlich Ausbildungs-, Motivations- und Organisationsverbesserung zu ermitteln ○ statistische Auswertungen zu interpretieren und neue Probleme auf statistische Auffälligkeiten zu testen ○ die Qualität mit etablierten Vorgehensweisen zu bewerten
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination (120 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	german
16	**Bibliography**	• Kamiske, G. F.; Brauer, J.-P.: Qualitätsmanagement von A - Z, Carl Hanser Verlag, München 2011 • Pfeifer, T.; Schmitt, R.: Masing Handbuch Qualitätsmanagement, Hanser, München 2021

1	**Module name** 97080	**Informatik für Ingenieure I** Computer science for engineers I	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Baumeister
5	**Contents**	In dieser Veranstaltungen werden ausgewählte Inhalte aus der Informatik für herangehende Ingenieure gelehrt. Hierbei wird Wert auf Pragmatik gelegt, d.h. die vermittelten Inhalte sollen möglichst praktischer Natur sein, die im späteren Berufsleben oder in einer wissenschaftlichen Karriere in Maschinenbau, Wirtschaftsingenieurswesen, o.Ä. angewandt werden können. **Kapitel des Moduls** • Rechnerarchitektur • Betriebssysteme • Rechnerkommunikation • Datenbanken • Künstliche Intelligenz • Programmierung/Softwareentwicklung (Python) Dieses Modul ist kein reines Programmiermodul! Auch wenn Programmierung (zum Teil) behandelt wird, soll nicht die Erwartung bestehen, dass man am Ende die Veranstaltung als Fullstack Senior Software Developer verlässt.
6	**Learning objectives and skills**	Die Studierenden... • bewerten verschiedene Möglichkeiten der Informationsdarstellung • kennen den grundsätzlichen Aufbau eines Computers • analysieren einfache logische Schaltungen • charakterisieren die im Modul vorgestellten Konzepte von Betriebssystemen • differenzieren die im Modul vorgestellten Konzepte Programmierparadigmen • unterscheiden die im Modul vorgestellten Konzepte Datenstrukturen und Suchalgorithmen • beschreiben die im Modul vorgestellten Konzepte Strategien zum Entwurf effizienter Algorithmen • beschreiben die im Modul vorgestellten Konzepte relationaler Datenbanken • stellen einfache SQL-Anfragen • erklären Referenzmodelle für verteilte und Kommunikationssysteme
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!

9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	german
16	**Bibliography**	

1	**Module name** 46287	**Transmission Electron Microscopy in Material Science II** Transmission electron microscopy in materials science II	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Transmission Electron Microscopy in Material Science II (2 SWS)	3 ECTS
3	Lecturers	Dr.-Ing. Benjamin Apeleo Zubiri Dr. Johannes Will Dr. Mingjian Wu Prof. Dr. Erdmann Spiecker	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	• The module deals with the fundamentals of micro- and nanostructure research with the focus on todays state-of-the art capabilities of transmission electron microscopy in the investigation of materials down to the atomic scale. • The module is the continuation of module "Transmission Electron Microscopy in Material Science I and comprises the introduction and application to current research topics of advanced TEM techniques, including imaging (HRTEM, STEM), spectroscopic (EDXS, EELS, EFTEM) and 3D (ET) techniques. • The aim is always to give insight into both the contrast mechanisms and physics of as well as the achievable information delivered by the different techniques. • This module can only be chosen as "Wahlmodul and not in combination with "Kernfachmodule WW9 ("Fundamentals of Micro- and Nanostructure Research & "Applied Micro- and Nanostructure Research).
6	**Learning objectives and skills**	**The students** **Professional competence** • Knowledge about the application of high resolution techniques for nanomaterials **Understanding** • In-depth understanding of microscopy techniques for micro- and nanostructure research • In-depth understanding of basic and advanced imaging, diffraction and spectroscopic TEM techniques and their application to material science • Insight into the structure property relationship of materials **Training** • Hands-on-training on modern analysis software for EM applications • Hands-on-training and experience on transmission electron microscopes accompanied with suitable exercises (3 days of practical exercise during the lecture period)
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!

9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (15 Min.) oral exam (15 min).
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Goodhews, Humphreys and Beanland: Electron Microscopy and Analysis Williams & Carter: Transmission Electron Microscopy Reimer & Kohl: Transmission Electron Microscopy Fultz & Howe: Transmission Electron Microscopy and Diffractometry of Materials Reimer: Transmission Electron Microscopy P. Haasen: Physikalische Metallkunde G. Gottstein: Physikalische Grundlagen der Materialkunde J. M. Cowley: Diffraction Physics Lecture notes.

1	**Module name** 46285	**Scattering Methods for Nanostructured Materials** Scattering methods for nanostructured materials	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	The module focuses on the application of scattering methods for crystal structure determination in general (diffraction), the investigation of supported nanostructures and thin films (grazing incidence diffraction and reflectometry) and for the size and shape analysis of nanostructures in solution (small-angle scattering). Basic concepts of Fourier transforms will be applied to the interaction of a primary probe with a periodically ordered object. Moreover, the impact of multiple scattering events on the diffracted intensity and its angular dependence will be discussed in a unified model for neutrons, x-rays and electrons. Those theoretical considerations will built the basis for the understanding of the methods named above. For all methods, current published research examples will be showcased.
6	**Learning objectives and skills**	**The students** Unterstanding professional competences Basics of Fourier transform and convolution Understanding of the interaction of neutrons, x-rays and electrons with atoms and their arrays Physical principles of the interaction of a scattering probe with an extended crystalline lattice Understanding how scattering methods contribute and which kind of information can be extracted for todays challenges in material science **Appliation** Each topic will be accompanied with suitable exercises
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Micro- and Nanostructure Research Master of Science Nanotechnology 20232
10	**Method of examination**	Oral
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	• D.S. Sivia: Elementary Scattering Theory • B.E. Warren: X-ray Diffraction • J. M. Cowley: Diffraction Physics • A. Authier: Dynamical Scattering Theory • Als-Nielsen & McMorrow: Elements of modern X-ray physics • J. Daillant and A. Gibaud: X.ray and Neutron Reflectivity: Principles and Applications • Renaud et al. 2009, Probing surface and interface morphology with Grazing Incidence Small Angle X-ray Scattering, Surface Science Reports 64, 255-380. • Rivnay et al. 2012, Quantitative Determination of Organic Semiconductor Microstructure from the Molecular to Device Scale, Chem. Rev. 112, 5488-5519.

1	**Module name** 46284	**3D Characterization in Materials Science** 3D characterization in materials science	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: 3D Characterization in Materials Science (2 SWS) Praktikum: Practical Course to 3D Characterization in Materials Science (2 SWS)	3 ECTS 2 ECTS
3	Lecturers	Dr.-Ing. Benjamin Apeleo Zubiri Prof. Dr. Erdmann Spiecker	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	The module focuses on the application of 3D characterization methods in materials science. Techniques on different length scales (meters down to angstroms) using different probes (e.g. visible light, X-rays, electrons) are covered. The aim of this module is to give an overview over available techniques, to teach the underlying physical principles and to point out specific advantages, challenges and limits, demonstrated on recent research examples. Focal topics are transmission tomography methods on the nano- and microscale, namely high-resolution X-ray computed tomography (Nano-CT) and electron tomography. Sample preparation, data acquisition, 3D reconstruction, data handling and analysis are taught in both the lecture and the practical course. The theoretical background of 3D reconstruction techniques for transmission tomography is also part of the lecture.
6	**Learning objectives and skills**	**Professional competence** **Knowledge** Overview over 3D characterization techniques on different length scales using different probes, demonstrated on recent research examples **Understanding** Understand the underlying physical principles and specific advantages, challenges and limits of different 3D techniques in materials science **Analyzing** Learn theoretical and practical aspects of sample preparation, data acquisition, 3D reconstruction and analysis of transmission tomography on the nanoscale
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Micro- and Nanostructure Research Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Minuten) --- currently taking an oral exam (15 minutes)

11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• G. Hübschen, I. Altpeter, ... H.-G. Herrmann: Materials Characterization Using Nondestructive Evaluation (NDE) Methods. Elsevier. • J. Frank: Electron Tomography - Methods For Three-Dimensional Visualization of Structures in the Cell. Springer. • T. M. Buzug: Computed Tomography. Springer. • Burnett et al. 2014, Correlative Tomography, Scientific Reports 4, 4711. • Hauser et al. 2017, Correlative Super-Resolution Microscopy: New Dimensions and New Opportunities, Chem. Rev. 117, 7428-7456. • Lecture notes.

1	**Module name** 46283	**Scanning Electron Microscopy in Materials Science and Nanotechnology** Scanning electron microscopy in materials science and nanotechnology	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	The module focuses on the introduction to and application of Scanning Electron Microscopy (SEM) in Materials Science and Nanotechnology and comprises a lecture with corresponding exercises. Amongst others, the following topics are addressed: • Components of an SEM instrument • Elastic/inelastic electron-probe/sample interactions, interaction volume, generation of secondary and backscattered electrons • Contrast mechanisms of different detector systems • Topographic und chemically-sensitive imaging • Electron diffraction and its application in SEM • Scanning Transmission Electron Microscopy (STEM) • Quantitative X-ray spectroscopy • Focused ion beams (Dual-Beam FIB, He-ion microscopy) **Preparation-specific challenges** Application examples Specific topics are accompanied with suitable exercises (e.g. Monte-Carlo simulations to simulate electron trajectories).
6	**Learning objectives and skills**	**The students** • professional competence • knowledge • Introduction to the basic concepts of and physics behind SEM **Understanding** Overview over applications and deeper understanding of SEM and FIB techniques in materials science on the micro- and nanoscale Enhancement of knowledge through teaching of current SEM applications and state-of-the-art developments in research **Application** Application and consolidation of taught contents by SEM-related exercises
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (15 Min.) oral exam (15 min.)

11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Reimer, Scanning Electron Microscopy, Springer Verlag. Goodhews, Humphreys and Beanland: Electron Microscopy and Analysis Goldstein et al., Scanning Electron Microscopy and X-Ray Microanalysis (2003) N. Yao, Focused Ion Beam Systems, Basics and Applications, Cambridge University Press, 2010. L.A. Gianuzzi, F.A. Stevie, Introduction to Focused Ion Beams. Instrumentation, Theory, Techniques and Practice, Springer, 2005. J. Orloff, M. Utlaut, L. Swanson, High Resolution Focused Ion Beams: FIB and its Applications, Springer, 2003 Lecture notes.

1	**Module name** 46276	**Foundations of phase field modelling**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Advanced Materials Simulation with Phase Field (2 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Dr. Frank Wendler	

4	**Module coordinator**	Dr. Frank Wendler
5	**Contents**	1. Continuum modeling; 2. Introduction to the phase field method; 3. Advanced materials simulation with the phase field method; 4. Practicals and hands-on activities
6	**Learning objectives and skills**	Students • gain an extensive knowledge of the phase field method, from the more general aspects to the most advanced current applications • become familiar with the theoretical tools of the phase field method • acquire the practical aspects of its numerical implementations, through extensive practical sessions.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46275	**Microstructure Modeling** Microstructure modeling	**5 ECTS**
2	Courses / lectures	Seminar: Seminar Computational Materials Science (2 SWS, SoSe 2025) Vorlesung: Modelling Materials with Finite Elements Simulations (SoSe 2025) Vorlesung mit Übung: Modelling Materials with FEM simulations (SoSe 2025)	- - -
3	Lecturers	Dr. Frank Wendler PD Dr. Paolo Moretti	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	1. Finite element simulation methods 2. Dislocation theory and simulation 3. Discrete and continuum microstructural modeling 4. Discretization schemes 5. Network models
6	**Learning objectives and skills**	Students • develop advanced knowledge in the field of computer-aided microstructure modeling techniques. • develop advanced knowledge in discrete methods • develop advanced knowledge in continuum models in conjunction with the appropriate discretization techniques. • understand the theoretical aspects of continuum and discrete microstructure
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (15 Min.) oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46274	**Materials Informatics** Materials informatics	**5 ECTS**
2	Courses / lectures	Vorlesung: Materials Data Engineering in Industrial Practice (2 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Dr. Johannes Möller	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	1. Data science in materials modeling 2. Correlations and methods of statistical inference 3. Machine learning techniques 4. Elements of high performance computing 5. Data structures in microstructure modeling
6	**Learning objectives and skills**	the students • acquire advanced knowledge of computer-based techniques of data analysis and materials modeling • learn methods of relevance in the treatment of data coming from both simulations and experiments. • become familiar with concepts and tools of machine learning and high performance computing, of relevance in the study of materials properties, through extensive practical sessions
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46273	**Material Theory** Material theory	**5 ECTS**
2	Courses / lectures	Vorlesung: Generalized Continuum Models of Materials Mechanics (1 SWS, SoSe 2025) Vorlesung mit Übung: Atomistic Methods: phase diagrams and processes (SoSe 2025)	1,5 ECTS -
3	Lecturers	Prof. Dr. Luca Ghiringhelli	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	1. Theoretical foundations of atomistic models 2. Coarse graining and formulation of continuum theories 3. Generalized continuum theories.
6	**Learning objectives and skills**	students learn the theoretical foundations of the models behind current state-of-the-art simulation techniques • develop a critical understanding of current modeling tools and approximation methods • develop a critical understandingof relevance both for atomistic modeling and for continuum approaches
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 45 h Independent study: 105 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46266	**Advanced applications: Composites and Surfaces** Advanced applications: Composites and surfaces	**5 ECTS**
2	Courses / lectures	Vorlesung: Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine (2 SWS) Vorlesung: Composites and Nanomaterials in Medical technology (2 SWS) Vorlesung: Dental Biomaterials (2 SWS)	1,5 ECTS 2,5 ECTS 3 ECTS
3	Lecturers	Prof. Dr. Sannakaisa Virtanen Prof. Dr.-Ing. Aldo Boccaccini Dr. Julia Will apl. Prof. Dr. Ulrich Lohbauer	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	*Verbundwerkstoffe und Nanomaterialien in der Medizintechnik* • Vorteile von Verbundwerkstoffen als Werkstoffe in der Medizin • Gefüge-Eigenschaft-Korrelation bei Verbundwerkstoffen • Beispiele für Verbundwerkstoffe und deren Einsatz in der Medizintechnik • Bedeutung der Nanomaterialien in der Medizintechnik • Charakterisierung von Nanomaterialien • Nanoteilchen, Nanotubes • Zelltoxizität und Grenzen des Einsatzes von Nanoteilchen in der Medizintechnik • Sol-Gel-Verfahren zur Herstellung von Nanoteilchen • Kolloidale Prozesse und Funktionalisierung von Nanoteilchen • Herstellung von Nanoteilchen auf der Bioroute • Biogene Nanopartikel • "Green Chemistry" für die Herstellung von Nanoteilchen • Ausgewählte Beispiele aus dem Bereich der Nanobiomedizin. *Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine* This course introduces the basics of chemistry and physics of surfaces including characterization methods for biomaterial surfaces. Surface properties which are relevant for protein and cell attachment are discussed. Fundamentals of protein and protein adsorption on biomaterials are presented as well as the effect of chemical composition, topography, hydrophobic and hydrophilic surfaces, stiffness of the biomaterial and ion release effects from the biomaterial on cell attachment and success of the implanted material in general. The lecture also gives surface modification strategies for implants and scaffolds including biomedical coatings and bioactive surfaces. The course covers also functionalization strategies for biomaterials. Protein adsorption mechanisms and the basics of the interaction between a biomaterial (implant) and tissues (foreign body reaction) are covered. Protein adsorption mechanisms and the basics of the interaction between a biomaterial (implant) and tissues (foreign body reaction) are covered.

		Dentale Biomaterialien • Aufbau der Zähne • Zahnkrankheiten • Biomechanik • Dentale Konstruktionslehre, Präparation • Zemente & Polymere • Befestigung am Zahn • Befestigung am Substrat • Implantate • digitaler Workflow, klinische Fraktografie • Mechanische Eigenschaften & Prüfung • Dentalkeramik |*Content:*| *Composite materials and nanomaterials in medical technology* • Advantages of composites as materials for medicine • Microstructure-property-correlation in composites • Gefüge-Eigenschaft-Korrelation bei Verbundwerkstoffen • Examples of composites and their usage in medical technology • Importance of nanomaterials in medical technology • Characterisation of nanomaterials • Nanoparticles, nanotubes • Cell toxicity and limitations of use of nanoparticles in medical technology • Sol-gel-processes for fabrication of nanoparticles • Colloidal processes and functionalization of nanoparticles • Production of nanoparticles using the bio-route • Biogenic nanoparticles • "Green chemistry" for the synthesis of nanoparticles • Selected examples from the area of nanobiomedicine *Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine:* see above *Dental Biomaterials* • Structure of teeth • Tooth diseases • Biomechanics • Dental design theory, preparation • Cements & polymers • Attachment on teeth • Attachment on substrate • Implants • Digital workflow, clinical fractography • Mechanical properties and examination • Dental ceramics
6	**Learning objectives and skills**	*Verbundwerkstoffe und Nanomaterialien in der Medizintechnik* Die Studierenden • gewinnen einen Überblick über die aktuell und zukünftig in der Medizintechnik eingesetzten Nanomaterialien.

- kennen spezifische Eigenschaften, Anwendungen und Vorteile von Nanokompositen.
- verstehen die Zusammensetzung und Entwicklung solcher Verbundwerkstoffe für die Medizintechnik in Anwendungen wie Beschichtungen, Scaffolds, Drug-Delivery Systeme und antimikrobielle Oberflächen.

Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine: see below

Dentale Biomaterialien

Die Studierenden

- kennen den Aufbau und die Struktur von Zähnen und die daraus abgeleiteten mechanischen und physikalischen Eigenschaften.
- kennen die Struktur und die Zusammensetzung dentaler Biomaterialien wie hochgefüllte Polymere, Dentalkeramiken oder Titanimplantate.
- verstehen die relevanten Krankheitsbilder, die zum Zahnverlust führen können und bekommen Einblick in die Kariesätiologie.
- entwickeln das Verständnis für die Prinzipien dentaler Konstruktionslehre (Kavitätenpräparation) im Hinblick auf die unterschiedlichen Restaurationsmaterialien und Befestigungstechniken.
- klassifizieren die Prinzipen der dentalen Befestigungstechnik und speziell der adhäsiven Klebetechnik.
- können den Unterschied zwischen direkter, plastischer Füllungstherapie und indirekten, prothetischen Restaurationen diskutieren.
- sind in der Lage dentale Biomaterialien, anwendungsspezifisch hinsichtlich mechanischer, physikalischer, chemischer und biologischer Eignung zu untersuchen.

|*Educational objectives and competences:*|

Composite Materials and Nanomaterials in Medical Technology

The students

- obtain an overview on the current and future nanomaterials used in medical technology.
- know specific properties, applications and advantages of nanocomposites.
- understand the composition and development of such composite materials for medical technology for applications such as coatings, scaffolds, drug-delivery systems and antimicrobial surfaces

Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine

The students

- learn the basics of different aspects of interfaces of biomaterials. In particular, focus will be placed on the interaction between different biomaterials (polymers, metals,

		ceramics) with the physiological fluids and the surrounding tissue. • can apply their knowledge in order to judge the success of the different biomaterials and to optimize the surface properties for specific applications • know and can explain methods of surface characterization. *Dental biomaterials* The students • know the structure of a tooth and their mechanical and physical properties. • understand the structure and the composition of dental biomaterials, such as highly filled polymers, dental ceramics or titanium implants. • understand the relevant clinical pictures, which lead to tooth loss, and an insight into the etiology of caries formation. • develop an understanding for the principles of dental design theory (Cavity preparation) with view to the different restoration materials and fixation techniques, • classify the principles of dental fixation techniques, in particular the adhesive technique. • can discuss the difference between direct, plastic restorative therapy and indirect, prosthetic restorations. • are able to examine dental biomaterials from a user specific standpoint regarding mechanical, physical, chemical and biological suitability.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Biomaterials Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Minuten) currently taking an oral exam (15 minutes)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	*Verbundwerkstoffe und Nanomaterialien in der Medizintechnik/ Composites and nanomaterials in medical technology* • Ambrosio (ed.): Biomedical composites; Oxford, 2010 • Wintermantel, Suk-Woo: Medizintechnik; Berlin, 2009

		Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine • Biomaterials Science, 2nd ed., B. D Ratner et al. (eds.), Elsevier, 2004. • Surface Modification of Biomaterials: Methods analysis and applications, R. Williams (ed.), Woodhead Publishing, 2010 Further recommended reading will be announced in the lectures. *Dentale Biomaterialien/Dental Biomaterials* • Rosentritt M., Ilie N., Lohbauer U. Werkstoffkunde in der Zahnmedizin. Thieme Verlag. 2018 (ISBN 978-3-1324-0123-5)

1	**Module name** 46265	**Advanced applications: Biofabrication and Drug Delivery** Advanced applications: Biofabrication and drug delivery	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	*Vorlesung Biofabrikation* • Anwendungsfelder Additive Fertigung- Grundprinzip • Aufbau und Funktionsweise eines 3D Druckers • Unterschiedliche Systeme des 3D Druckens • Anforderungen an Biotinten • Eigenschaften synthetischer und natürlicher Biotinten • Synthese und Vernetzungsmechanismen von Hydrogelen • mechanische und chemische Charakterisierung der Biotinte • Zell-Drucken und Zell-Reifung • Verschiedene Anwendungen der Biofabrikation: Organ on a Chip und Gewebeanaloga *Praktikum "Drug Delivery Systeme"*: Experimentelle Arbeiten zur Vertiefung der Vorlesungsinhalt Hydrogele *Prakikum "3D Drucken"*: Experimentelle Arbeiten zur Vertiefung der Vorlesungsinhalt Additive Fertigung von Biopolymeren: 3D Extrusionsdrucken von Polycaprolacton und Alginat |*Content:*| *Lecture Biofabrication* • Application fields Additive Manufacturing- basic principle • Setup and operating principle of 3D printer • Different systems of 3D printing • Requirements for bioinks • Properties of synthetic and natural bioinks • Synthesis and cross-linking of hydrogels • Mechanical and chemical characterisation of bioinks • Cell-printing and cell-maturation • Different applications of biofabricaation: Organ on a Chip and tissue analogs *Practical "Drug Delivery Systems":* Experimental work to consolidate the content oft he lecture course hydrogels *Practical "3D Printing":* Experimental work to consolidate the content of the lecture course Additive Manufacturing of Biopolymers: 3D Extrusion printing of Polycaprolacton and Alginate
6	**Learning objectives and skills**	* Biofabrikation* Die Studierenden • erfassen die Wichtigkeit verschiedener Konzepte im Bereich der Biofabrikation. • lernen physikalische/chemische Grundlagen von Hydrogelen, Zellen-Gewebe und 3D Drucken.

		• versehen der Interaktion von Biotinte, 3D Drucken und Zellen • verstehen der Mechanismen der 3D Generierung: |Organ on a Chip bis hin zu Gewebeanaloga| *Praktikum Drug-Delivery-Systeme* Die Studierenden • ᵒ lernen das sterile Arbeiten, Pipettieren und Mikroskopieren. ᵒ verstehen die Freisetzungskinetik von Drug-Delivery-Systemen. ᵒ haben einen Überblick über Methoden der Herstellung und Charakterisierung von Mikrokapseln im Hinblick auf die biomedizinische Anwendung. ᵒ grasp the importance of the different concepts in the area of biofabrication. ᵒ learn physical/chemical fundamentals on hydrogels, cells-tissues and 3D printing. ᵒ understand the interaction between bioinks, 3D printing and cells ᵒ understand the mechanisms of 3D generation: from Organ on a Chip to tissue analogs ᵒ understand the importance of polymeric materials for biofabrication processes *Practical 3D-Printing* The students learn to work in sterile conditions, using a pipette and microscope. understand the release kinetics of drug-delivery-systems. get an overview on fabrication and characterisation methods of microcapsules in regards of biomedical applications.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Biomaterials Master of Science Nanotechnology 20232
10	**Method of examination**	Variable (45 minutes) derzeit mündliche Prüfung (15 Minuten) currently taking an oral exam (15 minutes)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	*Biofabrikation/Biofabrication* • Moroni, L., et al. (2018). "Biofabrication: A Guide to Technology and Terminology. Trends in Biotechnology.

		• Groll, J., et al. (2018). "A definition of bioinks and their distinction from biomaterial inks. Biofabrication, 11(1) • Valot, L., Martinez, J., Mehdi, A., and Subra, G. (2019). "Chemical insights into bioinks for 3D printing. Chemical Society Reviews, 48(15), 40494086. • Yi, H.-G., Lee, H., and Cho, D.-W. (2017). "3D Printing of Organs-On-Chips. Bioengineering, 4(4), 10. *Drug-Delivery-Systeme/Drug-Delivery-Systems* • Augst, A. D., Kong, H. J., and Mooney, D. J. (2006). "Alginate hydrogels as biomaterials. Macromolecular bioscience, 6(8), 623633. • Smidsrød O, Skjåk-Braek G. (1990) "Alginate as immobilization matrix for cells. Trends Biotechnol.;8(3):71-8. • Productinformation: Bradford Reagent, Prod.No. B6916, Sigma * 3D Drucken/3D Printing* • Liaw, C. Y., and Guvendiren, M. (2017). "Current and emerging applications of 3D printing in medicine. Biofabrication. • Chia, H. N., and Wu, B. M. (2015). "Recent advances in 3D printing of biomaterials. Journal of Biological Engineering, 9(1), 4.

1	**Module name** 46262	**Crystal Growth 3** Crystal growth 3	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr.-Ing. Peter Wellmann
5	**Contents**	• Basics of computer simulation of a crystal growth process • Introduction to the COMSOL Multi-Physics software package • Application of numerical modeling in crystal growth (melt crystallization, solution growth and gas phase growth)
6	**Learning objectives and skills**	• The students acquire in-depth knowledge of the computer simulation of materials science processes (focus: crystallization). • Getting to know digital techniques in materials science, writing technical reports, teamwork
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Practical achievement derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Practical achievement (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 120 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46259	**Crystal Growth 1** Crystal growth 1	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr.-Ing. Peter Wellmann
5	**Contents**	**Fundamentals of crystal growth and semiconductor technology** • Fundamentals of crystal growth • Basics of silicon semiconductor technology (oxidation, doping by diffusion and ion implantation, etching, metallization, lithography, packaging) • Deepening: Large band gap semiconductors
6	**Learning objectives and skills**	The students acquire in-depth knowledge of material properties and their application in electronic components.
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 The module can be used as an elective or compulsory elective in the MWT, NT and ET master's courses.
10	**Method of examination**	Variable Die Vorlesungen des Moduls werden im Format "**Flipped Classroom**" durchgeführt (synchrone Lerneinheiten im Hörsaal & asynchrone Lerneinheiten über Studon: https://www.studon.fau.de/studon/goto.php?target=crs_3259598 https://www.studon.fau.de/studon/goto.php?target=crs_4514743 Die Prüfung findet entweder **mündlich** (15 min) oder als **elektronische Klausur** (30 min) statt. Die elektronische Klausur enthält teilweise Multiple Choice Fragen. Es gilt: Jede Antwortmöglichkeit wird bei richtiger

		Beantwortung mit der zugewiesenen Punktzahl bewertet; falsche Beantwortung geht innerhalb der Frage mit negativen Punkten ein. Es werden alle Punkte der Antwortmöglichkeitenaddiert. Es gibt keine Negativpunkte für falsch markierte Aufgaben. --- The lectures of the module are held in the "Flipped Classroom" format (synchronous learning units in the lecture hall & asynchronous learning units via Studon: https://www.studon.fau.de/studon/goto.php?target=crs_3259598 https://www.studon.fau.de/studon/goto.php?target=crs_4514743 The exam takes place either orally (15 min) or as an electronic exam (30 min). The electronic exam partly contains multiple choice questions. The following applies: Each answer option is rated with the assigned number of points if the answer is correct; Incorrect answer goes within the question with negative points. All points of the possible answers are added up. There are no penalties for incorrectly marked tasks.
11	**Grading procedure**	Variable (100%) Die Prüfung findet entweder **mündlich** (15 min) oder als **elektronische Klausur** (30 min) statt. Die elektronische Klausur enthält teilweise Multiple Choice Fragen. Es gilt: Jede Antwortmöglichkeit wird bei richtiger Beantwortung mit der zugewiesenen Punktzahl bewertet; falsche Beantwortung geht innerhalb der Frage mit negativen Punkten ein. Es werden alle Punkte der Antwortmöglichkeiten addiert. Es gibt keine Negativpunkte für falsch markierte Aufgaben. The exam takes place either orally (15 min) or as an electronic exam (30 min). The electronic exam partly contains multiple choice questions. The following applies: Each answer option is rated with the assigned number of points if the answer is correct; Incorrect answer goes within the question with negative points. All points of the possible answers are added up. There are no penalties for incorrectly marked tasks.
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english

16	**Bibliography**	S.M. Sze, Semiconductor Devices – Physics and Technology, John Wiley & Sons, Inc. 2002 P. Wellmann, Materialien der Elektronik und Energietechnik – Halbleiter Graphen, Funktionale Materialien, Springer-Vieweg 2015 (1st edition) and 2019 (2nd edition)

1	**Module name** 46257	**Advanced Semiconductor Technologies** **Photovoltaic Systems I - Fundamentals** Advanced semiconductor technologies - Photovoltaic systems I - Fundamentals	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Christoph Brabec Prof. Dr. Wolfgang Heiß
5	**Contents**	**Lecture / Exercise / Lab work** The lecture will introduce into the fundamentals of photovoltaic energy conversion. The conversion of light into electricity is one of the most efficient power technologies by today and is expected to transform our energy system towards a renewable scenario. The limits of photovoltaic energy conversion, the materials and architectures of major PV technologies and advanced characterization methods for modules as well as solar fields will be introduced theoretically and experimentally during the lecture, a seminar and the lab works.
6	**Learning objectives and skills**	• The students will learn the concept of black body radiation and the radiation laws and the limits of light energy conversion. The fundamental semiconductor junctions (p-n, M-i-M, Shottky and Hetero Junction are repeated. The one diode and two diodes replacement circuits are explained . Electrical, optical, recombination and extraction loss mechanisms are discussed separately and demonstrated at the hand of numerical drift-diffusion equation solvers. The most important solar cell concepts (Si, CIGS, CdTe, GaAs, Perovksites, Organics) are introduced, and the strengths and weaknesses of each technology are analysed. • Characterization of Photovoltaic Modules will trained by flashed measurements in the lab. Defect imaging methods like DLIT, EL or PL imaging will be trained at the hand of module installations in Erlangen.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232
10	**Method of examination**	Variable

		Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (Prüfungsnummer: 62571) Examination performance, oral examination, duration (in minutes): 15, graded, 5 ECTS Share in the calculation of the module grade: 100.0% Alternative examination forms: written exam (90 min). Choice of the examination form is done on the basis of the didactic character of the module. The decision for the examination form will be communicated: • in semesters where the lecture takes place: no more than two weeks after lecture start in the lecture and in the StudOn group • in semesters without lecture: at least two weeks before the repetition exam in the StudOn group
11	**Grading procedure**	Variable (100%) Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (examination number: 62571) Share in the calculation of the module grade: 100.0 %
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 40 h Independent study: 110 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46256	**Advanced Semiconductor Technologies Solution Processed Semiconductors III - Processing** Advanced semiconductor technologies: Solution processed semiconductors III: Processing	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Advanced Semiconductor Technologies - Solution Processed Devices / Applications (2 SWS, SoSe 2025)	3 ECTS
3	Lecturers	Dr.-Ing. Thomas Heumüller Prof. Dr. Christoph Brabec	

4	**Module coordinator**	Prof. Dr. Christoph Brabec
5	**Contents**	**Lecture / Exercise / Lab work** The lecture will introduce into the specifics of electronic transport in disordered semiconductors as compared to inorganic semiconductors. As a consequence of the transport properties, quite unique device architectures are developed for disordered semiconductor devices. As a prototype representative, organic semiconductor devices (organic solar cells and LEDs) are discussed in more detail.
6	**Learning objectives and skills**	• The students will learn the major electronic transport models for disordered semiconductors. Marcus theory is introduced to describe charge migration. The Gaussian Disorder Modell is introduced to derive the temperature and field dependence of mobility and conductivity. • Organic LEDs are one of the leading display technologies nowadays. Materials concepts for OLEDs, recombination of singlet and triplet populations, energy transfer, device architecture and production aspects are discussed Organic Photovoltaics is an emerging PV Technology. The leading materials concepts and composites for OPV are bilayer and bulk heterojunction concepts, charge generation and charge recombination is discussed as a function of microstructure. • Single junction and tandem junction architectures are analysed, steady state and transient measurement methods are introduced to characterize such devices. • Processing and characterization of organic, perovskite, etc solar cells, LEDs , displays or X-Ray detectors will be trained in the lab work.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232

		1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors III - Processing) 2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors III - Processing) 3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Advanced Semiconductor Technologies – Solution Processed Semiconductors III - Processing) Dieses Modul ist daneben auch in den Studienfächern "Nanotechnologie (Master of Science)" verwendbar.
10	**Method of examination**	Variable **Studien-/Prüfungsleistungen:** Advanced Semiconductor Technologies – Solution Processed Semiconductors III - Processing (Prüfungsnummer: 62561) Examination performance, oral examination, duration (in minutes): 20, graded, 5 ECTS **Associated courses:** • Lab Work Solution Processed Electronics • Advanced Semiconductor Technologies - Solution Processed Devices / Applications further explanations: Oral examination and report from lab work Language of examination: German or English

Alternative examination forms: written exam (90 min). Choice of the examination form is			

		done on the basis of the didactic character of the module. The decision for the examination form will be communicated: • in semesters where the lecture takes place: no more than two weeks after lecture start in the lecture and in the StudOn group • in semesters without lecture: at least two weeks before the repetition exam in the StudOn group			
11	**Grading procedure**	Variable (100%)			

		Share in the calculation of the module grade: 100.0 % Oral examination determines the grade of the module. The LabWork should be accepted by the direct supervisor.
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 50 h Independent study: 100 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Will be presented in the StudOn page of the course

1	**Module name** 46255	**Advanced Semiconductor Technologies Solution Processed Semiconductors II - Processing** Advanced semiconductor technologies: Solution processed semiconductors II: Processing	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Advanced Semiconductor Technologies - Processing (including Lab Work Organic Electronics Processing) (2 SWS, SoSe 2025)	3 ECTS
3	Lecturers	Dr. Larry Lüer	

4	**Module coordinator**	Hans-Joachim Egelhaaf
5	**Contents**	**Lecture / Exercise / Lab work** The lecture will give an introduction to coating and printing technologies for the manufacturing of (opto-)electronic devices by solution processing. Special emphasis will be on upscaling from lab scale devices to large area commercial products. The fundamentals of the different technologies as well as their application for the manufacturing of active layers, transparent electrodes and transparent barriers will be described in detail. Exercises will provide a more quantitative approach to thin film processing while lab work will allow hands on experience of the lecture content.
6	**Learning objectives and skills**	• The students will be introduced to the inventory of printing, coating and patterning technologies available for the solution processing of organic, hybrid and inorganic (opto-)electronic devices (FETs, LEDs, solar cells and photodetectors) and its application to the manufacturing of organic, perovskite and quantum dot devices. • After discussing the fundamentals of wet film deposition (wetting, viscosity, drying), the working principles and application ranges of coating (spin coating, doctor blading, slot die coating), printing (letter press, gravure, flexo, screen, ink jet printing) as well as of patterning techniques (printing, scratching, laser ablation) will be introduced. • The specific requirements of "printed electronics will be introduced and compared to those of "silicon based electronics on one hand and "visual printing on the other hand. • The students will learn how to manufacture transparent electrodes (thin metal films, finger electrodes, nanowire meshes, transparent conductive oxides), active layers (bulk heterojunctions, perovskite films, nanoparticle layers), and barriers from the respective inks. They will also learn how to decide for the appropriate coating/printing technology. The inventory of materials for printed electronics will be presented and concepts for rational development of inks from these materials (Hansen solubility theory) will be introduced. • Exercises will teach the students to base their decisions for materials, coating/printing technologies and patterning methods on quantitative considerations. These will include the

		calculation of resistance losses in transparent electrodes, of the viscosities and surface tensions of inks as well as of the water vapor transmission rates of barriers. • Deposition and patterning of electrodes, active layers, and barriers for organic or perovskite solar cells will be trained in the lab work.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering, Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232 Usability of the module / integration into the sample curriculum: 1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) 2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) 3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) This module can also be used in the subjects "Nanotechnology (Master of Science)".
10	**Method of examination**	Variable Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing (examination number: 62551) • in semesters where the lecture takes place: no more than two weeks after lecture start in the lecture and in the StudOn group

		• in semesters without lecture: at least two weeks before the repetition exam in the StudOn group Examination performance, oral examination, duration (in minutes): 15, graded, 5 ECTS Share in the calculation of the module grade: 100.0% **Associated courses:** • Advanced Semiconductor Materials - Excited States and Charge Transport in Organic Semiconductors • Advanced Semiconductor Technologies - Processing (including Lab Work Organic Electronics Processing - 1 experiment / 20 pages report) Examiner: Prof. Christoph J. Brabec Alternative examination forms: written exam (90 min). Choice of the examination form is done on the basis of the didactic character of the module. The decision for the examination form will be communicated: | | |
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 67 h Independent study: 110 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46254	**Advanced Semiconductor Technologies Solution Processed Semiconductors I: Materials - Nanocrystals** Advanced semiconductor technologies: Solution processed semiconductors I: Materials - nanocrystals	**5 ECTS**
2	Courses / lectures	Vorlesung: Kolloidale Nanokristalle (2 SWS, SoSe 2025) Seminar: Seminar über "Solution Processed Semiconductors" (2 SWS, SoSe 2025)	3 ECTS 2 ECTS
3	Lecturers	Prof. Dr. Wolfgang Heiß	

4	**Module coordinator**	Miroslaw Batentschuk Prof. Dr. Wolfgang Heiß
5	**Contents**	Lecture / Seminar / Lab work Applications of colloidal nanocrystal materials Growth models to describe nucleation, growth and ripening of nanocrystals Optical properties of quantum dot materials Colloidal nanocrystals operating in the infrared Perovskite based colloidal nanocrystals Devices based on colloidal nanocrystals Topological insulators and two-dimensional materials Synthetic routes towards colloidal nanocrystals Fundamentals of charge transport and optical properties of conjugated polymers Organic semiconductor materials Fundamentals of carbon allotropes
6	**Learning objectives and skills**	Obtaining a detailed understanding of the physics and chemistry of semiconductor nanocrystals Understanding and practically performing the synthesis of a colloidal semiconductor material Independent development and presentation of new research results from the literature on the topic of solution processed semiconductors Understanding of special optical processes in semiconductor nanocrystals Knowledge of nanocrystal applications in devices Understanding fundamentals of organic semiconductors and carbon allotropes
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232

10	**Method of examination**	Variable Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (Prüfungsnummer: 62571) Examination performance, oral examination, duration (in minutes): 15, benotet, 5 ECTS Share in the calculation of the module grade: 100.0 % Related Lab Work - 1 experiment / 20 pages report
11	**Grading procedure**	Variable (100%) Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (Prüfungsnummer: 62541) Share in the calculation of the module grade: 100.0 %
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46253	**Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management** Photovoltaics (PV) and PV Systems II: Light conversion and light management	**5 ECTS**
2	Courses / lectures	Praktikum: Lab Work Manufacturing and Characterization of Phosphors and Storage Phosphors (3 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Miroslaw Batentschuk	

4	**Module coordinator**	Miroslaw Batentschuk
5	**Contents**	The module consists of a lecture and a lab course: • Phosphors for Light Conversion in Photovoltaic Devices and LEDs (Im Wintersemester) (Vorlesung, 2 SWS, Miroslaw Batentschuk • Lab Work Manufacturing and Characterization of Phosphors and Storage Phosphors (im Sommersemester) (Praktikum, 3 SWS, Andres Osvet et al., Zeit n. V., Labore LS i-MEET) ; Scope: 1 experiment, 20 pages report. Contents: • Classification of phosphors according to their principle of operation and by field of application. • Establishing the relationships between crystal structure of phosphors as well as their composition and the desirable absorption and emission properties. • Energy transfer between the crystal lattice and active ions as well as between these ions • Consideration of several examples • Theoretical analysis of phosphor engineering with the purpose to reach maximal energy efficiency during transformation of the ionizing radiation • Basics and to methods of storage phosphor manufacturing • Analysis of requirements to the properties and new trends in development of phosphors for white light emitting diodes and for adaptation of the sun light spectrum to the sensitivity of solar cells and plants
6	**Learning objectives and skills**	• The students will get the theoretical background and the ability to determine the required parameters for engineering new phosphors as a part of photovoltaic modules and devices for modern lighting. • The students will be trained in processing of phosphors and dielectric layers. The students will gain knowledge in characterization of phosphors and improved solar cells.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1

<table>
<tr><td>9</td><td>Module compatibility</td><td>1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232
<h3>Verwendbarkeit des Moduls / Einpassung in den Musterstudienplan:</h3>
1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management)
2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management)
3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management)

Dieses Modul ist daneben auch in den Studienfächern "Nanotechnologie (Master of Science)" verwendbar. Details</td></tr>
<tr><td>10</td><td>Method of examination</td><td>Variable
<h3>Studien-/Prüfungsleistungen:</h3><h3>Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management (Prüfungsnummer: 62531)</h3>Prüfungsleistung, mündliche Prüfung, Dauer (in Minuten): 15, benotet, 5 ECTS Anteil an der Berechnung der Modulnote: 100.0 % weitere Erläuterungen:
zusätzlich zur mündlichen Prüfung - unbenoteter Nachweis vom Praktikum, Bericht 20 Seiten Prüfungssprache: Englisch Erstablegung: SS 2022, 1. Wdh.: WS 2022/2023
weitere Erläuterungen:
mögliche weitere Prüfungsformen sind Klausur (45 Min.) oder Hausarbeit benotet (ca. 20 Seiten)
Oral examination, exercises, and report from lab work Prüfungssprache: Deutsch oder Englisch
<table><tr><td>1. Prüfer:</td><td>Miroslaw Batentschuk,</td><td>2. Prüfer:</td><td>Andres Osvet</td></tr></table></td></tr>
<tr><td>11</td><td>Grading procedure</td><td>Variable (100%)</td></tr>
<tr><td>12</td><td>Module frequency</td><td>Only in winter semester</td></tr>
<tr><td>13</td><td>Workload in clock hours</td><td>Contact hours: 40 h
Independent study: 110 h</td></tr>
<tr><td>14</td><td>Module duration</td><td>2 semester</td></tr>
</table>

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46252	**Semiconductor Devices and Applications** Semiconductor devices and applications	**5 ECTS**
2	Courses / lectures	Praktikum: Lab Work Thin Film Semiconductors (2 SWS, SoSe 2025)	2 ECTS
3	Lecturers	Dr. Andres Osvet	

4	**Module coordinator**	Prof. Dr. Christoph Brabec
5	**Contents**	Lecture / Exercise / Lab work • Introduction into the fundamentals, materials and application of thin film semiconducting devices • semiconductor junctions • display technologies • photovoltaic technologies • photodetector and X-Ray technologies • thin film transistor, memory , storage and energy harvesting technologies
6	**Learning objectives and skills**	• The students will get a detailed introduction and overview on various selected thin film device technologies, with emphasis on display technologies, lighting, energy harvesting and photovoltaics (renewable energies). • Independent development of a selected AST topic to the level of comprehension that the student can give a 25 min tutorial / presentation, presentation skills and techniques, • Processing and characterization of thin film semiconductors and semiconducting devices such as photovoltaics, LEDs, light conversion layers (lab course). • Data handling, data storage and written reporting in material science (lab course)
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232 Verwendbarkeit des Moduls / Einpassung in den Musterstudienplan: 1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | Grund- und Ergänzungsmodul | Semiconductor Devices and Applications) 2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik

		(Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | Grund- und Ergänzungsmodul | Semiconductor Devices and Applications) 3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Semiconductor Devices and Applications) Dieses Modul ist daneben auch in den Studienfächern "Nanotechnologie (Master of Science)" verwendbar. Details
10	**Method of examination**	Variable Studien-/Prüfungsleistungen: (englischer Titel: Semiconductor Devices and Applications) Semiconductor Devices and Applications (Prüfungsnummer: 62521) Prüfungsleistung, Portfolio, Dauer (in Minuten): 15, benotet, 5 ECTS Anteil an der Berechnung der Modulnote: 100.0 % Zugeordnete Lehrveranstaltungen: • Advanced Semiconductors Introduction: Devices & Applications • Lab Work Thin Film Semiconductors weitere Erläuterungen: Lecture - graded certificate (students choose either exam on processsing and characterization of a thin film device or a written report of 10 to 20 pages including a final discussion on the results or a presentation of an independent topic in a seminar). Lab Work (1 practical with final report of approximately 1- - 15 pages) Prüfungssprache: Englisch Erstablegung: SS 2022, 1. Wdh.: WS 2022/2023 1. Prüfer: Christoph J. Brabec
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Wird an der Vorlesung dargestellt

1	**Module name** 46247	**Wahlmodul Polymere** Elective module polymers	**5 ECTS**
2	Courses / lectures	Vorlesung: Polymers - I (2 SWS, WiSe 2025) Vorlesung: Polymer and Interface Physics in Theory and industrial Application (1 SWS, WiSe 2025) Praktikum: Labwork Polymers - Basics (1 SWS, SoSe 2025)	3 ECTS 1,5 ECTS 1 ECTS
3	Lecturers		

4	**Module coordinator**	Prof. Dr. Dirk Schubert
5	**Contents**	• Wissensvermittlung zu Grundlagen, Technologie, Charakterisierung und Anwendungen von Polymerwerkstoffen, Polymerblends und -composites • Herstellung und Eigenschaftsprofil von dünnen Polymerfilmen, Fasern und Nanofasern • Einfluss der Größenskala auf Eigenschaften • Wissensvermittlung zu den Vorgängen an Grenzflächen in polymeren Werkstoffsystemen, Kompatibilität verschiedener Polymere • interaktive Gruppenübung zu aktuellen Fragestellungen und Anwendungen von Polymerwerkstoffen **English** • Knowledge transfer on fundamentals, technology, characterization and applications of polymer materials, polymer blends and composites. • Fabrication and property profile of polymer thin films, fibers and nanofibers • Influence of size scale on properties • knowledge transfer on processes at interfaces in polymeric material systems, compatibility of different polymers • interactive group exercise on current issues and applications of polymer materials
6	**Learning objectives and skills**	Die Studierenden • erhalten einen tiefgehenden Einblick in die Thematik Polymere Werkstoffe • erwerben ein wichtiges Grundlagenverständnis (Struktur-Eigenschaftsbeziehungen auf allen Größenskalen) • sind in der Lage, Modifizierungsstrategien für Polymer-werkstoffe in Bezug auf Optimierung von Eigenschaften zu erarbeiten und durchzuführen • haben ein Verständnis für industrierelevante Arbeits-methodiken gewonnen • kennen wesentliche Anwendungen und Entwicklungsfelder **English** The students • gain an in-depth insight into the topic of polymer materials

		• acquire an important basic understanding (structure-property relationships on all size scales) • are able to develop and implement modification strategies for polymer materials with regard to optimization of properties • have gained an understanding of industry-relevant working methodologies • know essential applications and development fields
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Variable mündliche Prüfung (!5 Min.) oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46246	**Verarbeitung von Polymerwerkstoffen** Processing of polymer materials	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Processing of Polymers (2 SWS) Praktikum: Labwork Polymer Processing (2 SWS)	3 ECTS 2 ECTS
3	Lecturers	Dr.-Ing. Joachim Kaschta	

4	**Module coordinator**	Dr.-Ing. Joachim Kaschta Prof. Dr. Dirk Schubert
5	**Contents**	Wissensvermittlung zu Aufbau von Verarbeitungs-maschinen und Ablauf von Verarbeitungsverfahren für Polymerwerkstoffe, Polymerblends und -composites • Einfluss von Werkstoffeigenschaften auf Maschinendesign und Verarbeitungsparameter • Einfluss der Verfahrensparameter auf Eigenschaften • Wissensvermittlung zu Additiven und den Vorgängen an Grenzflächen in polymeren Werkstoffsystemen, Kompatibilität verschiedener Polymere • interaktive Gruppenübung zu aktuellen Fragestellungen und Anwendungen von Polymerwerkstoffen **English** Knowledge transfer on the design of processing machines and the sequence of processing methods for polymer materials, polymer blends and composites • Influence of material properties on machine design and processing parameters • Influence of process parameters on properties • Knowledge transfer on additives and the processes at interfaces in polymer material systems, compatibility of different polymers • interactive group exercise on current issues and applications of polymer materials
6	**Learning objectives and skills**	• kennen wesentliche Anwendungen und Entwicklungsfelder aus den genannten Themenfelder • identifizieren Stärken und Schwächen verschiedener Verarbeitungsverfahren und daraus resultierende Produkteigenschaften • beschreiben wesentliche Struktur-Eigenschaftsbeziehungen • analysieren und bewerten Messdaten von Fertigungsprozessen • sind in der Lage, Modifizierungsstrategien für Polymer-werkstoffe in Bezug auf Optimierung von Eigenschaften durch Verarbeitungsverfahren zu erarbeiten und durchzuführen • stufen die eigenen Ergebnisse ein. • haben ein Verständnis für industrierelevante Arbeits-methodiken gewonnen

		English • know essential applications and development fields from the mentioned topics • identify strengths and weaknesses of different processing methods and resulting product properties • describe essential structure-property relationships • analyze and evaluate measurement data from manufacturing processes • are able to develop and implement modification strategies for polymer materials with regard to optimization of properties by processing methods • classify their own results • have gained an understanding of industry-relevant working methodologies
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Variable mündliche Prüfung (15 Min.) oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46238	**Oberflächenanalyse II** Surface analysis II	**5 ECTS**
2	Courses / lectures	Seminar: Seminar Surface Science and Corrosion (2 SWS) Übung: Übung Surface Analysis II (1 SWS) Vorlesung: Surface Analysis II (2 SWS)	1 ECTS 1 ECTS 3 ECTS
3	Lecturers	Prof. Dr. Sannakaisa Virtanen Dr. Anca Valentina Mazare	

4	**Module coordinator**	Prof. Dr. Patrik Schmuki
5	**Contents**	***Surface Analysis I + II (Vl+Ü)*** The generation of nanostructured materials gained relevance in the recent years and efficient characterization methods were developed, permitting insight into the topographical and chemical nanostructure of materials. The scope of this course covers a range of surface analytical instruments, discussing their principle mode of operation, application and data interpretation. All discussed instruments are also available at the chair and tutorials at the machines are a part of the lecture. The fabrication of nanostructured materials from particles to complex 3 dimensional structures is the topic of the second part of this lecture. Die Strukturierung von Werkstoffoberflächen auf der Nanoskala erlangte in jüngster Vergangenheit große Bedeutung was nicht zuletzt auf der Entwicklung hocheffizienter Charakterisierungsmethoden fußt. Diese erlauben eine hochauflösende Analyse der topografischen sowie chemischen Natur der Oberfläche. Im Zuge dieser Lehrveranstaltung (Teil I) werden eine Vielzahl Oberflächenanalytischer Verfahren und Instrumente erläutert und deren Funktionsprinzip und etwaige Betriebsmodi besprochen, wobei auch auf die Messdateninterpretation Wert gelegt wird. Für die am LS vorhandenen Verfahren erfolgt außerdem eine Begehung der Labore wobei die Studierenden einen konkreten Eindruck der diversen Techniken erhalten können. Im zweiten Teil der Lehrveranstaltung (Teil II) wird die Darstellung nanostrukturierter Werkstoffe besprochen. Hierbei wird auf Partikel bis hin zu komplexen dreidimensionalen Strukturen eine große Bandbreite der Oberflächenmodifikation abgedeckt. ***Seminar Surface Science and Corrosion*** Das Seminar Surface Science and Corrosion bietet die Gelegenheit Einblicke in den aktuellen Stand der Forschungsfelder des Lehrstuhls zu erlangen. Hierbei werden Fallbeispiele präsentiert und diskutiert und so ein tiefgehendes Verständnis der Messmethoden, welche in der VL Surface Analysis vermittelt werden, ermöglicht. Neben dieser inhaltlichen Komponente der Art eines Frontalunterrichtes, ist es möglich und sehr erwünscht die Thematiken zu diskutieren. Den Studierenden ist es hierbei neben dem Erwerb von Fachwissen möglich, einen ersten Eindruck vom Ablauf wissenschaftlicher Konferenzen bzw. Tagungen zu erhalten.

		The seminar Surface science and Corrosion offers the opportunity to gather insights into the current research areas of the chair. In the course of the seminar results are presented and discussed what enables a profound understanding of the techniques that are taught within the lecture Surface Analysis. Besides this factual part, the students have furthermore the chance (and are supposed) to ask questions to the speakers. This is an important insight into the academic working environment that might be especially relevant for prospective PhD-students.
6	**Learning objectives and skills**	**Surface Analysis I + II (Vl+Ü):** **Die Studierenden** • beschreiben fundamentale Konzepte im Bereich Kristallographie. • diskutieren die Vor- und Nachteile verschiedener Verfahren der Oberflächencharakterisierung. • verstehen die theoretischen Grundlagen von STM/AFM, SEM/ EDX, XPS/Auger, XRD, ToF-SIMS. • kennen verschiedene Herstellungsmethoden für Nanostrukturen und Anwendung von CVD. • verstehen den sol-gel Prozesses und könnenihn wiedergeben. • kennen versiedene Anwendungen nanostrukturierter Oberflächen. • können Verfahren zur Oberflächenanalyse bei Nanomaterialien kritisch diskutieren. **The students** • Describing of basic concepts in crystallography. • Evaluating different kinds of surface characterization techniques (pros and cons). • Elucidating the theoretical background of STM/AFM, SEM/ EDX, XPS/Auger, XRD, ToF-SIMS. • Defining fabrication methods of nanostructures and elucidation of nanostructured CVD. • Describing the sol-gel process. • Reporting applications of nanostructured surfaces. • Elucidation of surface analytical techniques for nanomaterial characterization. **Seminar Surface Science and Corrosion** **Die Studierenden:** • wenden wissenschaftliche Verfahren und Techniken in der Forschung (Beispiele) an. • haben Erfahrung in Bezug auf Ablauf und Gepflogenheiten im wissenschaftlichen Arbeitsumfeld durch aktive Teilnahme an Diskussionen. • erwerben Softskills (VortraDarstellung / Diskussion) zur Vorbereitung auf eine wissenschaftliche Karriere. **The students**

		• Appliance of scientific techniques in research (discussion of examples). Generating experience in scientific community. Participation in scientific discussions. • Acquiring of soft-skills for futural scientific careers.
7	**Prerequisites**	Belegung des Wahlmoduls 2: Oberflächenanalyse I Immatrikulation im MA-Studium --- Enrollment in elective module 2: Surface Analysis I Enrollment in the MA program
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination schriftliche Prüfung (45 Min.) written exam (45 min.)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Wird im Zuge der Lehrveranstaltung bekannt gegeben.

1	**Module name** 46248	**Tribologie und Oberflächentechnik und Schadensanalyse** Tribiology, surface finishing and damage analysis	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Werkstoffe: Tribologie und Oberflächentechnik (2 SWS) Praktikum: Praktikum: Tribologie (2 SWS) Praktikum: Labwork Failure Analysis (0 SWS) Vorlesung mit Übung: Grundlagen der Schadensanalyse an Bauteilen (2 SWS)	2 ECTS 3 ECTS - 3 ECTS
3	Lecturers	apl. Prof. Dr. Heinz Werner Höppel Christina Hasenest Prof. Dr. Peter Weidinger	

4	**Module coordinator**	apl. Prof. Dr. Heinz Werner Höppel
5	**Contents**	*Tribologie und Oberflächentechnik, V, 2 SWS, 2 ECTS* • Beschichtungstechnologien • Grundlagen der Tribologie • Verschleißmechanismen • Einführung in die Oberflächentechnik *Schadensanalyse metallischer Werkstoffe, V, 2 SWS, 2 ECTS * Praktikum:Tribologie, 1 SWS, 1 ECTS* *Grundlagen der Schadensanalyse mit Praktikum, 1 SWS, 1 ECTS* • Grundlegendes Vorgehen bei der Schadensanalyse • Schadenshypothesen • Schadensabhilfemaßnahmen • praktische Fallbeispiele Courses: Lectures: 1) Materials: Tribology and Surface Engineering (Lecture with exercise, 2 SWS) Failure analysis of metallic materials Lecture with exercise, 2 SWS) Practical Courses: 1) Tribology: Practical Course, 1 SWS expected start 2nd half of the semester! 2) Failure analysis of metallic materials Practical course, 1 SWS, block course Content: • Tribology and Surface Technology, • Coating Technologies • Basics of tribology • Wear mechanisms • Introduction to surface technology

		• Failure Analysis • Practical course: Tribology • Practical Course: Failure Analysis
6	**Learning objectives and skills**	*Fachkompetenz Evaluieren (Beurteilen)* Die Studierenden • vertiefen ihr Wissen über die vielfältigen strukturellen Aufbauten der Werkstoffe und können diese beurteilen • vertiefen das Verständnis über die Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen und über tribologische Vorgänge • vertiefen ihr Wissen zu Beschichtungstechnologien und Schichteigenschaften • vertiefen ihr Verständnis der Zusammenhänge zwischen Aufbau, thermomechanischer Vorgeschichte und Eigenschaften der Werkstoffe und können diese eklären • vertiefen die erlernten Inhalte durch Praktikum • erlernen und wenden neuen Methoden an • erlernen und verstehen tribologische Vorgänge und evaluieren Kriterien zur Auswahl von Werkstoffen und Beschichtungen für tribologische Anwendungen Technical competence Evaluating (assessing) Students will • deepen their knowledge about the various structural compositions of materials and are able to evaluate the • deepen their understanding of the relationships between the chemical composition, structure and properties of materials and of tribological processes • deepen their knowledge of coating technologies and coating properties • deepen their understanding of the relationships between structure, thermomechanical history and properties of materials and are able to clarify these relationships • deepen their knowledge through practical training • learn and apply new methods • learn and understand tribological processes and evaluate criteria for selecting materials and coatings for tribological applications • learn and understand failure analysis methods • apply learned methods and strategies in case studies
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Variable

		derzeit mündliche Prüfung (15 Min.) currently oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46245	**Anwendungen von Polymeren II** Applications of polymers II	**5 ECTS**
2	Courses / lectures	Vorlesung: Basics of six-Sigma - Tool to improved processes in Industry (1 SWS, SoSe 2025) Vorlesung: Polymer Materials for Medical Applications (2 SWS, WiSe 2025) Praktikum: Labwork Polymers - Aplications 2 (1 SWS, SoSe 2025)	1,5 ECTS 3 ECTS 1 ECTS
3	Lecturers	Prof. Dr. Dirk Schubert	

4	**Module coordinator**	Dr.-Ing. Joachim Kaschta Prof. Dr. Dirk Schubert
5	**Contents**	• Wissensvermittlung zu Grundlagen, Technologie, Charakterisierung und Anwendungen von Polymeren in der Medizintechnik, • Einfluss des chemischen Aufbaus auf die relevanten Eigenschaften in der medizinischen Anwendung • Wissensvermittlung zu dem Einfluss der Morphologie auf die relevanten Eigenschaften in der medizinischen Anwendung Prozesse basierend auf qualifizierter Beobachtung und statistischer Analyse • Strategien zur Analyse und Verbesserung beliebiger Prozesse • Anwendung des Wissens in dem Praktikum • interaktive Gruppenübung zu aktuellen Fragestellungen und Anwendungen von Polymerwerkstoffen **English** • Knowledge transfer on fundamentals, technology, characterization and applications of polymers in medical technology, • Influence of the chemical structure on the relevant properties in medical application • Knowledge transfer on the influence of morphology on the relevant properties in medical application Processes based on qualified observation and statistical analysis • Strategies for analysis and improvement of any process • application of the knowledge in the practical course • interactive group exercise on current issues and applications of polymer materials
6	**Learning objectives and skills**	Die Studierenden • kennen wesentliche Anwendungen und Entwicklungsfelder aus den genannten Themenfelder • identifizieren Stärken und Schwächen verschiedener Verfahrensweisen und Werkstofflösungen • beschreiben wesentliche Struktur-Eigenschaftsbeziehungen • analysieren und bewerten Messdaten aus Experimentem • stufen die eigenen Ergebnisse ein. • haben ein Verständnis für industrierelevante Arbeitsmethodiken gewonnen

		English The students • know essential applications and development fields from the mentioned topics • identify strengths and weaknesses of different processes and material solutions • describe essential structure-property relationships • analyze and evaluate measurement data from experiments • classify their own results • have gained an understanding of industry-relevant working methodologies
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Polymer Materials Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46243	**Rheologie** Rheology	**5 ECTS**
2	Courses / lectures	Übung: Excerises Rheology (0 SWS, WiSe 2025) Vorlesung: Rheology - Fundamentals and Measurement Technology (2 SWS, WiSe 2025) Praktikum: Labwork Rheolology (1 SWS, SoSe 2025)	1,5 ECTS 3 ECTS 1 ECTS
3	Lecturers		

4	**Module coordinator**	Dr.-Ing. Joachim Kaschta
5	**Contents**	Rheologische Messgrößen und ihre anwendungstechnische Bedeutung • Grundlagen, Technologie, Messtechnik zur Ermittlung rheologischer Stoffeigenschaften • Verhalten in Scherung Dehnung • Beschreibungsgleichungen • Temperaturabhängigkeit der rheologischen Eigenschaften **English** Rheological measurands and their significance for application • Basics, technology, measuring technique for the determination • rheological material properties • Behavior in shear strain • Equations of description • Temperature dependence of rheological properties
6	**Learning objectives and skills**	Die Studierenden • erhalten einen tiefgehenden Einblick in die Thematik der Rheologie • erwerben ein wichtiges Grundlagenverständnis (Struktur-Eigenschaftsbeziehungen auf allen Größenskalen) • kennen wesentliche Anwendungen und Entwicklungsfelder • identifizieren Stärken und Schwächen verschiedener Verfahrensweisen und Werkstofflösungen • analysieren und bewerten Messdaten von rheologischen Messungen • stufen die eigenen Ergebnisse ein. • haben ein Verständnis für industrierelevante Arbeitsmethodiken gewonnen • kennen wesentliche Anwendungen und Entwicklungsfelder **English** The students • gain an in-depth insight into the subject of rheology • acquire an important basic understanding (structure-property relationships on all size scales)

		• know essential applications and fields of development • identify strengths and weaknesses of different methods and material solutions • analyze and evaluate measurement data from rheological measurements • classify their own results • have gained an understanding of industry-relevant working methodologies • know essential applications and development fields
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Polymer Materials Master of Science Nanotechnology 20232
10	**Method of examination**	Variable mündliche Prüfung (15 Min.) oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 95067	**Machine Learning for Engineers I - Introduction to Methods and Tools** Machine learning for engineers I - Introduction to methods and tools	**5 ECTS**
2	Courses / lectures	Vorlesung: Machine Learning for Engineers I: Introduction to Methods and Tools (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Björn Eskofier Thomas Altstidl Prof. Dr. Nico Hanenkamp Prof. Dr.-Ing. Jörg Franke	

4	**Module coordinator**	Prof. Dr. Björn Eskofier
5	**Contents**	This is an introductary course presenting fundamental algorithms of machine learning (ML) that are typically applied to data science problems. Knowledge is deepened by two practical exercises to gain hands-on experience. The course covers • Introduction to Python programming in the field of data science • Review of typical task domains (such as regression, classification and dimensionality reduction) • Theoretical understanding of widely used machine learning methods (such as linear and logistic regression, support vector machines (SVM), principal component analysis (PCA) and deep neural networks (DNN)) • Practical application of these machine learning methods on engineering problems
6	**Learning objectives and skills**	After successfully participating in this course, students should be able to • independently recognize the task domain at hand for new applications • select a suitable and promising machine learning methodology based on their known theoretical properties • apply the chosen methodology to the given problem using Python
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 4
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination Electronic exam (online), 90min
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 0 h Independent study: 150 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english

16	**Bibliography**	1) Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press, 2012 2) The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Trevor Hastie, Robert Tibshirani, and Jerome Friedman, Springer, 2009 3) Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016

1	**Module name** 92327	**Algorithms, Programming, and Data Representation** Algorithms, programming, and data representation	**10 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Bernhard Kainz
5	**Contents**	This module provides an introduction to computer science and programming, covering fundamental concepts and techniques. Students will develop a solid foundation in computer programming using the Python programming language. The module aims to foster independent learning and effective collaborative programming through practical work and problem-solving activities. Week 1: Motivation and Logistics, Introduction to Computers - This session sets the stage by discussing the motivation behind studying computer science and covers the logistics of the module. Week 2: Data Representation, Boolean Algebra, and Python Basics - Topics include data representation in computers, Boolean algebra, and an introduction to Python programming language. Students will learn about organization and basic operations in Python. Week 3: Memory Organization, Branching, and Control Statements - This week focuses on memory organization, branching, and control statements. Students will explore different number representations and continue learning about Boolean algebra. They will also delve into control statements, specifically if-else statements. Week 4: Decomposition, Functions, and Control Statements (Loops) - Students will learn about decomposition, abstraction, and functions. The session will cover topics such as tuples, lists, recursion, and dictionaries. Additionally, control statements related to loops will be discussed, and students will submit their solutions for mathematical operation questions. Week 5: Testing, Debugging, Exceptions, and Object-Oriented Programming - This week emphasizes the importance of testing, debugging, and handling exceptions. Students will gain an understanding of object-oriented programming concepts and how to implement them in Python. They will also explore advanced Python data types and submit their solutions for control statements (if-else) questions. Week 6: Classes, Inheritance, Program Efficiency, and Debugging - The session focuses on classes, inheritance, and program efficiency. Students will deepen their knowledge of recursion and learn about

		debugging techniques, including the use of try-except statements. They will submit solutions for debugging and try-except statements questions. Week 7: Program Efficiency, Searching, and Sorting - Topics covered include program efficiency optimization, searching algorithms, and sorting algorithms. Students will continue their exploration of object-oriented programming and submit their solutions for recursion questions. Week 8: Version Management with Git and Object-Oriented Programming - This week introduces version management using Git and emphasizes its importance in collaborative programming projects. Students will further enhance their understanding of object-oriented programming and submit their solutions for advanced Python data types questions. Week 9: Trees and Searching - The focus of this week is on trees, their representation, and searching algorithms. Students will also submit their solutions for searching and sorting questions. Week 10: Graphs, Dijkstra's Algorithm, and Graph Algorithms - Students will learn about graphs, graph algorithms, and specifically Dijkstra's algorithm for finding the shortest path in a graph. They will submit their solutions for Dijkstra's algorithm questions. Week 11: Hashtables - This session introduces hashtables as a data structure for efficient searching and retrieval. Students will gain practical knowledge of implementing hashtables. Week 12: Revision and Q&A - This week is dedicated to revising the covered topics and addressing any questions or concerns students may have. Learning Goals and Competencies: - Independent organization and coordination of own work - Problem-solving and solution development in theoretical and programming tasks - Quality assurance of submitted solutions - Responsibility and evaluation of own work By the end of this module, students will have a solid foundation in computer science, programming principles, and collaborative programming skills necessary for further studies and practical application of computer science concepts.
6	**Learning objectives and skills**	1. Understanding Computer Science and Programming Basics: - Acquire fundamental knowledge about computer science and programming.

- Understand the motivation and logistics behind studying computer science.
- Gain a preliminary understanding of computers and their components.

2. Proficiency in Python Programming Language:
- Learn basic operations and organization in Python.
- Comprehend and implement different data types in Python such as tuples, lists, dictionaries, etc.
- Develop proficiency in control statements, branching, loops, and functions.
- Understand and apply principles of object-oriented programming, classes, and inheritance in Python.
- Learn about error handling and debugging in Python.

3. Learning about Memory Organization:
- Understand how data is represented in computers.
- Learn about memory organization, Boolean algebra, and different number representations.

4. Developing Problem-Solving Skills:
- Solve mathematical problems using programming concepts.
- Apply programming concepts to solve practical problems.
- Learn how to search, sort, and apply algorithms to solve complex problems.
- Implement searching algorithms in different data structures like trees, graphs, and hashtables.

5. Understanding and Implementing Version Control using Git:
- Understand the importance of version management in collaborative programming projects.
- Learn how to use Git for version management.

6. Mastering Debugging Techniques and Exception Handling:
- Understand the importance of testing and debugging.
- Learn about different debugging techniques and how to handle exceptions using try-except statements in Python.

7. Developing Independent Learning and Collaborative Programming Skills:
- Cultivate the ability to organize and coordinate personal work independently.
- Enhance problem-solving skills and solution development in theoretical and programming tasks.
- Learn to assure the quality of submitted solutions and evaluate personal work.
- Understand how to work in a collaborative programming environment.

		8. Familiarity with Different Data Structures and Algorithms: - Learn about data structures like trees, graphs, and hashtables. - Understand different searching algorithms and sorting algorithms. - Learn about Dijkstra's algorithm for finding the shortest path in a graph. 9. Understanding Program Efficiency: - Gain knowledge about program efficiency and its optimization. - Learn about the application of recursion in improving program efficiency.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination (120 minutes) Graded examination achievement (Prüfungsleistung): Written examination (120 min) Ungraded course achievement (Studienleistung): weekly submission of exercises; at least 50% of total points required to pass
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Guttag JV. Introduction to computation and programming using Python. Mit Press; 2013 Aug 9.

1	**Module name** 95345	**Automotive Engineering II** Automotive engineering II	**2,5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Automotive Engineering 2	2,5 ECTS
3	Lecturers	Dr.-Ing. Stefan Götz Jan Kopatsch Prof. Dr.-Ing. Sandro Wartzack Dr. Stefan Dengler	

4	**Module coordinator**	Prof. Dr.-Ing. Sandro Wartzack
5	**Contents**	Die Vorlesung ist an alle ingenieurwissenschaftliche Studiengänge und Studierenden mit Interesse an einer Tätigkeit in der Automobilindustrie oder deren Umfeld gerichtet. Es werden die Themen der Produktentstehung bis zur Fertigung und Vertrieb beleuchtet. Dabei wird der Aspekt des interdisziplinären Agierens aus unterschiedlichen Blickwinkeln dargestellt. Zum einen werden Einblicke in die technische, konstruktive Umsetzung von wesentlichen Elementen eines Automobils gestreift, zum anderen sollen aber auch strategische und betriebswirtschaftlich bestimmende Größen vermittelt und deren Bedeutung für den Ingenieur vertieft werden. Ziel ist es ein Gesamtverständnis für den Komplex der Automobilindustrie zu vermitteln. Das Automobil ist zunehmend eines der komplexesten Industriegüter. Es ist geprägt durch gesellschaftliche Anforderungen, gesetzliche Restriktionen und unterschiedlichste Markt- und Kundenwünschen weltweit. Lernen Sie die Herausforderungen für die Ingenieurwissenschaften in der Automobilindustrie kennen, die Zusammenhänge verstehen und die Lösungen zu erarbeiten. Folgende thematischen Schwerpunkte werden in der Vorlesung behandelt: • Überblick über die Abläufe und Rahmenbedingungen für die Entwicklung in der Automobilindustrie. • Die Produktentstehung • Der Produktionsprozess in der Automobilindustrie • Integrierte Absicherung • Handelsorganisation: Markteinführung, Marketingkonzepte, Service und Aftermarket Strategien • Elektrifizierung, Hybrid, alternative Antriebe • Elektronik im Fahrzeug: Fahrerassistenz, Navigation, Kommunikation • Neue Technologien für die Herstellung von Karosserien • Passive und aktive Sicherheit. Trend und Markttendenzen, technische Lösungen • Entwicklung der Fahrdynamik • IT-Systeme in der Automobilindustrie • Spitzenleistungen als faszinierende Herausforderungen (Designstudien, Experimentalfahrzeuge, Rennsport) • Qualitätsmanagement

6	**Learning objectives and skills**	Nach besuch der Vorlesung sind die Studierenden in der Lage: • Einen Überblick über die Produktentstehung bin hin zur Serienentwicklung zu geben • Die Produktionsprozesse im Automobilbau zu verstehen • Supportprozesse wie die integrierte Absicherung zu verstehen • Die Vor- und Nachteile der unterschiedlichen Antriebstechnologien zu nennen • Einen Überblick von Elektrik und Elektronik im Fahrzeug zu haben • Einflüsse auf die Fahrzeugdynamik zu verstehen
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 5
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 45 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46532	**Surface and Interface Science** Surface and interface science	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Surfaces and Interface Science (3 SWS)	-
3	Lecturers	Prof. Dr.-Ing. Marcus Bär	

4	**Module coordinator**	Prof. Dr. Jörg Libuda
5	**Contents**	• Vacuum and pressure measurement (pumps, pressure and flow ranges) • Lab-based and synchrotron-based light sources (principles, optics, insertion devices, etc.) • Theory of photoemission and electronic structure • XPS (elemental / chemical sensitivity, cross sections, quantification, examples) • UPS (gas phase, adsorbates, 2D band structures, 3D band structures, orbital tomography) • IPES (probing of unoccupied states, energy level alignment determination) • HAXPES (depth-resolved photoemission measurements, examples) • PEEM (spatially-resolved photoemission measurements, examples) • NEXAFS (principle and examples) • XES & RIXS (principle and examples) • Structure of surfaces/ diffraction at surfaces (LEED, definitions and examples) • X-ray spectroscopy based materials research on energy conversion devices (examples from current research)
6	**Learning objectives and skills**	Students ... • understand the principles of photoemission variants and their applications • can judge the quality of data evaluation and its pitfalls • can deliberately select an X-ray spectroscopic analysis method to address given scientific question and are able to evaluate the collected data
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1;2;3
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 • Lecture module within the Compulsory elective module "Advances in Interfaces and Catalysis" in M.Sc. Chemistry or M. Sc. Molecular Science (20 ECTS in total) • Lecture module as part of the Elective Module in M.Sc. Chemistry or M. Sc. Molecular Science (5 ECTS, not graded)
10	**Method of examination**	Oral (20 minutes)
11	**Grading procedure**	Oral (100%)

		As part of the elective module: 0% - pass/fail
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 45 h Independent study: 105 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Hüfner: Photoelectron Spectroscopy: Principles and Applications" Springer-Verlag Berlin Heidelberg • Ertl, Küppers: Low Energy Electrons and Surface Chemistry" VCH Weinheim • D. Attwood, Soft X-rays and Extreme Ultraviolett Radiation, Cambridge University Press, 1999 • D. Briggs, M.P. Seah: PracticalSurface Analysis: AugerandX-Ray PhotoelectronSpectroscopy, Wiley, 1996 • M. Bär, L. Weinhardt, and C. Heske: Advanced Characterization Techniques for Thin Film Solar Cells, edited by D. Abou-Ras, T. Kirchartz, and U. Rau (Wiley VCH Verlag GmbH & Co KGaA, ISBN: 978-3-527-33992-1), 2nd Extended Edition, Volume 2, Chap. 18. • A. Meisel, G. Leonhardt, R. Szargan: X-ray Spectra and Chemical Binding, Springer, 1989

1	**Module name** 46267	**Scientific Writing**	**5 ECTS**
2	Courses / lectures	No courses / lectures available for this module!	
3	Lecturers	No lecturers available since there are no courses / lectures for this module!	

4	**Module coordinator**	Steffen Neumeier
5	**Contents**	no content description available!
6	**Learning objectives and skills**	no learning objectives and skills description available!
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Seminar achievement
11	**Grading procedure**	Seminar achievement (100%)
12	**Module frequency**	no Module frequency information available!
13	**Workload in clock hours**	Contact hours: ?? h (keine Angaben zum Arbeitsaufwand in Präsenzzeit hinterlegt) Independent study: ?? h (keine Angaben zum Arbeitsaufwand im Eigenstudium hinterlegt)
14	**Module duration**	?? semester (no information for Module duration available)
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46308	**Iron and Steel**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Iron and steel II (2 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Prof. Dr. Peter Felfer	

4	**Module coordinator**	Prof. Dr. Peter Felfer
5	**Contents**	Eisen- und Stahlwerkstoffe I+II , V+Ü, 2+3 SWS, 2+3 ECTS • Grundlagen der Stahlherstellung • Grundlagen der Wärmebehandlungen • Eigenschaften und Anwendung der verschiedenen Stahlklassen • Schweißmetallurgie • Eigenschaften und Anwendungen von Eisengusswerkstoffen Content: Iron and steel materials I+II , V+Ü, 2+3 SWS, 2+3 ECTS • Basics of steel production • Basics of heat treatments • Properties and application of the different steel classes • Welding metallurgy • Properties and applications of iron casting materials
6	**Learning objectives and skills**	*Fachkompetenz Evaluieren (Beurteilen)* Die Studierenden • vertiefen ihr Wissen über die vielfältigen strukturellen Aufbauten der Werkstoffe Eisen und Stahl und können diese beurteilen • vertiefen das Verständnis über die Zusammenhänge zwischen der chemischen Zusammensetzung, der Struktur und den Eigenschaften von Werkstoffen • können Legierungsthermodynamik anwenden und Zustandsdiagrammen analysieren • vertiefen das Wissens zu den mechanischen Eigenschaften und Härtungsmechanismen bei Stählen • können Struktur-Eigenschaftskorrelationen erschließen und überprüfen bei Stählen • beurteilen eigenständig Struktur-Eigenschaftsbeziehungen an Beispielen • vertiefen ihr Verständnis der Zusammenhänge zwischen Aufbau, thermomechanischer Vorgeschichte und Eigenschaften der Werkstoffe und können diese erklären *Lern- bzw. Methodenkompetenz* Neue Methodenkompetenzen, die erworben werden können: • o deepen their knowledge of the diverse structural compositions of iron and steel materials and are able to evaluate them

		◦ deepen their understanding of the relationships between the chemical composition, structure and properties of materials ◦ can apply alloy thermodynamics and analyze state diagrams ◦ deepen knowledge of mechanical properties and hardening mechanisms of steels ◦ can develop and check structure-property correlations for steels ◦ independently assess structure-property relationships using examples ◦ deepen their understanding of the relationships between structure, thermomechanical history and properties of materials and are able to explain these relationships. ◦ Basic experimental techniques
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 General Materials Properties Master of Science Nanotechnology 20232
10	**Method of examination**	Variable mündliche Prüfung (15 Min.) oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 42923	**Photovoltaic systems - Fundamentals**	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Christoph Brabec
5	**Contents**	The lecture will introduce to the fundamentals of photovoltaic energy conversion. The conversion of light into electricity is one of the most efficient power technologies of today and is expected to transform our energy system towards a renewable scenario. The limits of photovoltaic energy conversion, the materials and architectures of major PV technologies and advanced characterization methods for modules as well as solar fields will be introduced theoretically and experimentally during the lecture and exercices.
6	**Learning objectives and skills**	• The students will learn the concept of black body radiation and the radiation laws and the limits of light energy conversion. The fundamental semiconductor junctions (p-n, M-i-M, Shottky and Hetero Junction are repeated. The one diode and two diodes replacement circuits are explained . Electrical, optical, recombination and extraction loss mechanisms are discussed separately and demonstrated at the hand of numerical drift-diffusion equation solvers. The most important solar cell concepts (Si, CIGS, CdTe, GaAs, Perovksites, Organics) are introduced, and the strengths and weaknesses of each technology are analysed. • Characterization of Photovoltaic Modules will trained by flashed measurements in the lab. Defect imaging methods like DLIT, EL or PL imaging will be trained at the hand of module installations in Erlangen.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1;2;3;4
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Variable Prüfungsform: Klausur (45 Minuten), benotet Written exam (45 minutes, graded)
11	**Grading procedure**	Variable (100%) The exam counts 100%
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	• Will be provided via StudOn

1	**Module name** 94476	**Technology of Tissue Engineering (TechTE)**	**7,5 ECTS**
2	Courses / lectures	Praktikum: Praktikum zu Technology of Tissue Engineering (3 SWS) Vorlesung: Technology of Tissue Engineering (3 SWS)	- 5 ECTS
3	Lecturers	Dr.-Ing. Michael Haug Christian Lesko Julian Bauer Oliver Friedrich Prof. Dr.-Ing. Aldo Boccaccini Dr. Julia Will	

4	**Module coordinator**	PD Dr. habil. Martin Vielreicher
5	**Contents**	• Biomaterials for scaffolds • Biodegradable polymers, composites and bioactive ceramics/ glasses • Technologies for the processing of tissue scaffolds • 3D Bioprinting and electrospinning methods • High-resolution deep scaffold imaging: 2-photon imaging, Second Harmonic Generation imaging, light sheet imaging, examples from TE using biomaterials • Top-down TE, decellularization/recellularizartion common con-cepts, challenges, different protocols and chemical processing, opti-cal clearing of bio-scaffolds for 2-photon imaging • Selected decell-/recell systems: lung, heart, kidney and required bio-reactor technologies • Challenges in skeletal muscle TE and MyoBio bioreactor technology (related to prac class) *Prac class:* • Decellularization of a whole skeletal muscle organ in a custom-engineered bioreactor system with optical and environmental contin-uous monitoring (MyoBio)
6	**Learning objectives and skills**	Students • understand the importance of different concepts in tissue engineering (TE) • know the materials most commonly used in biomaterials, as well as their production and characterization • are familiar with the processing and use of different types of materials such as metals, ceramics and polymers as scaffold structures in TE • conceive the relevance of biomaterials in Tissue Engineering and Regenerative Medicine • are competent to distinguish between the advantages of named biomaterials over others in tissue reconstruction according to the physico-chemical requirements and the cellular seeding prerequisites

		• apply the different approaches of bottom-up and top-down TE according to respective research questions and applications in Medicine and Industry • are able to choose appropriate optical readout and sensor technologies to monitor the maturation and remodelling of scaffolds by seeded/printed cells • are able to conceptualise bioreactors for tissue maturation according to the target tissue biophysical, physico-chemical and physiological needs • are able to critically evaluate scientific publications on the lecture topics in the accompanying exercise classes ("Übung) and present study contents and analyses in an oral presentation to the class
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Practical achievement Variable (45 minutes)
11	**Grading procedure**	Practical achievement (33%) Variable (67%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 165 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Boccaccini, et al. (eds.): Tissue engineering using ceramics and polymers; Elsevier Woodhead, Cambridge, 2014 • Polak, Mantalaris, Harding (eds.): Advances in Tissue Engineering; Oxford u.a., 2010 • Hench, Jones (eds.): Biomaterials, artificial organs and tissue engineering; Oxford, 2005 • Reviews on organ decell-/recell, e.g. Scarritt et al. (2015) A review of cellulariza-tion strategies for tissue engineering of whole organs. Front Bioeng Biotechnol 3:43

1	**Module name** 65785	**Mathematics of Learning** Mathematics of learning	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Frauke Liers-Bergmann
5	**Contents**	• Machine learning: empirical risk minimization, kernel methods and variational models • Mathematical aspects of deep learning • Ranking problems • Mathematical models of network interaction
6	**Learning objectives and skills**	Students • develop understanding of modern big data and state of the art methods to analyze them, • apply state of the art algorithms to large data sets, • derive models for network / graph structured data.
7	**Prerequisites**	Prerequisites: Basic knowledge in numerical methods and optimization is recommended.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination (60 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• Goodfellow, Bengio, Courville, Deep Learning, MIT Press, 2015 • Hastie, Tibshirani, Friedman, The Elements of Statistical Learning, 2008

Glass and Ceramics

1	**Module name** 46221	**Keramische Werkstoffe: Grundlagen und Technologien** Ceramic materials: Foundations and technologies	**10 ECTS**
2	Courses / lectures	Vorlesung: Sintering and advanced densification methods (0 SWS, SoSe 2025) Vorlesung mit Übung: Physical and chemical properties of glass and ceramics II: Non-equilibrium systems (2 SWS, SoSe 2025)	3 ECTS 3 ECTS
3	Lecturers	Prof. Dr. Kyle Grant Webber Prof. Dr. Dominique de Ligny Dr. Maria Rita Cicconi	

4	**Module coordinator**	Tobias Fey Prof. Dr. Dominique Ligny Prof. Dr. Kyle Grant Webber
5	**Contents**	|Physikalisch-chemische Grundlagen von Glas und Keramik I: Equilibrium systems | • Atomic bonds • Common crystal structures • Volume, thermal expansion and compressibility • Heat capacity and entropy • Solutions • Phase diagrams • Homogeneous systems • Heterogeneous systems • Phase transition |Mechanokeramik| • Keramik als Konstruktionswerkstoff • Festigkeit (bruchmechanische Grundlagen, Berechnungskonzeptionen) • Konstruieren (Grundlagen, keramische Bauteile, lösbare Verbindungen) • Bearbeiten (abrasive und nichtabrasive Verfahren) • Verbindungstechnik (form-, kraft- und stoffschlüssige Verbindungen) • Bauteilprüfung (proof test, zerstörungsfreie Prüfverfahren) • Werkstoffe und Anwendungen • Oxidkeramiken (Al2O3, ZrO2, Al2TiO5, Al6Si2O13, Mg2Al4Si5O18) • Nichtoxidkeramiken (C, B4C, SiC, Si3N4, AlN) • Faserverbundkeramik |Physikalisch-chemische Grundlagen von Glas und Keramik II: Non-equilibrium systems| • Time related properties: • Thermal conductivity, Thermal shock and thermal fatigue, Viscosity, Relaxation, Superplasticity • Glass transition and their characteristic properties • Chemical behavior at high temperatures:

- Oxidation, corrosion, devitrification
- Design of glass ceramics:
- Theory of nucleation and growth, Morhology, Applications

|Sintering and advanced densification methods|

- Hochtemperaturprozesse bei polykristallinischer Keramiken (Grundlagen des Sinterns, Diffusionsmechanismen, Defekte)
- Mikrostrukturkontrolle (Sinterparameter, Zusammensetzungseffekte)
- Einfluss der Gefüge auf die physikalischen Eigenschaften

English

|Physico-chemical fundamentals of glass and ceramics I: Equilibrium systems |

- Atomic bonds
- Common crystal structures
- Volume, thermal expansion and compressibility
- Heat capacity and entropy
- Solutions
- Phase diagrams
- Homogeneous systems
- Heterogeneous systems
- Phase transition

|Mechanoceramics|

- Ceramics as a structural material
- Strength (fracture mechanics basics, calculation concepts)
- Design (basics, ceramic components, detachable connections)
- Machining (abrasive and non-abrasive processes)
- Joining technology (form-fit, force-fit and material-fit joints)
- Component testing (proof test, non-destructive testing methods)
- Materials and applications
- Oxide ceramics (Al2O3, ZrO2, Al2TiO5, Al6Si2O13, Mg2Al4Si5O18)
- Non-oxide ceramics (C, B4C, SiC, Si3N4, AlN)
- Fiber composite ceramics

|Physico-chemical fundamentals of glass and ceramics II: Non-equilibrium systems|

- Time related properties:
- Thermal conductivity, Thermal shock and thermal fatigue, Viscosity, Relaxation, Superplasticity
- Glass transition and their characteristic properties
- Chemical behavior at high temperatures:
- Oxidation, corrosion, devitrification
- Design of glass ceramics:
- Theory of nucleation and growth, Morphology, Applications

|Sintering and advanced densification methods|

- High temperature processes in polycrystalline ceramics (basics of sintering, diffusion mechanisms, defects)
- Microstructure control (sintering parameters, composition effects)

		• Influence of microstructure on physical properties
6	**Learning objectives and skills**	Die Studierenden • erlernen des strukturellen Aufbaus von Gläsern und Keramiken und der damit verbundenen Grundeigenschaften sowie der Einteilung nichtmetallisch-anorganischer Werkstoffklassen • vertiefen die wissenschaftlichen und praktischen Kenntnisse auf dem Gebiet der mechanischen Eigenschaften von Gläsern und Keramiken für Tätigkeiten im institutionellen und industriellen Umfeld. • verstehen die Thermodynamik und die Zustandsdiagramme dieser Werkstoffklassen • können die Eigenschaften nichtmetallisch-anorganischer Werkstoffe im Zusammenhang mit der chemischen Zusammensetzung, Aufbereitung, Struktur und Gefüge bewerten • können selbständig über Werkstoffauswahl vor dem Hintergrund von Anwendungsprofilen entscheiden *English* The students • learn the structural composition of glasses and ceramics and the basic properties associated with them, as well as the classification of non-metallic-inorganic material classes • deepen the scientific and practical knowledge in the field of mechanical properties of glasses and ceramics for activities in institutional and industrial environments. • understand the thermodynamics and the state diagrams of these classes of materials • can evaluate the properties of non-metallic inorganic materials in relation to chemical composition, preparation, structure and microstructure • can independently decide on material selection against the background of application profiles
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit mündliche Prüfung (30 Min.) currently taking an oral exam (30 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 90 h Independent study: 210 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english

16	**Bibliography**	

1	**Module name** 46222	**Keramische Werkstoffe: Prozessierung und Eigenschaften** Ceramic materials: Processing and properties	**5 ECTS**
2	Courses / lectures	Übung: Processing of Ceramics only for WS 24/25 students that got no place (1 SWS, SoSe 2025) Vorlesung mit Übung: Functional and Optical Properties of Glass and Ceramics (2 SWS, SoSe 2025)	3 ECTS 3 ECTS
3	Lecturers	Tobias Fey Dr. Maria Rita Cicconi	

4	**Module coordinator**	Tobias Fey Prof. Dr. Dominique Ligny
5	**Contents**	|Processing of Ceramics| • o Halbleiter und Leiter (Defektstrukturen, Dotierung) o Anwendungsbeispiele o advanced experiments on the production and characterization of ceramics |Functional and Optical Properties of Glass and Ceramics | Semiconductors and conductors (defect structures, doping) application examples
6	**Learning objectives and skills**	Die Studierenden • o haben ein vertieftes Verständnis folgender Eigenschaften von Glas und Keramik: optische, elektrische, thermische und mechanische Eigenschaften o erlernen die Prozesse zur Herstellung von Gläsern und Keramiken sowie die Methoden zur Bestimmung wichtiger Eigenschaften, Erklärung der Zusammenhänge zwischen Zusammensetzung, Gefüge, Eigenschaften o deepen the practical knowledge in the field of production of ceramic materials have a deeper understanding of the following properties of glass and ceramics: optical, electrical, thermal and mechanical properties learn the processes for the production of glasses and ceramics as well as the methods for determining important properties, explain the relationships between composition, microstructure, properties
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 45 h

		Independent study: 105 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46223	**Funktionskeramiken I** Functional ceramics I	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey Prof. Dr. Kyle Grant Webber
5	**Contents**	|Funktionskeramik | Dieser Kurs bietet eine Einführung in die Funktionskeramik, einschließlich Abschnitten über dielektrische, piezoelektrische, ferroelektrische und ferroelastische Eigenschaften der Elektrokeramik. Die Konzepte werden mit makroskopischen Materialeigenschaften dargestellt und in Verbindung mit den mikrostrukturellen Ursprüngen diskutiert. |Übung für Funktionskeramik I: Elektrische Eigenschaften | In diesem Laborkurs werden die Teilnehmer in die Messung dielektrischer Eigenschaften mit einem LCR-Meter und einem Impedanzspektrometer eingeführt. Es wird ein Equivalent-Circuit aufgebaut, um die Fähigkeit der Impedanzspektroskopie zu demonstrieren, verschiedene zeitabhängige Prozesse z.B. am Kristallgitter und an der Korngrenze zu trennen. *English* |Functional Ceramics I | This course provides an introduction to functional ceramics, including sections on dielectric, piezoelectric, ferroelectric, and ferroelastic properties of electroceramics. Concepts are presented with macroscopic material properties and discussed in conjunction with microstructural origins. |Exercise for Functional Ceramics I: Electrical Properties | In this laboratory course, students will be introduced to the measurement of dielectric properties using an LCR meter and an impedance spectrometer. An equivalent circuit will be set up to demonstrate the ability of impedance spectroscopy to separate different time-dependent processes, e.g., at the crystal lattice and at the grain boundary.
6	**Learning objectives and skills**	Die Studierenden • kennen den Aufbau, die Herstellung, die Eigenschaften von Funktionskeramiken • können diese carakterisieren • kennen deren Anwendung für Tätigkeiten im institutionellen und industriellen Umfeld mit diesem Werkstoffschwerpunkt . • haben ein vertieftes Verständnis folgender Eigenschaften von Keramik: elektrische und mechanische Eigenschaften • haben vertiefte Kenntnisse in den Prozessen zur Herstellung von Keramiken sowie der Methoden zur Bestimmung wichtiger

		Eigenschaften, Erklärung der Zusammenhänge zwischen Zusammensetzung, Gefüge, Eigenschaften *English* The students • know the structure, the production, the properties of functional ceramics • can characterize them • know their application for activities in the institutional and industrial environment with this material focus . • have an in-depth understanding of the following properties of ceramics: electrical and mechanical properties
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46224	**Funktionskeramiken II** Functional ceramics II	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey Prof. Dr. Kyle Grant Webber
5	**Contents**	**Structural analysis of functional ceramics using advanced diffraction techniques** This course will cover basic crystallography, advanced diffraction techniques (e.g., x-ray, neutron and electron) including instrumentation, strategies to collect diffraction data (ex situ and in situ) and different data analysis methods. The course has been designed in such a way that, in addition to the development of theoretical background, students can have hands-on experience with different data analysis methods and software. At the initial stage we will cover basics of crystallography and principle of diffraction technique. An in-depth discussion on different (e.g., x-ray, 2D x-ray, neutron and electron) diffraction techniques and their use in the field of materials science and engineering will then be presented. In the next step we will discuss ferroelectric/ferroelastic materials and how diffraction technique can be used to investigate microscopic origin of macroscopic functional properties. **Exercises for functional ceramics II: Structural Analysis** Students will learn how to extract various structural parameters using different data analysis (e.g. Selected peak-fitting, Le Bail fitting and Rietveld structural refinement) techniques and how these structural parameters can be correlated with different macroscopic properties. A brief overview of the recent developments and future scopes in the field of structural analysis (e.g., 3D- XRD, diffuse scattering) using diffraction technique will be highlighted to conclude the course
6	**Learning objectives and skills**	**The students** • know the necessary scientific and practical knowledge for the microstructural characterization of ceramics using diffraction methods. • have an in-depth understanding of the following properties of ceramics: electrical, thermal and mechanical properties • understand the influences of structure and microstructure on electromechanical properties • know and understand how diffraction techniques work and what basic models are available for analysis • can use the appropriate software.

7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Irregular
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46225	**Funktionskeramiken III** Functional ceramics III	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey Prof. Dr. Kyle Grant Webber
5	**Contents**	|Mechanical Properties and Fracture of Ceramics | • ◦ Das Laborpraktikum vermittelt praktische Erfahrungen in der makroskopischen mechanischen Charakterisierung von keramischen Werkstoffen, wobei speziell linear elastische und ferroelastische Werkstoffe untersucht werden. *English* |Mechanical Properties and Fracture of Ceramics | This course will introduce participants to the origins of the mechanical behavior of ceramic materials through discussions of atomic structure and microstructure. Here, participants will be introduced to linear elastic fracture mechanics and some concepts related to nonlinear fracture mechanics. Then, various toughness mechanisms will be presented and discussed, including phase transforamtion, ferroelasticity, and crack bridging. In the final section of the lecture, fractographic techniques for the analysis of fracture surfaces as well as subcritical crack growth will be presented. |Exercise for Functional Ceramics III: Mechanical Properties | This laboratory practical course provides hands-on experience in the macroscopic mechanical characterization of ceramic materials, specifically studying linear elastic and ferroelastic materials.
6	**Learning objectives and skills**	Die Studierenden • lernen die Ursprünge der mechanischen Eigenschaften von Keramiken kennen • verstehen, wie sich keramische Werkstoffe nichtlinear, hysteretisch oder plastisch verformen können und wie dies das Bruchverhalten beeinflussen kann • erlernen der Grundlagen der linear-elastischen Bruchmechanik, insbesondere der Hintergründe der Energiefreisetzungsrate und des Spannungsintensitätsfaktors • verstehen Bruchflächen zur Analyse der Bruchentstehung genutzt werden können • verstehen, woe Risse unterkritisch wachsen können und können diese charakterisieren *English* The students • learn the origins of the mechanical properties of ceramics

		• understand how ceramic materials can deform nonlinearly, hysteretically, or plastically and how this can affect fracture behavior • learn the fundamentals of linear elastic fracture mechanics, especially the background of the energy release rate and stress intensity factor • understand fracture surfaces can be used to analyze fracture initiation • understand where cracks can grow subcritically and be able to characterize them
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46226	**Porous and cellular Ceramics I** Porous and cellular ceramics I	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey
5	**Contents**	|Microstructural characterization | • Strukturelle Charakterisierung poröser und zellularer Keramiken durch den Einsatz gängiger Methoden wie He-Pyk, Hg-Porosimetrie, µCT, SEM, Permeabilität • Einsatz von Bildanalyse und Simulationen zur Strukturparameterberechnung wie Zellgröße, Stegbreite, Anisotropie, Interkonnektivität und Tortuosität • Strukturelle Besonderheiten poröser Werkstoffe |Thermal and mechanical characterisation | • Bestimmung thermischer / mechanischer Eigenschaften an porösen und zellularen Werkstoffen • Bestimmung des Einflusses der Porosität, Porenform und Porenform auf die physikalischen Eigenschaften *English* |Microstructural characterization| • Structural characterization of porous and cellular ceramics by using common methods such as He-Pyk, Hg-porosimetry, µCT, SEM, permeability • Use of image analysis and simulations to calculate structural parameters such as cell size, web width, anisotropy, interconnectivity and tortuosity • Structural features of porous materials |Thermal and mechanical characterization| • Determination of thermal / mechanical properties of porous and cellular materials • Determination of the influence of porosity, pore shape and pore form on physical properties
6	**Learning objectives and skills**	Die Studierenden • Erlernen die Auswahl von Charakterisierungsmethoden und deren Einsatz sowie Grenzen der Anwendbarkeit der Untersuchungsmethoden und Algorithmen • Entscheiden die Auswahl der Charakterisierungsmethodik vor dem Hintergrund der Einsatzgrenzen • Vermittlen der notwendigen wissenschaftlichen und praktischen Kenntnisse zur Charakterisierung von porösen und Keramiken für Tätigkeiten im institutionellen und industriellen Umfeld mit diesem Werkstoffschwerpunkt. • Vertiefen das Verständnis über die Mikrostruktur poröser und zellularer keramischer Werkstoffe und deren Auswirkung auf die physikalischen Eigenschaften

		English Students will • Learn the selection of characterization methods and their use as well as limits of applicability of the investigation methods and algorithms • Decide the choice of characterization methodology in the light of the limits of application • Provide the necessary scientific and practical knowledge to characterize porous and ceramics for activities in institutional and industrial settings with this material focus. • Deepen understanding of the microstructure of porous and cellular ceramic materials and its effect on physical properties.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232 mündliche Prüfung (15 Min.) oral exam (15 min.)
10	**Method of examination**	Oral
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46227	**Porous and cellular Ceramics II** Porous and cellular ceramics II	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Porous and cellular Ceramics for engineers (2 SWS) Vorlesung mit Übung: Porous and cellular applications (2 SWS)	3 ECTS -
3	Lecturers	Tobias Fey	

4	**Module coordinator**	Tobias Fey
5	**Contents**	**Porous and cellular Ceramics for engineers** • Architecture and structure of porous and cellular ceramics over different length scales • manufacturing processes of porous and cellular ceramics from conventional to additive processes • physical properties depending on the porosity, pore shape and pore type • areas of applications of porous and cellular structures in particular a) light weight constructions b) catalysis c) energy and d) scaffolds **Porous and cellular applications** • Practical production of ceramic porous scaffolds using different methods discussed in the lecture • Variation of the manufacturing parameters to modify the microstructure and pore shape and type for the respective application (open / closed cell) • Implementation of application-oriented studies
6	**Learning objectives and skills**	**The students** • learn the necessary scientific basics for the structure and composition as well as the production and application of porous and cellular ceramics • intensify your knowledge of the production of porous and cellular ceramic materials and their effect on structural and physical properties • learn how to select materials and processes against the background of application profiles using examples • deepen the scientific basics in application-oriented studies
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (15 Min.)

		oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46228	**Glas I** Glass I	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Dominique Ligny
5	**Contents**	|Optical properties of glasses| • Fundamental concepts: The electromagnetic spectrum and units, Absorption, Luminescence, Scattering • Optical transparency of solids: Optical magnitudes and the dielectric constant, The Lorentz Oscillator, Metals, Semiconductors and insulators, Excitons, Reflection and polarization • Optical glasses: Optical aberration and solutions, Dispersion properties and composition • Colors in glasses: The eye, Optically Active Centers, Transition metals in glasses, Metallic and Chalcogenide nanoparticles • Chromism: Thermochromism, Photochromism, Gasochromism, Electrochromism • IR glasses: Chalcogenide, Fluorite glasses • Optical Fibers: Principle, Manufacturing, Applications, Photonic fibers |Vibrational spectroscopies, from theory to practice | • Nature of vibrations inside matter • Interaction light matter • Instrumentation • Raman application • Infrared Spectroscopy • Advanced technics
6	**Learning objectives and skills**	|Spectroscopy techniques applied to amorphous materials | The students will • Understand the solid state physic background link to the optical properties of all type of materials • Be able to explain the different ways to create colors • Choose the appropriate glass compositions to realize optical device in the infrared region • Have an overview of the different technologies link to light management • Know the different parameters that define an Optical glass fiber and choose them in regard of the attended application |Vibrational spectroscopies, from theory to practice| The student will • Understand in a comprehensive way the solid state physic background link to these spectroscopies

		• Know the different parts of a spectrometer and their characteristic parameter • Exercise himself to set the parameters of an observation and run the measurements • Treat the data by applying the needed corrections • Evaluate the data using peak fitting, momentum calculations and Principal Component Analysis • Deduce information on the structure of common glasses
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46229	**Glas II** Glass II	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Glass formulation using project management (2 SWS) Vorlesung mit Übung: Glass and Ceramic for Energy-Technology (2 SWS)	- -
3	Lecturers		

4	**Module coordinator**	Prof. Dr. Dominique Ligny
5	**Contents**	Glass formulation using project management: Intensive exercise of 6 half days at the end of the semester. The teaching follows an "on time approach. After presentation of the case study, an introduction to the project management is given. Analytical tools are given to the students than can use them directly on the case study. The project is then defined through brainstorming followed by Solution analysis and quotation. The rules for scheduling, monitoring and controlling a project are introduced before the case study is started to be solved. An emphasis is given on reporting by quick presentation at the end of each half day by the project team. In conclusion a last time is taken to analyze the personal issues encounter during these six half days. That help the students to have a pragmatic thinking about what could have been a better project team and the need of a leader. Glass and Ceramic for Energy-technology: • Materials and energy • Solar Energy • Solar Thermal • Photovoltaic Energy • Insulation • Wind Energy • Nuclear waste glass storage • Energy in glass processing • Fuel Cell and Ion conductivity • Lighting LED and LASER REE technology
6	**Learning objectives and skills**	Glass formulation using project management The student will • Learn the different concept used in project management as well as its specific vocabulary • Practice the project management in a small team • Use the different tools of project management • Go from an application to the conception of a product Glass and Ceramic for Energy-technology The student will • Understand the global environmental issues related to the use of glasses for: • Nonrenewable energy sources • Renewable energy sources • Energy efficiency

		• Energy storage • Know the improvement needed in the future • Look for solution by linking the expected performance to the glass properties • Be able to choose the good glass composition, production and shaping processes
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46233	**Seminar modul** Seminar module	**5 ECTS**
2	Courses / lectures		
3	Lecturers	-	

4	**Module coordinator**	Tobias Fey Prof. Dr. Dominique Ligny Prof. Dr. Kyle Grant Webber PD Dr. Stephan Wolf
5	**Contents**	**Science Seminar with reports on scientific projects** • o Vortragende aus der Industrie berichten aktuelle wissenschaftliche Themen und Projekte Literature seminar Zusammenfassung eines wissenschaftlichen Papers in Form eines Vortrages und eines Posters Science Seminar with reports on scientific projects • Summary of a scientific project that comes from the current research environment • Industry report seminar • Lecturers from industry report on current scientific topics and projects Literature seminar Summary of a scientific paper in the form of a lecture and a poster
6	**Learning objectives and skills**	**Die Studierenden** • vertiefen Ihre Kenntnisse über Präsentationstechniken • erlernen die Recherche von Literatur durch den Einsatz von Datenbanken • verstehen den inhaltlichen Aufbau von wissenschaftlichen Vorträgen und Berichten und können dies umsetzten • erlernen die Erstellung von wissenschaftlichen Postern und Berichten **The students** • deepen your knowledge of presentation techniques • learn how to research literature using databases • understand the structure of the content of scientific lectures and reports and can implement this • learn how to create scientific posters and reports
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Glass and Ceramics Master of Science Nanotechnology 20232
10	**Method of examination**	Achievement credit Leistungsschein

		Performance certificate
11	**Grading procedure**	Achievement credit (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 105 h Independent study: 45 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Surface Science and Corrosion

1	**Module name** 46294	**Surface Science and Corrosion** Surface technology and electrochemistry	**10 ECTS**
2	Courses / lectures	Vorlesung: Surface Analysis I (2 SWS, WiSe 2025) Vorlesung: Advanced Corrosion Science (2 SWS, WiSe 2025) Vorlesung: Basics Electrochemistry II (2 SWS, SoSe 2025) Vorlesung: Basics Electrochemistry I (2 SWS, WiSe 2025) Seminar: Seminar Surface Science and Corrosion (2 SWS, SoSe 2025)	3 ECTS 3 ECTS 3 ECTS 3 ECTS 1 ECTS
3	Lecturers	Dr.-Ing. Michael Höhlinger Prof. Dr. Sannakaisa Virtanen Karthikeyan Hariharan Prof. Dr. Patrik Schmuki	

4	**Module coordinator**	Prof. Dr. Sannakaisa Virtanen
5	**Contents**	*Advanced Corrosion Science* Recap of fundamental background in electrochemistry and corrosion Introduction to advanced methods in corrosion science: Electrochemical methods (Polarization curve, EIS, EC noise) Local techniques (SVET, SKP, SIET, LEIS) Non electrochemical techniques: Respirometry, mass loss, solution analysis, resitance method Surface analysis (SEM, TEM, EDX, XPS, Auger, ToF SIMS, GDOES, atom probe analysis) Discussion of current issues in corrosion science: Biodegradable metals Passive films und localized corrosion Atmospheric corrosion Corrosion in nuclear waste repositories Corrosion of advanced materials: AM, BMG, high entropy alloys und ultrafine-grained materials Drinking water corrosion, microbially induced corrosion, cathodic protection Inhibitors und smart coatings Mg und Al corrosion Corrosion Modelling, DFT (Corrosion in) Electrochemical energy storage and conversion Corrosion failure case studies and analysis: Discussion of the conditions and mechanisms that led to corrosion failure based on observations and experimental evidence and derivation of a solution to the problem. *Surface Modification Techniques* Innerhalb der Materialwissenschaften kommt der Oberflächenmodifikation entscheidende Bedeutung zu.

Neben der Verbesserung der Korrosionsbeständigkeit sowie der tribologischen Eigenschaften können dadurch auch gänzlich neue Eigenschaften generiert werden. Im Zuge dieser Lehrveranstaltung werden diverse Methoden der Oberflächenmodifikation und Oberflächenfunktionalisierung beleuchtet. Es werden die Grundlagen aber auch Fallbeispiele derartiger Verfahren erläutert und deren Rolle im Alltäglichen Leben ebenso wie in industriellen Anwendungen Rechnung getragen. Neben den etablierten Methoden werden auch neuartige Ansätze aus den aktuellen Forschungsgebieten des Lehrstuhls erläutert.
The tailored modification of surfaces plays an important role in material science. Besides improving e.g. the corrosion- and tribological-properties of material-surfaces by specific methods and approaches, furthermore completely new properties can be achieved. In this course common methods of surface modification and surface functionalization are elucidated. The theoretical background and examples, indicating the relevance of these methods in everyday life as well as for industrial applications, are presented. In addition to the common methods new highly promising approaches are introduced and discussed.

Berechnung von Korrosionsproblemen
Die World Corrosion Organization (WCO) schätzte 2009 die wirtschaftlichen Schäden durch Korrosion auf weltweit 1,8 Billionen US-Dollar. In Industriestaaten belaufen sich die jährlichen Kosten durch Korrosion auf bis zu 4 Prozent des Bruttoinlandsproduktes, in Deutschland also auf bis zu 104 Milliarden Euro" [Deutsches Lackinstitut]. Die hier angeführten Zahlen zeigen, dass Korrosion ein wirtschaftlich sehr bedeutendes Problem darstellt, dem große Beachtung beigemessen werden muss. Das Lernziel der Vorlesung Berechnung von Korrosionsproblemen" ist es, mittels im Bachelorstudium erworbenen Kenntnissen, Fallbeispiele typischer Korrosionsprobleme fachlich tiefgehend verstehen und beurteilen zu können. Hierfür werden zum einen häufige grundlegende praxisnahe Probleme definiert und beschrieben.
Zum anderen werden durch Abstraktion komplexe Beispiele und Anwendungen auf bekannte Grundlagen heruntergebrochen, quantitativ beschrieben und somit fassbar gemacht.
Basics Electrochemistry
Der Elektrochemie kommt große Bedeutung sowohl im wissenschaftlichen als auch technologischen Kontext zu. Heutige Forschungsarbeiten konzentrieren sich hauptsächlich (aber nicht ausschließlich) auf die Themengebiete Nanotechnologie und Anwendungen der Energietechnik wie Brennstoffzellen, Batteriesysteme und Solarzellen. Prinzipiell widmet sich die Elektrochemie dem Zusammenspiel von Elektrizität und chemischen Reaktionensabläufen in der Art, dass freie chemische Energie, die mit einer Reaktion einhergeht, in elektrische Energie konvertiert wird (z.B. Brennstoffzellen) oder aber elektrische Energie Verwendung findet um beispielsweise stabile Verbindungen zu zersetzen (z.B. Chlorgaserzeugung). Die Lehrveranstaltung leitet die Studierenden an, die Grundlagen der

		Elektrochemie zu verstehen und erläutert grundlegende Methoden und Arbeitsweisen um elektrochemische Reaktionen und darauf basierende Anwendungen zu verstehen. Electrochemistry plays an important role in scientific and technological fields. Nowadays, the research areas are focused, but not limited, on nanotechnology and energy devices, i.e. fuel cells, battery systems and solar cells. In principle, the electrochemistry involves the study of relationship between electricity and chemical reactions, such that chemical free energy associated with a reaction is converted into electrical energy (e.g. fuel cells) or conversely, electricity is used to decompose stable chemical systems (e.g. production of chlorine). The lecture program provides an opportunity for students to understand the basics of electrochemistry and provide the fundamental tools for understanding electrochemical-reactions and electrochemical-devices.
6	**Learning objectives and skills**	***Advanced Corrosion Science*** **The students are able to:** • Identify, distinguish, and explain corrosion mechanism and different forms of corrosion. • Illustrate and explain electrochemical, local, non-electrochemical and surface analysis methods that are used in corrosion science. • Interpret results of the characterisation methods described above • Explain the different concepts of smart coatings and self-healing coatings including triggers and release mechanisms of inhibitors. • Present the details that play a role atmospheric corrosion processes like salts, relative humidity, electrolyte film thickness, time of wetness, influence of gases, wet dry cycling and corrosion product formation. • Explain different test methods for atmospheric corrosion, like lab exposure, accelerated corrosion tests and field exposure tests. • Discuss special features in the corrosion mechanisms of Mg and Al alloys (anomalous H2 evolution). • Review different mechanisms of localized corrosion and explain the significance of pit initiation and pit growth, critical pitting potential, critical pitting temperature and repassivation in localized corrosion. • Explain cathodic and anodic paint disbonding or delamination and how it can be studied using SKP. • Assess findings of scientific investigations of corrosion failure, determine corrosion mechanisms that lead to the corrosion issue and develop a concept for solving the corrosion problem. • Explain mechanisms of different types of corrosion inhibitors. • Summarize corrosion properties of advanced materials like high entropy alloys, bulk metallic glasses, additive manufactured materials or ultrafine-grained materials.

- Describe corrosion related aspects of nuclear waste storage and the influence of radiation on corrosion.
- Compare different types of metals in their applicability as a biodegradable metal and explain surface treatments to control the degradation behavior.
- Understand the complexity of simulated body fluids and possible discrepancy between in vitro and in vivo experiments.
- Describe mechanisms of microbially induced corrosion, dezincification.
- Explain cathodic protection strategies by sacrificial anodes and impressed current cathodic protection.

Surface Modification Techniques
Die Studierenden

- können die Grundlagen von Korrosionsmechanismen und -arten wiedergeben.
- lernen verschiedene Methoden der Oberflächenvorbehandlung kennen.
- können abschätzen, welche Oberflächenvorbehandlung für die Entfernung verschiedener Verunreinigungen eingesetzt werden können.
- können den zugrundeliegenden Mechanismus einer Konversionsbeschichtung am Beispiel der Phosphatierung und Chromatierung beschreiben.
- erklären die Mechanismen von elektrochemischer Abscheidung und elektrophoretischer Beschichtung
- erkennen den Zusammenhang verschiedener Schritte und Parameter der Oberflächenvorbereitung auf die finale Oberflächenqualität einer Beschichtung.
- lernen die Bestandteile und Wirkungsweise einer Reinigungslösung kennen
- Die Studierenden werden auf Besonderheiten hinsichtlich des Umweltschutzes bei der Oberflächentechnik sensibilisiert.
- Erklären die verschiedene Verfahren und Beschichtungsmechanismen von PVD und CVD Prozessen.
- Erklären von Verfahren des thermischen Spritzens und von Sol-Gel Beschichtungen
- können chemische und elektrochemische Konversionsschichten (Phosphatierung, Chromierung, Anodisierung)
- Erläutern Besonderheiten verschiedener organischer Beschichtungen (Lacke).
- Erklären selbstorganisierender Monolagen und Konzepte zur Erzeugung superhydrophober Oberflächen
- Beschreiben den Mechanismus der Ausbildung von selbstorganisierenden anodische Oxidschichten (Nanoporen und Nanoröhren).

- Illustrating the mode of action of chemical mechanical pretreatment.

- Describing plasma aided methods, Laser and electron beam methods as well as ion implantation.
- Illustrating the mode of action of chemical conversion layers (phosphatization, chromating), electrodeposition, electrophoresis, electrochemical conversion layers (anodizing) and CVD/PVD techniques.
- Understanding the basics of organic coatings (paints and lacquers), self-assembled monolayers, self-organized anodic oxide layers (Nanopores, Nanotubes).

Berechnung von Korrosionsproblemen

Die Studierenden sind in der Lage:

- den Wirkzusammenhang von Kinetik und Potential bei Korrosionsreaktionen quantitativ zu erfassen.
- Den Unterschied und die Einflüsse auf Diffusions- und Aktivierungskontrolle zu erklären
- Korrosionsvorgänge anhand schematischer Stromdichte-Potential Kurven zu veranschaulichen
- Pourbaix-Diagramme zu erstellen zu verstehen und anzuwenden.
- die Nernst Gleichung anzuwenden und leiten sie her.
- Fragestellungen der Hochtemperaturoxidation zu bewerten.
- Möglichkeiten des Korrosionsschutzes zu beurteilen.

Quantitative elucidation of the cause-effect relationship between kinetics and potential, Construction of Pourbaix diagrams, applying nernst equation, Assessment of high-temperature oxidation behaviors of metals and alloys, Evaluation of corrosion-protection approaches

Basics Electrochemistry

Die Studierenden

- definieren und beherrschen rechnerisches Anwenden thermodynamischer Grundbegriffe und Modelle (Enthalpie, Entropie, Gibbs-Energie, chemische Gleichgewichte).
- vergleichen von Elektrolyten (Wässrige Lösungen, Organische Lösungen, Festphasenelektrolyte.
- vergleichen verschiedener Elektrodenarten und deren Elektrodenpotential.
- wenden die Nernst-Gleichung an.
- definieren elektrochemischer Systeme (Elektrolysezellen, Galvanische Zellen).
- verstehen Elektroden/Elektrolyt-Grenzflächen (elektrochemische Doppelschicht).
- können die Zusammenhanges von Reaktionsrate und Stromstärke diskutieren.
- bewerten die Kinetik von Elektrodenreaktionen (stofftrans portkontrolliert, ladungsdurchtrittskontrolliert, reaktionskontrolliert).
- können die Butler-Volmer-Gleichung herleiten.

		• verstehen die theoretischen Grundlagen instrumenteller Techniken und technologischer Anwendungen (Brennstoffzellen, Batteriesysteme, elektrochemische Bauteile und Anwendungen). **The students** • Defining and operating with fundamental thermodynamic concepts and models (enthalpy, entropy, free energy, chemical equilibrium). • Comparing of Electrolytes (aqueous solutions, organic solutions, solid phase electrolytes. • Comparing different types of electrodes and their electrode potential. Applying the Nernst equation. • Defining electrochemical systems (electrolytic cells and galvanic cells). • Elucidating Electrode-solution interfaces (electric double layer). • Discussing the relationship between electrochemical reaction rate and current. • Assessing electrode kinetics (mass transport control, charge transfer control, reaction control). • Deriving the Butler-Volmer equation. • Describing the theoretical background of instrumental techniques and technologies (fuel cells, battery systems, electrochemical devices).
7	**Prerequisites**	Immatrikulation im MA-Studium
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Written mündliche Prüfung (30 Min.) oral exam (30 min.)
11	**Grading procedure**	Written (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Vorbereitende LiteraturWird im Zuge der Lehrveranstaltungen vorgestellt.

1	**Module name** 46295	**Surface Modification Techniques**	**5 ECTS**
2	Courses / lectures	Vorlesung: Surface Modification techniques (2 SWS) Seminar: Seminar Surface Science and Corrosion (2 SWS) Übung: Exercise Surface Modification Techniques (1 SWS)	3 ECTS 1 ECTS 1 ECTS
3	Lecturers	Michael Strebl Dr.-Ing. Michael Höhlinger Prof. Dr. Sannakaisa Virtanen Prof. Dr. Patrik Schmuki	

4	**Module coordinator**	Prof. Dr. Sannakaisa Virtanen
5	**Contents**	Im Ergänzungsmodul Praktikum zur Korrosion und Oberflächenanalyse werden unter Anleitung von Betreuern im Rahmen eines Praktikums Versuche aus den Bereichen Korrosion und Oberflächentechnik abgehandelt. Das Modul besteht aus 4 einzelnen Versuchen. Die Studierenden erlernen im Zuge dieser Lehrveranstaltung neben dem selbstständigen Durchführen elektrochemischer Messungen, dem Anodisieren sowie der Charakterisierung der Hochtemperaturoxidationsbeständigkeit von Metallen und Legierungen, die Anwendung verschiedener Verfahren der Oberflächenanalyse. Neben diesen genannten methodischen Lernzielen wird fachliches Wissen über eine Auswahl besonders wichtiger Werkstoffe im Kontext der Korrosion und Oberflächentechnik vermittelt, wobei die Studierenden lernen Messergebnisse zu evaluieren und qualitative sowie quantitative Urteile über das Werkstoffverhalten zu fällen. **English version** Within the practical lab course students absolve experiments belonging to the field of Surface Science & Electrochemistry & Corrosion guided by experienced supervisors. The practical course is subdivided in 4 single experiments. The students learn the practical knowledge about conducting electrochemical measurements, anodization, and characterizing the high-temperature oxidation behavior of metals and alloys. Therefore a variety of surface-sensitive characterization techniques are introduced. Beside the latter methodical issues, furthermore expertise knowledge for a selection of especially important materials that are typically important in the context of corrosion and surface science is taught along the way. The students learn to evaluate measurement data and to interpret qualitative- and quantitatively the measured material behavior.
6	**Learning objectives and skills**	Die Studierenden • bewerten den Einfluss von Legierungselementen und Beschichtungen auf das Degradationsverhalten von Implantatwerkstoffen (Magnesium), Implantatwerkstoffe

		• kennen und verstehen die Herausforderungen im Legierungsdesign, • bewerten den Einfluss verschiedener Oberflächenvorbehandlungen sowie Oxidationsparameter auf die Ausbildung schützender Oxidschichten im Zuge der Hochtemperaturoxidation, • verstehen die Vorrausetzungen und Mechanismen die der Ausbildung schützender Oxidschichten (Hochtemperaturoxidation) zu Grunde liegen, • erzeugen anodisierten Bauteiloberflächen, • bewertuen Tof-SIMS Daten, • wenden Rasterelektronenmikroskopie (REM) an **English version** Evaluation of the influence of alloying elements and coatings on the degradation behavior of implant materials, Implants elucidation of the challenges in alloy design, Assessment of the influence of different surface modification techniques and oxidation parameters on the formation of protective oxide scales during high temperature oxidation, Creating anodized components surfaces, Evaluation and interpretation of Tof-SIMS data, Application of Scanning Electron Microscopy (SEM)
7	**Prerequisites**	Voraussetzungen für die TeilnahmeFundierte Kenntnisse in der Elektrochemie und Hochtemperaturoxidation. Vorlesungen vom LS LKO/ WW4 im Bachelorstudium oder äquivalente Kenntnisse. Immatrikulation im MA-Studium.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Written Hausarbeit (=Praktikumsprotokolle; Leistungsnachweis) und schriftliche Prüfung nach Beendigung des Praktikums Homework (=internship protocols; proof of performance) and written examination after completion of the internship
11	**Grading procedure**	Written (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 70 h Independent study: 80 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Vorbereitende LiteraturWird im Zuge der Lehrveranstaltung vorgestellt.

Polymer Materials

1	**Module name** 46241	**Polymere** Polymers	**10 ECTS**
2	Courses / lectures	Vorlesung: Polymers - I (2 SWS, WiSe 2025) Übung: Excercises Polymer 1 (1 SWS, WiSe 2025) Vorlesung mit Übung: Processing of Polymers (2 SWS, SoSe 2025) Übung: Exercises Processing of Polymers (1 SWS, SoSe 2025) Praktikum: Labwork Polymer Processing (2 SWS, SoSe 2025)	3 ECTS 1,5 ECTS 3 ECTS 1,5 ECTS 2 ECTS
3	Lecturers	Dr.-Ing. Joachim Kaschta Michael Redel	

4	**Module coordinator**	Prof. Dr. Dirk Schubert
5	**Contents**	• Wissensvermittlung zu Grundlagen, Technologie, Charakterisierung und Anwendungen von Polymerwerkstoffen, Polymerblends und -composites • Herstellung und Eigenschaftsprofil von dünnen Polymerfilmen, Fasern und Nanofasern • Einfluss der Größenskala auf Eigenschaften • Wissensvermittlung zu den Vorgängen an Grenzflächen in polymeren Werkstoffsystemen, Kompatibilität verschiedener Polymere • interaktive Gruppenübung zu aktuellen Fragestellungen und Anwendungen von Polymerwerkstoffen **English** • Knowledge transfer on fundamentals, technology, characterization and applications of polymer materials, polymer blends and composites. • Fabrication and property profile of polymer thin films, fibers and nanofibers • Influence of size scale on properties • knowledge transfer on processes at interfaces in polymeric material systems, compatibility of different polymers • interactive group exercise on current issues and applications of polymer materials
6	**Learning objectives and skills**	Die Studierenden • erhalten einen tiefgehenden Einblick in die Thematik Polymere Werkstoffe" • erwerben ein wichtiges Grundlagenverständnis (Struktur-Eigenschaftsbeziehungen auf allen Größenskalen) • sind in der Lage, Modifizierungsstrategien für Polymer-werkstoffe in Bezug auf Optimierung von Eigenschaften zu erarbeiten und durchzuführen • haben ein Verständnis für industrierelevante Arbeits-methodiken gewonnen • kennen wesentliche Anwendungen und Entwicklungsfelder

		English The students • gain an in-depth insight into the topic of "polymer materials • acquire an important basic understanding (structure-property relationships on all size scales) • are able to develop and implement modification strategies for polymer materials with regard to optimization of properties • have gained an understanding of industry-relevant working methodologies • know essential applications and development fields
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Polymer Materials Master of Science Nanotechnology 20232 mündliche Prüfung (30 Min.) oral exam (30 min.)
10	**Method of examination**	Variable
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46242	**Vertiefung Polymere** Specialization: Polymers	**5 ECTS**
2	Courses / lectures	Vorlesung: Polymer and Interface Physics in Theory and industrial Application (1 SWS, WiSe 2025) Vorlesung mit Übung: Polymers - 2 (2 SWS, SoSe 2025) Übung: Exercises Polymers - 2 (1 SWS, SoSe 2025)	1,5 ECTS 3 ECTS 1,5 ECTS
3	Lecturers	Prof. Dr. Dirk Schubert Dr.-Ing. Joachim Kaschta Michael Redel	

4	**Module coordinator**	Prof. Dr. Dirk Schubert
5	**Contents**	• Wissensvermittlung zu Grundlagen, Technologie, Charakterisierung und Anwendungen von Polymerwerkstoffen, Polymerblends und -composites • Herstellung und Eigenschaftsprofil von dünnen Polymerfilmen, Fasern und Nanofasern • Einfluss der Größenskala auf Eigenschaften • Wissensvermittlung zu den Vorgängen an Grenzflächen in polymeren Werkstoffsystemen, Kompatibilität verschiedener Polymere • interaktive Gruppenübung zu aktuellen Fragestellungen und Anwendungen von Polymerwerkstoffen **English** • Knowledge transfer on fundamentals, technology, characterization and applications of polymer materials, polymer blends and composites. • Fabrication and property profile of polymer thin films, fibers and nanofibers • Influence of size scale on properties • knowledge transfer on processes at interfaces in polymeric material systems, compatibility of different polymers • interactive group exercise on current issues and applications of polymer materials
6	**Learning objectives and skills**	Die Studierenden • erhalten einen tiefgehenden Einblick in die Thematik Polymere Werkstoffe" • erwerben ein wichtiges Grundlagenverständnis (Struktur-Eigenschaftsbeziehungen auf allen Größenskalen) • sind in der Lage, Modifizierungsstrategien für Polymer-werkstoffe in Bezug auf Optimierung von Eigenschaften zu erarbeiten und durchzuführen • haben ein Verständnis für industrierelevante Arbeits-methodiken gewonnen • kennen wesentliche Anwendungen und Entwicklungsfelder **English**

		The students • gain an in-depth insight into the topic of "polymer materials • acquire an important basic understanding (structure-property relationships on all size scales) • are able to develop and implement modification strategies for polymer materials with regard to optimization of properties • have gained an understanding of industry-relevant working methodologies • know essential applications and development fields
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Polymer Materials Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (15 Min.) oral exam (15 min).
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46243	**Rheologie** Rheology	**5 ECTS**
2	Courses / lectures	Übung: Excerises Rheology (0 SWS, WiSe 2025) Vorlesung: Rheology - Fundamentals and Measurement Technology (2 SWS, WiSe 2025) Praktikum: Labwork Rheolology (1 SWS, SoSe 2025)	1,5 ECTS 3 ECTS 1 ECTS
3	Lecturers		

4	**Module coordinator**	Dr.-Ing. Joachim Kaschta
5	**Contents**	Rheologische Messgrößen und ihre anwendungstechnische Bedeutung • Grundlagen, Technologie, Messtechnik zur Ermittlung rheologischer Stoffeigenschaften • Verhalten in Scherung Dehnung • Beschreibungsgleichungen • Temperaturabhängigkeit der rheologischen Eigenschaften **English** Rheological measurands and their significance for application • Basics, technology, measuring technique for the determination • rheological material properties • Behavior in shear strain • Equations of description • Temperature dependence of rheological properties
6	**Learning objectives and skills**	Die Studierenden • erhalten einen tiefgehenden Einblick in die Thematik der Rheologie • erwerben ein wichtiges Grundlagenverständnis (Struktur-Eigenschaftsbeziehungen auf allen Größenskalen) • kennen wesentliche Anwendungen und Entwicklungsfelder • identifizieren Stärken und Schwächen verschiedener Verfahrensweisen und Werkstofflösungen • analysieren und bewerten Messdaten von rheologischen Messungen • stufen die eigenen Ergebnisse ein. • haben ein Verständnis für industrierelevante Arbeitsmethodiken gewonnen • kennen wesentliche Anwendungen und Entwicklungsfelder **English** The students • gain an in-depth insight into the subject of rheology • acquire an important basic understanding (structure-property relationships on all size scales)

		• know essential applications and fields of development • identify strengths and weaknesses of different methods and material solutions • analyze and evaluate measurement data from rheological measurements • classify their own results • have gained an understanding of industry-relevant working methodologies • know essential applications and development fields
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Polymer Materials Master of Science Nanotechnology 20232
10	**Method of examination**	Variable mündliche Prüfung (15 Min.) oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46245	**Anwendungen von Polymeren II** Applications of polymers II	**5 ECTS**
2	Courses / lectures	Vorlesung: Basics of six-Sigma - Tool to improved processes in Industry (1 SWS, SoSe 2025) Vorlesung: Polymer Materials for Medical Applications (2 SWS, WiSe 2025) Praktikum: Labwork Polymers - Aplications 2 (1 SWS, SoSe 2025)	1,5 ECTS 3 ECTS 1 ECTS
3	Lecturers	Prof. Dr. Dirk Schubert	

4	**Module coordinator**	Dr.-Ing. Joachim Kaschta Prof. Dr. Dirk Schubert
5	**Contents**	• Wissensvermittlung zu Grundlagen, Technologie, Charakterisierung und Anwendungen von Polymeren in der Medizintechnik, • Einfluss des chemischen Aufbaus auf die relevanten Eigenschaften in der medizinischen Anwendung • Wissensvermittlung zu dem Einfluss der Morphologie auf die relevanten Eigenschaften in der medizinischen Anwendung Prozesse basierend auf qualifizierter Beobachtung und statistischer Analyse • Strategien zur Analyse und Verbesserung beliebiger Prozesse • Anwendung des Wissens in dem Praktikum • interaktive Gruppenübung zu aktuellen Fragestellungen und Anwendungen von Polymerwerkstoffen **English** • Knowledge transfer on fundamentals, technology, characterization and applications of polymers in medical technology, • Influence of the chemical structure on the relevant properties in medical application • Knowledge transfer on the influence of morphology on the relevant properties in medical application Processes based on qualified observation and statistical analysis • Strategies for analysis and improvement of any process • application of the knowledge in the practical course • interactive group exercise on current issues and applications of polymer materials
6	**Learning objectives and skills**	Die Studierenden • kennen wesentliche Anwendungen und Entwicklungsfelder aus den genannten Themenfelder • identifizieren Stärken und Schwächen verschiedener Verfahrensweisen und Werkstofflösungen • beschreiben wesentliche Struktur-Eigenschaftsbeziehungen • analysieren und bewerten Messdaten aus Experimentem • stufen die eigenen Ergebnisse ein. • haben ein Verständnis für industrierelevante Arbeitsmethodiken gewonnen

		English The students • know essential applications and development fields from the mentioned topics • identify strengths and weaknesses of different processes and material solutions • describe essential structure-property relationships • analyze and evaluate measurement data from experiments • classify their own results • have gained an understanding of industry-relevant working methodologies
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Polymer Materials Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Materials for Electronics and Energy Technology

1	**Module name** 46251	**Semiconductor Fundamentals, Characterization, Materials & Processing** Semiconductor fundamentals, characterization, materials & processing	**10 ECTS**
2	Courses / lectures	Vorlesung: Advanced Semiconductors Introduction: Characterization (2 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Prof. Dr. Wolfgang Heiß	

4	**Module coordinator**	Miroslaw Batentschuk Prof. Dr. Wolfgang Heiß
5	**Contents**	Lecture • Crystal structure of solids • Introduction to quantum mechanics in solids • Carrier concentration and charge transport • Excess carriers in semiconductors • The pn junction • Measurement of resistivity, carrier concentration, and mobility • Characterization of defects semiconductors • Determination of optical parameters Lecture, Crystal growth and semiconductor technology • Fundamentals of crystal growth (melt ~, solution ~, vapor growth) • Fundamentals of Silicon Semiconductor Device Technology (Oxidation, Doping by diffusion and ion implantation, etching, metallization, lithography, packaging) • Processing of wide bandgap semiconductors
6	**Learning objectives and skills**	• The students will get the theoretical background and the ability to determine the required parameters for mathematically model the fundamental electrical properties of semiconductors and semiconductor junctions, representing the basic units used for photovoltaics and modern lighting. • The deepening of fundamental understanding of semiconductor properties, as a solid basis for further lectures dealing with the physics of semiconductor devices • Understanding typical experimental techniques to determine basic parameters of semiconductors and semiconductor devices by electronic or optical measurements. • The student gain fundamental knowledge in crystal growth and semiconductor technology.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232
10	**Method of examination**	Variable

		The lectures of the Crystal Growth 1 sub-module are held in the "Flipped Classroom" format (synchronous learning units in the lecture hall & asynchronous learning units via Studon: https://www.studon.fau.de/studon/goto.php?target=crs_3259598 https://www.studon.fau.de/studon/goto.php?target=crs_4514743 The partial examination of the Crystal Growth 1 sub-module takes place either orally (15 min) or as an electronic exam (30 min). The electronic exam partly contains multiple choice questions. The following applies: Each answer option is rated with the assigned number of points if the answer is correct; Incorrect answer goes within the question with negative points. All points of the possible answers are added up. There are no penalties for incorrectly marked tasks.
11	**Grading procedure**	Variable (100%) Semiconductor Fundamentals, Characterization, Materials & Processing (Prüfungsnummer: 62511) (englischer Titel: Semiconductor Fundamentals, Characterization, Materials & Processing) Prüfungsleistung, schriftiliche Prüfung und/oder elektronische Prüfung, Dauer (in Minuten): 45, benotet, 10 ECTS Anteil an der Berechnung der Modulnote: 100.0 % Weitere Erläuterungen: Es gibt 2 Prüfungsteile (Einen Teil über die Vorlesungen Crystal Growth+Wide Bandgap Semiconductors und einen Teil über Advanced Semiconductor Introduction: Fundamentals und Advanced Semiconductor Introduction: characterization). Beide Teile tragen jeweils zu 50% zur Note bei. Die beiden Prüfungsteile können auch getrennt abgelegt werden, z. B. ein Teil nach dem Winter- und ein weiterer Teil nach dem Sommersemester. Examination performance, written exam and/or electronic exam, duration (in minutes): 45, graded, 10 ECTS Contribution to the calculation of the module grade: 100.0% Further explanations: There are 2 exam parts (one part on the lectures Crystal Growth+Wide Bandgap Semiconductors and one part on Advanced Semiconductor Introduction: Fundamentals and Advanced Semiconductor Introduction: Characterization). Each part contributes 50% to the grade. The two exam parts can also be taken separately, for example, one part after the winter semester and another part after the summer semester
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester

15	**Teaching and examination language**	english
16	**Bibliography**	Semiconductor Physics and Devices, Donald A. Neaman, McGraw-Hill, ISBN: 978-0-07-352958-5 Semiconductor Material and Device Characterization, Dieter K. Schroder, John Wiley & Sons, Inc., ISBN:9780471739067 S.M. Sze, Semiconductor Devices – Physics and Technology, John Wiley & Sons, Inc. 2002 P. Wellmann, Materialien der Elektronik und Energietechnik – Halbleiter Graphen, Funktionale Materialien, Springer-Vieweg 2015 (1st edition) and 2019 (2nd edition)

1	**Module name** 46252	**Semiconductor Devices and Applications** Semiconductor devices and applications	**5 ECTS**
2	Courses / lectures	Praktikum: Lab Work Thin Film Semiconductors (2 SWS, SoSe 2025)	2 ECTS
3	Lecturers	Dr. Andres Osvet	

4	**Module coordinator**	Prof. Dr. Christoph Brabec
5	**Contents**	Lecture / Exercise / Lab work • Introduction into the fundamentals, materials and application of thin film semiconducting devices • semiconductor junctions • display technologies • photovoltaic technologies • photodetector and X-Ray technologies • thin film transistor, memory , storage and energy harvesting technologies
6	**Learning objectives and skills**	• The students will get a detailed introduction and overview on various selected thin film device technologies, with emphasis on display technologies, lighting, energy harvesting and photovoltaics (renewable energies). • Independent development of a selected AST topic to the level of comprehension that the student can give a 25 min tutorial / presentation, presentation skills and techniques, • Processing and characterization of thin film semiconductors and semiconducting devices such as photovoltaics, LEDs, light conversion layers (lab course). • Data handling, data storage and written reporting in material science (lab course)
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232 Verwendbarkeit des Moduls / Einpassung in den Musterstudienplan: 1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | Grund- und Ergänzungsmodul | Semiconductor Devices and Applications) 2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik

		(Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | Grund- und Ergänzungsmodul | Semiconductor Devices and Applications) 3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Semiconductor Devices and Applications) Dieses Modul ist daneben auch in den Studienfächern "Nanotechnologie (Master of Science)" verwendbar. Details
10	**Method of examination**	Variable Studien-/Prüfungsleistungen: (englischer Titel: Semiconductor Devices and Applications) Semiconductor Devices and Applications (Prüfungsnummer: 62521) Prüfungsleistung, Portfolio, Dauer (in Minuten): 15, benotet, 5 ECTS Anteil an der Berechnung der Modulnote: 100.0 % Zugeordnete Lehrveranstaltungen: • Advanced Semiconductors Introduction: Devices & Applications • Lab Work Thin Film Semiconductors weitere Erläuterungen: Lecture - graded certificate (students choose either exam on processsing and characterization of a thin film device or a written report of 10 to 20 pages including a final discussion on the results or a presentation of an independent topic in a seminar). Lab Work (1 practical with final report of approximately 1- - 15 pages) Prüfungssprache: Englisch Erstablegung: SS 2022, 1. Wdh.: WS 2022/2023 1. Prüfer: Christoph J. Brabec
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Wird an der Vorlesung dargestellt

1	**Module name** 46253	**Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management** Photovoltaics (PV) and PV Systems II: Light conversion and light management	**5 ECTS**
2	Courses / lectures	Praktikum: Lab Work Manufacturing and Characterization of Phosphors and Storage Phosphors (3 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Miroslaw Batentschuk	

4	**Module coordinator**	Miroslaw Batentschuk
5	**Contents**	The module consists of a lecture and a lab course: • Phosphors for Light Conversion in Photovoltaic Devices and LEDs (Im Wintersemester) (Vorlesung, 2 SWS, Miroslaw Batentschuk • Lab Work Manufacturing and Characterization of Phosphors and Storage Phosphors (im Sommersemester) (Praktikum, 3 SWS, Andres Osvet et al., Zeit n. V., Labore LS i-MEET) ; Scope: 1 experiment, 20 pages report. Contents: • Classification of phosphors according to their principle of operation and by field of application. • Establishing the relationships between crystal structure of phosphors as well as their composition and the desirable absorption and emission properties. • Energy transfer between the crystal lattice and active ions as well as between these ions • Consideration of several examples • Theoretical analysis of phosphor engineering with the purpose to reach maximal energy efficiency during transformation of the ionizing radiation • Basics and to methods of storage phosphor manufacturing • Analysis of requirements to the properties and new trends in development of phosphors for white light emitting diodes and for adaptation of the sun light spectrum to the sensitivity of solar cells and plants
6	**Learning objectives and skills**	• The students will get the theoretical background and the ability to determine the required parameters for engineering new phosphors as a part of photovoltaic modules and devices for modern lighting. • The students will be trained in processing of phosphors and dielectric layers. The students will gain knowledge in characterization of phosphors and improved solar cells.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1

<table>
<tr><td>9</td><td>Module compatibility</td><td>1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232
Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232
<h3>Verwendbarkeit des Moduls / Einpassung in den Musterstudienplan:</h3>
1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management)
2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management)
3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management)

Dieses Modul ist daneben auch in den Studienfächern "Nanotechnologie (Master of Science)" verwendbar. Details</td></tr>
<tr><td>10</td><td>Method of examination</td><td>Variable
<h3>Studien-/Prüfungsleistungen:</h3><h3>Photovoltaics (PV) and PV Systems II: Light Conversion and Light Management (Prüfungsnummer: 62531)</h3>Prüfungsleistung, mündliche Prüfung, Dauer (in Minuten): 15, benotet, 5 ECTS Anteil an der Berechnung der Modulnote: 100.0 % weitere Erläuterungen:
zusätzlich zur mündlichen Prüfung - unbenoteter Nachweis vom Praktikum, Bericht 20 Seiten Prüfungssprache: Englisch Erstablegung: SS 2022, 1. Wdh.: WS 2022/2023
weitere Erläuterungen:
mögliche weitere Prüfungsformen sind Klausur (45 Min.) oder Hausarbeit benotet (ca. 20 Seiten)
Oral examination, exercises, and report from lab work Prüfungssprache: Deutsch oder Englisch
<table><tr><td>1. Prüfer:</td><td>Miroslaw Batentschuk,</td><td>2. Prüfer:</td><td>Andres Osvet</td></tr></table></td></tr>
<tr><td>11</td><td>Grading procedure</td><td>Variable (100%)</td></tr>
<tr><td>12</td><td>Module frequency</td><td>Only in winter semester</td></tr>
<tr><td>13</td><td>Workload in clock hours</td><td>Contact hours: 40 h
Independent study: 110 h</td></tr>
<tr><td>14</td><td>Module duration</td><td>2 semester</td></tr>
</table>

15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46254	**Advanced Semiconductor Technologies Solution Processed Semiconductors I: Materials - Nanocrystals** Advanced semiconductor technologies: Solution processed semiconductors I: Materials - nanocrystals	**5 ECTS**
2	Courses / lectures	Vorlesung: Kolloidale Nanokristalle (2 SWS, SoSe 2025) Seminar: Seminar über "Solution Processed Semiconductors" (2 SWS, SoSe 2025)	3 ECTS 2 ECTS
3	Lecturers	Prof. Dr. Wolfgang Heiß	

4	**Module coordinator**	Miroslaw Batentschuk Prof. Dr. Wolfgang Heiß
5	**Contents**	Lecture / Seminar / Lab work Applications of colloidal nanocrystal materials Growth models to describe nucleation, growth and ripening of nanocrystals Optical properties of quantum dot materials Colloidal nanocrystals operating in the infrared Perovskite based colloidal nanocrystals Devices based on colloidal nanocrystals Topological insulators and two-dimensional materials Synthetic routes towards colloidal nanocrystals Fundamentals of charge transport and optical properties of conjugated polymers Organic semiconductor materials Fundamentals of carbon allotropes
6	**Learning objectives and skills**	Obtaining a detailed understanding of the physics and chemistry of semiconductor nanocrystals Understanding and practically performing the synthesis of a colloidal semiconductor material Independent development and presentation of new research results from the literature on the topic of solution processed semiconductors Understanding of special optical processes in semiconductor nanocrystals Knowledge of nanocrystal applications in devices Understanding fundamentals of organic semiconductors and carbon allotropes
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232

10	**Method of examination**	Variable Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (Prüfungsnummer: 62571) Examination performance, oral examination, duration (in minutes): 15, benotet, 5 ECTS Share in the calculation of the module grade: 100.0 % Related Lab Work - 1 experiment / 20 pages report
11	**Grading procedure**	Variable (100%) Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (Prüfungsnummer: 62541) Share in the calculation of the module grade: 100.0 %
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46255	**Advanced Semiconductor Technologies Solution Processed Semiconductors II - Processing** Advanced semiconductor technologies: Solution processed semiconductors II: Processing	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Advanced Semiconductor Technologies - Processing (including Lab Work Organic Electronics Processing) (2 SWS, SoSe 2025)	3 ECTS
3	Lecturers	Dr. Larry Lüer	

4	**Module coordinator**	Hans-Joachim Egelhaaf
5	**Contents**	**Lecture / Exercise / Lab work** The lecture will give an introduction to coating and printing technologies for the manufacturing of (opto-)electronic devices by solution processing. Special emphasis will be on upscaling from lab scale devices to large area commercial products. The fundamentals of the different technologies as well as their application for the manufacturing of active layers, transparent electrodes and transparent barriers will be described in detail. Exercises will provide a more quantitative approach to thin film processing while lab work will allow hands on experience of the lecture content.
6	**Learning objectives and skills**	• The students will be introduced to the inventory of printing, coating and patterning technologies available for the solution processing of organic, hybrid and inorganic (opto-)electronic devices (FETs, LEDs, solar cells and photodetectors) and its application to the manufacturing of organic, perovskite and quantum dot devices. • After discussing the fundamentals of wet film deposition (wetting, viscosity, drying), the working principles and application ranges of coating (spin coating, doctor blading, slot die coating), printing (letter press, gravure, flexo, screen, ink jet printing) as well as of patterning techniques (printing, scratching, laser ablation) will be introduced. • The specific requirements of "printed electronics will be introduced and compared to those of "silicon based electronics on one hand and "visual printing on the other hand. • The students will learn how to manufacture transparent electrodes (thin metal films, finger electrodes, nanowire meshes, transparent conductive oxides), active layers (bulk heterojunctions, perovskite films, nanoparticle layers), and barriers from the respective inks. They will also learn how to decide for the appropriate coating/printing technology. The inventory of materials for printed electronics will be presented and concepts for rational development of inks from these materials (Hansen solubility theory) will be introduced. • Exercises will teach the students to base their decisions for materials, coating/printing technologies and patterning methods on quantitative considerations. These will include the

		calculation of resistance losses in transparent electrodes, of the viscosities and surface tensions of inks as well as of the water vapor transmission rates of barriers. • Deposition and patterning of electrodes, active layers, and barriers for organic or perovskite solar cells will be trained in the lab work.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering, Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232 Usability of the module / integration into the sample curriculum: 1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) 2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) 3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) This module can also be used in the subjects "Nanotechnology (Master of Science)".
10	**Method of examination**	Variable Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing (examination number: 62551) • in semesters where the lecture takes place: no more than two weeks after lecture start in the lecture and in the StudOn group

		• in semesters without lecture: at least two weeks before the repetition exam in the StudOn group Examination performance, oral examination, duration (in minutes): 15, graded, 5 ECTS Share in the calculation of the module grade: 100.0% **Associated courses:** • Advanced Semiconductor Materials - Excited States and Charge Transport in Organic Semiconductors • Advanced Semiconductor Technologies - Processing (including Lab Work Organic Electronics Processing - 1 experiment / 20 pages report) Examiner: Prof. Christoph J. Brabec Alternative examination forms: written exam (90 min). Choice of the examination form is done on the basis of the didactic character of the module. The decision for the examination form will be communicated: | | |
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 67 h Independent study: 110 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46256	**Advanced Semiconductor Technologies Solution Processed Semiconductors III - Processing** Advanced semiconductor technologies: Solution processed semiconductors III: Processing	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Advanced Semiconductor Technologies - Solution Processed Devices / Applications (2 SWS, SoSe 2025)	3 ECTS
3	Lecturers	Dr.-Ing. Thomas Heumüller Prof. Dr. Christoph Brabec	

4	**Module coordinator**	Prof. Dr. Christoph Brabec
5	**Contents**	**Lecture / Exercise / Lab work** The lecture will introduce into the specifics of electronic transport in disordered semiconductors as compared to inorganic semiconductors. As a consequence of the transport properties, quite unique device architectures are developed for disordered semiconductor devices. As a prototype representative, organic semiconductor devices (organic solar cells and LEDs) are discussed in more detail.
6	**Learning objectives and skills**	• The students will learn the major electronic transport models for disordered semiconductors. Marcus theory is introduced to describe charge migration. The Gaussian Disorder Modell is introduced to derive the temperature and field dependence of mobility and conductivity. • Organic LEDs are one of the leading display technologies nowadays. Materials concepts for OLEDs, recombination of singlet and triplet populations, energy transfer, device architecture and production aspects are discussed Organic Photovoltaics is an emerging PV Technology. The leading materials concepts and composites for OPV are bilayer and bulk heterojunction concepts, charge generation and charge recombination is discussed as a function of microstructure. • Single junction and tandem junction architectures are analysed, steady state and transient measurement methods are introduced to characterize such devices. • Processing and characterization of organic, perovskite, etc solar cells, LEDs , displays or X-Ray detectors will be trained in the lab work.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232

		1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors III - Processing) 2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors III - Processing) 3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Advanced Semiconductor Technologies – Solution Processed Semiconductors III - Processing) Dieses Modul ist daneben auch in den Studienfächern "Nanotechnologie (Master of Science)" verwendbar.
10	**Method of examination**	Variable **Studien-/Prüfungsleistungen:** Advanced Semiconductor Technologies – Solution Processed Semiconductors III - Processing (Prüfungsnummer: 62561) Examination performance, oral examination, duration (in minutes): 20, graded, 5 ECTS **Associated courses:** • Lab Work Solution Processed Electronics • Advanced Semiconductor Technologies - Solution Processed Devices / Applications further explanations: Oral examination and report from lab work Language of examination: German or English

Alternative examination forms: written exam (90 min). Choice of the examination form is			

		done on the basis of the didactic character of the module. The decision for the examination form will be communicated: • in semesters where the lecture takes place: no more than two weeks after lecture start in the lecture and in the StudOn group • in semesters without lecture: at least two weeks before the repetition exam in the StudOn group				
11	**Grading procedure**	Variable (100%)				

		Share in the calculation of the module grade: 100.0 % Oral examination determines the grade of the module. The LabWork should be accepted by the direct supervisor.
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 50 h Independent study: 100 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Will be presented in the StudOn page of the course

1	**Module name** 46257	**Advanced Semiconductor Technologies** **Photovoltaic Systems I - Fundamentals** Advanced semiconductor technologies - Photovoltaic systems I - Fundamentals	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Christoph Brabec Prof. Dr. Wolfgang Heiß
5	**Contents**	**Lecture / Exercise / Lab work** The lecture will introduce into the fundamentals of photovoltaic energy conversion. The conversion of light into electricity is one of the most efficient power technologies by today and is expected to transform our energy system towards a renewable scenario. The limits of photovoltaic energy conversion, the materials and architectures of major PV technologies and advanced characterization methods for modules as well as solar fields will be introduced theoretically and experimentally during the lecture, a seminar and the lab works.
6	**Learning objectives and skills**	• The students will learn the concept of black body radiation and the radiation laws and the limits of light energy conversion. The fundamental semiconductor junctions (p-n, M-i-M, Shottky and Hetero Junction are repeated. The one diode and two diodes replacement circuits are explained . Electrical, optical, recombination and extraction loss mechanisms are discussed separately and demonstrated at the hand of numerical drift-diffusion equation solvers. The most important solar cell concepts (Si, CIGS, CdTe, GaAs, Perovksites, Organics) are introduced, and the strengths and weaknesses of each technology are analysed. • Characterization of Photovoltaic Modules will trained by flashed measurements in the lab. Defect imaging methods like DLIT, EL or PL imaging will be trained at the hand of module installations in Erlangen.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232
10	**Method of examination**	Variable

		Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (Prüfungsnummer: 62571) Examination performance, oral examination, duration (in minutes): 15, graded, 5 ECTS Share in the calculation of the module grade: 100.0% Alternative examination forms: written exam (90 min). Choice of the examination form is done on the basis of the didactic character of the module. The decision for the examination form will be communicated: • in semesters where the lecture takes place: no more than two weeks after lecture start in the lecture and in the StudOn group • in semesters without lecture: at least two weeks before the repetition exam in the StudOn group
11	**Grading procedure**	Variable (100%) Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (examination number: 62571) Share in the calculation of the module grade: 100.0 %
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 40 h Independent study: 110 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46258	**Crystal Growth 2** Crystal growth 2	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr.-Ing. Peter Wellmann
5	**Contents**	Elektronische Bauelemente und Materialfragen • Korrelation von Bauelementfunktion (Bipolar-Diode, Bipolar-Transistor, Schottky-Diode, Feldeffekt-Transistor, Leucht- und Laserdiode) mit Materialeigenschaften • Grundlagen der Epitaxie • Aufbau und Verbindungstechnik mit Bezug zur Leistungselektronik Wahlvorlesung aus dem Bereich der Elektrotechnik -Vertiefung von elektrotechnischen Anwendungen, welche starken Bezug auf Werkstoffe der Elektrotechnik nehmen Praktikum • Czochralski Kristallwachstum von InSb • Halbleitercharakterisierung **English** Electronic devices and material issues • Correlation of device function (bipolar diode, bipolar transistor, Schottky diode, field-effect transistor, light-emitting diode, laser diode) with material properties • Basics of epitaxy • Design and interconnection technology with reference to power electronics Elective lecture from the field of electrical engineering -deepening of electrical engineering applications, which strongly refer to materials of electrical engineering Practical course • Czochralski crystal growth of InSb • Semiconductor characterization
6	**Learning objectives and skills**	Die Studierenden erwerben fundierte Kenntnisse über Materialeigenschaften und deren Anwendung in elektronischen Bauelementen. Kennenlernen experimenteller Techniken in den Werkstoffwissenschaften, Verfassen von technischen Berichten, Teamarbeit **English** Students acquire in-depth knowledge of material properties and their application in electronic devices.

		Getting to know experimental techniques in materials science, writing technical reports, teamwork.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Materials for Electronics and Energy Technology Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Biomaterials

1	**Module name** 46263	**Basics of Biomaterials** Basics of biomaterials	**10 ECTS**
2	Courses / lectures	Praktikum: Praktikum II "Basics of Biomaterials" (Zell-Toxizität) (0 SWS, SoSe 2025) Vorlesung: Cell-Material-Interactions (2 SWS, SoSe 2025)	1,25 ECTS 2,5 ECTS
3	Lecturers	Dr.-Ing. Rainer Detsch	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	*Biomaterialien (Implantatwerkstoffe)* und *Übungen zu Biomaterialien (Implantatwerkstoffe)* • Definition Implantate • Geschichte der Biomaterialien • Beispiele für Implantate im menschlichen Körper z.B. Gelenkersatz, abbaubare Implantate, intraokulare Linsen etc. • Implantat-Beschichtungen • Testen von Biomaterialien *Zell-Werkstoff-Wechselwirkung* • Bedeutung der Oberfläche bei Biomaterialien • Grenzfläche Biomaterial/Zelle • Einfluss der Oberflächenchemie auf das Zellverhalten • Einfluss der Oberflächentopographie auf das Zellverhalten • Proteinadsorption auf Biomaterialoberflächen • Funktionalisierung von Biomaterialoberflächen/bioaktive Oberflächen *Praktikum "Basic of Biomaterials"* • Versuch 1 - Herstellung biomimetischer Schichten: Beschichtung von metallischen Substraten zur Erhöhung der Osteokonduktivität, Knocheneinheilungsprozesse an der Implantatoberfläche • Versuch 2 - Zell-Toxizität: Einfluss unterschiedlicher Biomaterial-Eluate auf das zelluläre Wachstum |*Content:|* *Biomaterials (Implant materials) and Tutorial on Biomaterials (Implant materials)* • Definition of implant • History of biomaterials • Examples of implants in the human body, e.g. joint replacement, resorbable implants, intraocular lenses etc. • Implant coatings • Testing of biomaterials *Cell-material-interaction* • Importance of the surface in biomaterials • Interface biomaterial/cell • Influence of surface chemistry on cell behaviour • Influence of surface topography on cell behaviour • Protein adsorption on biomaterial surfaces • Functionalisation of biomaterial surfaces/bioactive surfaces

		Practical "Basics of Biomaterials" • Experiment 1 Fabrication of biomimetic coatings: Coating of metallic substrates to improve osteoconductivity, bone healing processes on the implant surface. • Experiment 2 Cell toxicity: influence of different biomaterial eluates on cellular proliferation
6	**Learning objectives and skills**	*Biomaterialien (Implantatwerkstoffe)* und *Übungen zu Biomaterialien (Implantatwerkstoffe)* Die Studierenden • verstehen den Zusammenhang zwischen Eigenschaften eines Biomaterials und dessen Verhalten im menschlichen Körper • können den Erfolg von Biomaterialien im Körper anhand ihrer Eigenschaften beurteilen *Zell-Werkstoff-Wechselwirkung* Die Studierenden • verstehen die Bedeutung der Oberflächeneigenschaften für die Nutzung und Einsetzbarkeit von Biowerkstoffen. • entwickeln Verständnis über den Einfluss der Oberflächenchemie und -topographie von Biomaterialien auf die Zelladhäsion. *Praktikum "Basic of Biomaterials"* • Versuch 1 - Herstellung biomimetischer Schichten: Die Studierenden verstehen die Bedeutung von Beschichtungen zur Verbesserung von Implantatoberflächen. Es werden Möglichkeiten aufgezeigt, wie man Oberflächeneigenschaften gezielt einstellen kann. • Versuch 2 - Zell-Toxizität: Die Studierenden verstehen die Bedeutung von In-vitro Zytotoxizitätsuntersuchungen und lernen Techniken zur Erfassung des Einflusses unterschiedlicher Materialklassen auf Zellproliferation und Zellmorphologie kennen und zu beurteilen. |*Educational goals and competences:*| *Biomaterials (Implant materials)* and *Tutorial on Biomaterials (Implant materials)* The students • should understand the connection between properties of a biomaterial and its behaviour in the human body. • can evaluate the success of a biomaterial in the body by means of the material properties. *Cell-material-interaction* The students • understand the importance of surface properties for the application and the usability of biomaterials. • develop an understanding of the influence of surface chemistry and topography of biomaterials on cell adhesion. *Practical "Basics of Biomaterials"* • Experiment 1 Fabrication of biomimetic coatings: The students understand the importance of coatings to improve the surface

		properties of implants. Different possibility are shown how the surface properties can be tailored to a given application. • Experiment 2 - Cell-toxicity: The students understand the significance of in-vitro cell toxicity investigations and get to know and evaluate the techniques to determine the influence of different material classes on cell proliferation and cell morphology
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Biomaterials Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit schriftliche Prüfung (90 Min) currently written exam (90 min)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	*Biomaterialien (Implantatwerkstoffe)* und *Übungen zu Biomaterialien (Implantatwerkstoffe)*/*Biomaterials (Implant materials)* and *Tutorial on Biomaterials (Implant materials)* • B.Ratner et al "Biomaterials science. An introduction to materials in medicine" Elsevier • E. Wintermantel, S.-W. Ha "Medizintechnik und Life Science Engineering" Springer Verlag • M. Tanzi et al. "Foundations of Biomateral's Engineering" Academic Press *Zell-Werkstoff-Wechselwirkung*/*Cell-material-interaction* • o Will, J., Detsch, R. & Boccaccini, A. R. Structural and Biological Characterization of Scaffolds. in Characterization of Biomaterials 299310 (2013). doi:10.1016/B978-0-12-415800-9.00008-5 Langer, R. & Tirrell, D. A. Designing materials for biology and medicine. Nature (2004). doi:10.1038/nature02388 Augst, A. D., Kong, H. J. & Mooney, D. J. Alginate hydrogels as biomaterials. Macromol. Biosci. 6, 623633 (2006). *Praktikum/Pratical "Basic of Biomaterials"* Literaturangaben (begleitend und zur Vorbereitung) finden sich in den aktuellen Versuchsanleitungen/Bibliographical references (complementary and for preparation) are found in current script.

1	**Module name** 46264	**Advanced Applications: Tissue Engineering** Advanced applications: Tissue engineering	**5 ECTS**
2	Courses / lectures	Praktikum: Lab Course "Tissue Engineering" (PktTE, SS2024) (2 SWS) Vorlesung: Biomaterials for Tissue Engineering (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Dr.-Ing. Gerhard Frank Dr. Irem Ünalan Prof. Dr.-Ing. Aldo Boccaccini Dr. Julia Will	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	*Biomaterials for Tissue Engineering* • Tissue Engineering und regenerative Medizin: Konzepte, Definitionen und historische Entwicklung • Scaffolds: Anforderungen, Herstellung und Charakterisierung • Beispiele: scaffolds für Tissue Engineering von Knochen und Weichgeweben • Neue Konzepte: multifunktionelle scaffolds • Medikamentös wirksame scaffolds: Tissue Engineering und drug delivery *Praktikum "Tissue Engineering"* • Versuch 1: Polymer-beschichtete bioaktive Scaffolds für Knochen Tissue Engineering (Grundlagen des Tissue Engineerings [TE; Definitionen] mit dem Schwerpunkt auf Knochen-TE; Ansprüche an Scaffolds für Knochen-TE; Materialien für Scaffolds für Knochen-TE) • Versuch 2: Elektrophoretische Abscheidung von Funktionsschichten auf Biomaterialien |*Content:*| *Biomaterials for Tissue Engineering* • Tissue engineering and regenerative medicine: concepts, definitions and historical development • Scaffolds: requirements, fabrication and characterisation • Examples: scaffolds for tissue engineering of bone and soft tissues • New concepts: multifunctional scaffolds • Medicinally active scaffolds: Tissue engineering and drug delivery *Practical "Tissue Engineering"* • Experiment 1: Polymer-coated bioactive scaffolds for bone tissue engineering (basics of tissue engineering [TE; definitions] with emphasis on bone TE; materials for scaffolds for bone TE) • Experiment 2: Electrophoretic deposition of functional coatings for biomaterials
6	**Learning objectives and skills**	*Biomaterials for Tissue Engineering* Die Studenten sollen

- die überragende Wichtigkeit der Konzepte des Tissue Engineering und die Rolle der Biomaterialien dabei erfassen.
- mit der Bedeutung, Herstellung, Charakterisierung, Einsatz und Bewertung von Gerüststrukturen im Tissue Engineering vertraut sein.

Praktikum "Tissue Engineering"

|Versuch 1: Polymer-beschichtete bioaktive Scaffolds für Knochen Tissue Engineering|

Die Studenten

- lernen kennen und wenden an: Herstellungsverfahren, Beschichtungsverfahrenund Charakterisierungsmethoden für scaffold für Knochen-TE.
- können: Ein Protokoll der Experimente erstellen.
- bewerten und diskutieren: Die Verfahren und Ergebnisse der Versuche.

|Versuch 2: Elektrophoretische Abscheidung von Funktionsschichten auf Biomaterialien|

Die Studenten

- lernen kennen: Die Anforderungen an Biomaterialien, den Einfluss der EPD-Abscheidungsparameter auf die Funktionalität der Schichten.
- lernen kennen und wenden an: Das Verfahren der Elektrophoretischen Abscheidung, die Kontaktwinkelmessung als Charakterisierungsmehtode von Oberflächen.
- bewerten und diskutieren: Funktionsschichten bezüglich Ihres Einsates als Biomaterialien; die Ergebnisse der Versuche und Verfahren.

|*Educational objectives and competences:*|

Biomaterials for Tissue Engineering

The students need to

- comprehend the paramount importance of the concepts of tissue engineering and the role of biomaterials therein.
- to be familiar with the significance, fabrication, characterisation, application and evaluation of scaffold structures for tissue engineering.

Practical "Tissue engineering"

|Experiment 1:| Polymer coated bioactive scaffolds for bone tissue engineering

The students

- are familiarised with and apply: fabrication methods, coating techniques and characterisation methods for scaffolds for bone tissue engineering.
- are able to: devise a protocol of the experiment.
- assess and discuss: the procedures and results of the experiments.

|Experiment 2:| Electrophoretic deposition (EPD) of functional coatings on biomaterials

The students

		• get to know: the requirements for biomaterials, the influence of the EPD-process parameters on the functionality of the coatings. • apply: the processes of EPD, contact angle measurements as a characterisation method for surfaces. • assess and discuss: functional coatings regarding their application as biomaterials, the results of the experiments and the process in general.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Biomaterials Master of Science Nanotechnology 20232
10	**Method of examination**	Variable (45 minutes) derzeit mündliche Prüfung (15 Minuten) currently taking an oral exam (15 minutes)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	*Biomaterials for Tissue Engineering* • Boccaccini, Gough, J.E. (eds.): Tissue engineering using ceramics and polymers; Cambridge, 2007 • Polak, Mantalaris, Harding (eds.): Advances in Tissue Engineering; Oxford u.a., 2010 • Wintermantel, Suk-Woo: Medizintechnik; Berlin, 52009 • Hench, Jones (eds.): Biomaterials, artifical organs und tissue engineering; Oxford, 2005 *Praktikum/Practical "Tissue Engineering"* • Literaturangaben (begleitend und zur Vorbereitung) finden sich in den aktuellen Versuchsanleitungen/Bibliographical references (supporting and for the preparation) are included in the current script.

1	**Module name** 22802	**Grundlagen der Anatomie und Physiologie** Foundations of anatomy and physiology	**5 ECTS**
2	Courses / lectures	Vorlesung: Grundlagen der Anatomie und Physiologie für Medizintechniker, Naturwissenschaftler und Ingenieure (2 SWS, SoSe 2025)	-
3	Lecturers	Dr. Jana Dahlmanns Prof. Dr. Christian Alzheimer Prof. Dr. Peter Soba	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	Die Grundlagen der menschlichen Physiologie und Anatomie werden betrachtet. Dabei wird das grundlegende menschliche Nervensystem, Auge, Ohr, das somatosensorische System und die zentrale Motorik des Menschen betrachtet. Im zweiten Teil der Vorlesung wird das Herz-Kreislauf System sowie das Magen-Darm System und der Blut- und Atmungskreislauf erklärt. **Content:** The fundamentals of human physiology and anatomy are contemplated. At the same time, the underlying human nervous system, the eye, the ear, the somatosensory system and the central motor function of humans is detailed. In the second part of the lecture course, the cardiovascular system as well as the gastrointestinal and the blood circulation and breathing circuit are explained.
6	**Learning objectives and skills**	Die Studierenden • kennen den grundlegen Aufbau des menschlichen Körpers. • verstehen die Mechanismen des Blut- und Atmungskreislaufs, Motorik und des Herz- Kreislaufsystems. **Educational Goals and Competences:** The students • know the fundamental structure of the human body. • understand the mechanisms of blood and breathing circulation, motor function and the cardiovascular system.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Biomaterials Master of Science Nanotechnology 20232 derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
10	**Method of examination**	Written examination (60 minutes)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h

14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Geeignete begleitende Literatur wird in der Vorlesung genannt./ Relevant accompanying literature will be detailed during the lecture.

1	**Module name** 46265	**Advanced applications: Biofabrication and Drug Delivery** Advanced applications: Biofabrication and drug delivery	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	*Vorlesung Biofabrikation* • Anwendungsfelder Additive Fertigung- Grundprinzip • Aufbau und Funktionsweise eines 3D Druckers • Unterschiedliche Systeme des 3D Druckens • Anforderungen an Biotinten • Eigenschaften synthetischer und natürlicher Biotinten • Synthese und Vernetzungsmechanismen von Hydrogelen • mechanische und chemische Charakterisierung der Biotinte • Zell-Drucken und Zell-Reifung • Verschiedene Anwendungen der Biofabrikation: Organ on a Chip und Gewebeanaloga *Praktikum "Drug Delivery Systeme"*: Experimentelle Arbeiten zur Vertiefung der Vorlesungsinhalt Hydrogele *Prakikum "3D Drucken"*: Experimentelle Arbeiten zur Vertiefung der Vorlesungsinhalt Additive Fertigung von Biopolymeren: 3D Extrusionsdrucken von Polycaprolacton und Alginat |*Content:*| *Lecture Biofabrication* • Application fields Additive Manufacturing- basic principle • Setup and operating principle of 3D printer • Different systems of 3D printing • Requirements for bioinks • Properties of synthetic and natural bioinks • Synthesis and cross-linking of hydrogels • Mechanical and chemical characterisation of bioinks • Cell-printing and cell-maturation • Different applications of biofabricaation: Organ on a Chip and tissue analogs *Practical "Drug Delivery Systems":* Experimental work to consolidate the content oft he lecture course hydrogels *Practical "3D Printing":* Experimental work to consolidate the content of the lecture course Additive Manufacturing of Biopolymers: 3D Extrusion printing of Polycaprolacton and Alginate
6	**Learning objectives and skills**	* Biofabrikation* Die Studierenden • erfassen die Wichtigkeit verschiedener Konzepte im Bereich der Biofabrikation. • lernen physikalische/chemische Grundlagen von Hydrogelen, Zellen-Gewebe und 3D Drucken.

		• versehen der Interaktion von Biotinte, 3D Drucken und Zellen • verstehen der Mechanismen der 3D Generierung: |Organ on a Chip bis hin zu Gewebeanaloga| *Praktikum Drug-Delivery-Systeme* Die Studierenden • ᵒ lernen das sterile Arbeiten, Pipettieren und Mikroskopieren. ᵒ verstehen die Freisetzungskinetik von Drug-Delivery-Systemen. ᵒ haben einen Überblick über Methoden der Herstellung und Charakterisierung von Mikrokapseln im Hinblick auf die biomedizinische Anwendung. ᵒ grasp the importance of the different concepts in the area of biofabrication. ᵒ learn physical/chemical fundamentals on hydrogels, cells-tissues and 3D printing. ᵒ understand the interaction between bioinks, 3D printing and cells ᵒ understand the mechanisms of 3D generation: from Organ on a Chip to tissue analogs ᵒ understand the importance of polymeric materials for biofabrication processes *Practical 3D-Printing* The students learn to work in sterile conditions, using a pipette and microscope. understand the release kinetics of drug-delivery-systems. get an overview on fabrication and characterisation methods of microcapsules in regards of biomedical applications.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Biomaterials Master of Science Nanotechnology 20232
10	**Method of examination**	Variable (45 minutes) derzeit mündliche Prüfung (15 Minuten) currently taking an oral exam (15 minutes)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	*Biofabrikation/Biofabrication* • Moroni, L., et al. (2018). "Biofabrication: A Guide to Technology and Terminology. Trends in Biotechnology.

		• Groll, J., et al. (2018). "A definition of bioinks and their distinction from biomaterial inks. Biofabrication, 11(1) • Valot, L., Martinez, J., Mehdi, A., and Subra, G. (2019). "Chemical insights into bioinks for 3D printing. Chemical Society Reviews, 48(15), 40494086. • Yi, H.-G., Lee, H., and Cho, D.-W. (2017). "3D Printing of Organs-On-Chips. Bioengineering, 4(4), 10. *Drug-Delivery-Systeme/Drug-Delivery-Systems* • Augst, A. D., Kong, H. J., and Mooney, D. J. (2006). "Alginate hydrogels as biomaterials. Macromolecular bioscience, 6(8), 623633. • Smidsrød O, Skjåk-Braek G. (1990) "Alginate as immobilization matrix for cells. Trends Biotechnol.;8(3):71-8. • Productinformation: Bradford Reagent, Prod.No. B6916, Sigma * 3D Drucken/3D Printing* • Liaw, C. Y., and Guvendiren, M. (2017). "Current and emerging applications of 3D printing in medicine. Biofabrication. • Chia, H. N., and Wu, B. M. (2015). "Recent advances in 3D printing of biomaterials. Journal of Biological Engineering, 9(1), 4.

1	**Module name** 46266	**Advanced applications: Composites and Surfaces** Advanced applications: Composites and surfaces	**5 ECTS**
2	Courses / lectures	Vorlesung: Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine (2 SWS) Vorlesung: Composites and Nanomaterials in Medical technology (2 SWS) Vorlesung: Dental Biomaterials (2 SWS)	1,5 ECTS 2,5 ECTS 3 ECTS
3	Lecturers	Prof. Dr. Sannakaisa Virtanen Prof. Dr.-Ing. Aldo Boccaccini Dr. Julia Will apl. Prof. Dr. Ulrich Lohbauer	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	*Verbundwerkstoffe und Nanomaterialien in der Medizintechnik* • Vorteile von Verbundwerkstoffen als Werkstoffe in der Medizin • Gefüge-Eigenschaft-Korrelation bei Verbundwerkstoffen • Beispiele für Verbundwerkstoffe und deren Einsatz in der Medizintechnik • Bedeutung der Nanomaterialien in der Medizintechnik • Charakterisierung von Nanomaterialien • Nanoteilchen, Nanotubes • Zelltoxizität und Grenzen des Einsatzes von Nanoteilchen in der Medizintechnik • Sol-Gel-Verfahren zur Herstellung von Nanoteilchen • Kolloidale Prozesse und Funktionalisierung von Nanoteilchen • Herstellung von Nanoteilchen auf der Bioroute • Biogene Nanopartikel • "Green Chemistry" für die Herstellung von Nanoteilchen • Ausgewählte Beispiele aus dem Bereich der Nanobiomedizin. *Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine* This course introduces the basics of chemistry and physics of surfaces including characterization methods for biomaterial surfaces. Surface properties which are relevant for protein and cell attachment are discussed. Fundamentals of protein and protein adsorption on biomaterials are presented as well as the effect of chemical composition, topography, hydrophobic and hydrophilic surfaces, stiffness of the biomaterial and ion release effects from the biomaterial on cell attachment and success of the implanted material in general. The lecture also gives surface modification strategies for implants and scaffolds including biomedical coatings and bioactive surfaces. The course covers also functionalization strategies for biomaterials. Protein adsorption mechanisms and the basics of the interaction between a biomaterial (implant) and tissues (foreign body reaction) are covered. Protein adsorption mechanisms and the basics of the interaction between a biomaterial (implant) and tissues (foreign body reaction) are covered.

		Dentale Biomaterialien • Aufbau der Zähne • Zahnkrankheiten • Biomechanik • Dentale Konstruktionslehre, Präparation • Zemente & Polymere • Befestigung am Zahn • Befestigung am Substrat • Implantate • digitaler Workflow, klinische Fraktografie • Mechanische Eigenschaften & Prüfung • Dentalkeramik |*Content:*| *Composite materials and nanomaterials in medical technology* • Advantages of composites as materials for medicine • Microstructure-property-correlation in composites • Gefüge-Eigenschaft-Korrelation bei Verbundwerkstoffen • Examples of composites and their usage in medical technology • Importance of nanomaterials in medical technology • Characterisation of nanomaterials • Nanoparticles, nanotubes • Cell toxicity and limitations of use of nanoparticles in medical technology • Sol-gel-processes for fabrication of nanoparticles • Colloidal processes and functionalization of nanoparticles • Production of nanoparticles using the bio-route • Biogenic nanoparticles • "Green chemistry" for the synthesis of nanoparticles • Selected examples from the area of nanobiomedicine *Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine:* see above *Dental Biomaterials* • Structure of teeth • Tooth diseases • Biomechanics • Dental design theory, preparation • Cements & polymers • Attachment on teeth • Attachment on substrate • Implants • Digital workflow, clinical fractography • Mechanical properties and examination • Dental ceramics
6	**Learning objectives and skills**	*Verbundwerkstoffe und Nanomaterialien in der Medizintechnik* Die Studierenden • gewinnen einen Überblick über die aktuell und zukünftig in der Medizintechnik eingesetzten Nanomaterialien.

- kennen spezifische Eigenschaften, Anwendungen und Vorteile von Nanokompositen.
- verstehen die Zusammensetzung und Entwicklung solcher Verbundwerkstoffe für die Medizintechnik in Anwendungen wie Beschichtungen, Scaffolds, Drug-Delivery Systeme und antimikrobielle Oberflächen.

Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine: see below

Dentale Biomaterialien

Die Studierenden

- kennen den Aufbau und die Struktur von Zähnen und die daraus abgeleiteten mechanischen und physikalischen Eigenschaften.
- kennen die Struktur und die Zusammensetzung dentaler Biomaterialien wie hochgefüllte Polymere, Dentalkeramiken oder Titanimplantate.
- verstehen die relevanten Krankheitsbilder, die zum Zahnverlust führen können und bekommen Einblick in die Kariesätiologie.
- entwickeln das Verständnis für die Prinzipien dentaler Konstruktionslehre (Kavitätenpräparation) im Hinblick auf die unterschiedlichen Restaurationsmaterialien und Befestigungstechniken.
- klassifizieren die Prinzipen der dentalen Befestigungstechnik und speziell der adhäsiven Klebetechnik.
- können den Unterschied zwischen direkter, plastischer Füllungstherapie und indirekten, prothetischen Restaurationen diskutieren.
- sind in der Lage dentale Biomaterialien, anwendungsspezifisch hinsichtlich mechanischer, physikalischer, chemischer und biologischer Eignung zu untersuchen.

|*Educational objectives and competences:*|

Composite Materials and Nanomaterials in Medical Technology

The students

- obtain an overview on the current and future nanomaterials used in medical technology.
- know specific properties, applications and advantages of nanocomposites.
- understand the composition and development of such composite materials for medical technology for applications such as coatings, scaffolds, drug-delivery systems and antimicrobial surfaces

Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine

The students

- learn the basics of different aspects of interfaces of biomaterials. In particular, focus will be placed on the interaction between different biomaterials (polymers, metals,

		ceramics) with the physiological fluids and the surrounding tissue. • can apply their knowledge in order to judge the success of the different biomaterials and to optimize the surface properties for specific applications • know and can explain methods of surface characterization. *Dental biomaterials* The students • know the structure of a tooth and their mechanical and physical properties. • understand the structure and the composition of dental biomaterials, such as highly filled polymers, dental ceramics or titanium implants. • understand the relevant clinical pictures, which lead to tooth loss, and an insight into the etiology of caries formation. • develop an understanding for the principles of dental design theory (Cavity preparation) with view to the different restoration materials and fixation techniques, • classify the principles of dental fixation techniques, in particular the adhesive technique. • can discuss the difference between direct, plastic restorative therapy and indirect, prosthetic restorations. • are able to examine dental biomaterials from a user specific standpoint regarding mechanical, physical, chemical and biological suitability.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Biomaterials Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Minuten) currently taking an oral exam (15 minutes)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	*Verbundwerkstoffe und Nanomaterialien in der Medizintechnik/ Composites and nanomaterials in medical technology* • Ambrosio (ed.): Biomedical composites; Oxford, 2010 • Wintermantel, Suk-Woo: Medizintechnik; Berlin, 2009

		Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine • Biomaterials Science, 2nd ed., B. D Ratner et al. (eds.), Elsevier, 2004. • Surface Modification of Biomaterials: Methods analysis and applications, R. Williams (ed.), Woodhead Publishing, 2010 Further recommended reading will be announced in the lectures. *Dentale Biomaterialien/Dental Biomaterials* • Rosentritt M., Ilie N., Lohbauer U. Werkstoffkunde in der Zahnmedizin. Thieme Verlag. 2018 (ISBN 978-3-1324-0123-5)

Materials Simulation

1	**Module name** 46271	**Foundations of Materials Simulation** Foundations of materials simulation	**10 ECTS**
2	Courses / lectures	Praktikum: Kernfachpraktikum Werkstoffsimulation (WW8) (0 SWS, SoSe 2025) Seminar: Introduction to Advanced Maths and Calculus (1 SWS, SoSe 2025) Vorlesung mit Übung: Multi-scale Simulation Methods II (SoSe 2025) Vorlesung: Deep Learning For Materials (SoSe 2025)	5 ECTS - - -
3	Lecturers	PD Dr. Paolo Moretti Prof. Dr. Luca Ghiringhelli	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	1. Mathematical and numerical background in materials simulation; 2. Molecular dynamics; 3. Monte Carlo methods; 4. Kinetic Monte Carlo method; 5. Finite element method; 6. Phase field method; 7. Lattice and network models.
6	**Learning objectives and skills**	The students • gain an overview of the problem of materials simulation across scales • acquire knowledge on the general aspects of both atomistic and continuum modeling • gain experience in the practical application of these methods to real problems of materials mechanics modeling. • learn techniques of programming and data analysis of relevance in materials science • which includes theoretical content and hands-on experience
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Variable derzeit mündliche Prüfung (30 Min.) currently taking an oral exam (30 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english

16	**Bibliography**	

1	**Module name** 46272	**Discrete and Continuum Simulation** Discrete and continuum simulation	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Atomistic Modelling of Mechanical Properties (3 SWS, SoSe 2025) Vorlesung mit Übung: Foundations of Finite Element Simulation (WiSe 2025)	- -
3	Lecturers	Prof. Dr.-Ing. Erik Bitzek Prof. Dr. Michael Zaiser	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	1. Atomistic simulation methods; 2. Molecular dynamics simulations 3. Statics and energy minimization; 4. Continuum models for materials simulation 5. Mathematical formulation and discretization schemes 6. Finite element method
6	**Learning objectives and skills**	The students • understand and operate the state-of-the-art modeling techniques in materials simulation, both at the atomistic level and in the continuum. • acquire advanced knowledge of the molecular dynamics methods, • acquire advanced knowledge of the finite element method • acquire advanced knowledge of the advanced techniques of data analysis that are relevant in material modeling, both in research and in applications.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46273	**Material Theory** Material theory	**5 ECTS**
2	Courses / lectures	Vorlesung: Generalized Continuum Models of Materials Mechanics (1 SWS, SoSe 2025) Vorlesung mit Übung: Atomistic Methods: phase diagrams and processes (SoSe 2025)	1,5 ECTS -
3	Lecturers	Prof. Dr. Luca Ghiringhelli	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	1. Theoretical foundations of atomistic models 2. Coarse graining and formulation of continuum theories 3. Generalized continuum theories.
6	**Learning objectives and skills**	students learn the theoretical foundations of the models behind current state-of-the-art simulation techniques • develop a critical understanding of current modeling tools and approximation methods • develop a critical understandingof relevance both for atomistic modeling and for continuum approaches
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 45 h Independent study: 105 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46274	**Materials Informatics** Materials informatics	**5 ECTS**
2	Courses / lectures	Vorlesung: Materials Data Engineering in Industrial Practice (2 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Dr. Johannes Möller	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	1. Data science in materials modeling 2. Correlations and methods of statistical inference 3. Machine learning techniques 4. Elements of high performance computing 5. Data structures in microstructure modeling
6	**Learning objectives and skills**	the students • acquire advanced knowledge of computer-based techniques of data analysis and materials modeling • learn methods of relevance in the treatment of data coming from both simulations and experiments. • become familiar with concepts and tools of machine learning and high performance computing, of relevance in the study of materials properties, through extensive practical sessions
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46275	**Microstructure Modeling** Microstructure modeling	**5 ECTS**
2	Courses / lectures	Seminar: Seminar Computational Materials Science (2 SWS, SoSe 2025) Vorlesung: Modelling Materials with Finite Elements Simulations (SoSe 2025) Vorlesung mit Übung: Modelling Materials with FEM simulations (SoSe 2025)	- - -
3	Lecturers	Dr. Frank Wendler PD Dr. Paolo Moretti	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	1. Finite element simulation methods 2. Dislocation theory and simulation 3. Discrete and continuum microstructural modeling 4. Discretization schemes 5. Network models
6	**Learning objectives and skills**	Students • develop advanced knowledge in the field of computer-aided microstructure modeling techniques. • develop advanced knowledge in discrete methods • develop advanced knowledge in continuum models in conjunction with the appropriate discretization techniques. • understand the theoretical aspects of continuum and discrete microstructure
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (15 Min.) oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46276	**Foundations of phase field modelling**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Advanced Materials Simulation with Phase Field (2 SWS, SoSe 2025)	2,5 ECTS
3	Lecturers	Dr. Frank Wendler	

4	**Module coordinator**	Dr. Frank Wendler
5	**Contents**	1. Continuum modeling; 2. Introduction to the phase field method; 3. Advanced materials simulation with the phase field method; 4. Practicals and hands-on activities
6	**Learning objectives and skills**	Students • gain an extensive knowledge of the phase field method, from the more general aspects to the most advanced current applications • become familiar with the theoretical tools of the phase field method • acquire the practical aspects of its numerical implementations, through extensive practical sessions.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Materials Simulation Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Micro- and Nanostructure Research

1	**Module name** 46291	**Fundamentals of Micro- and Nanostructure Research NT** Fundamentals of micro- and nanostructure research NT	**10 ECTS**
2	Courses / lectures	Übung: Exercise Transmission Electron Microsopy in Material Science 2 (2 SWS, SoSe 2025) Vorlesung mit Übung: Transmission Electron Microscopy in Material Science II (2 SWS, SoSe 2025)	2 ECTS 3 ECTS
3	Lecturers	Dr. Mingjian Wu Prof. Dr. Erdmann Spiecker Dr.-Ing. Benjamin Apeleo Zubiri Dr. Johannes Will	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	The module deals with the fundamentals of micro- and nanostructure research with the focus on todays state-of-the art capabilities of transmission electron microscopy in the investigation of materials down to the atomic scale. The module begins (TEM 1 exercise, and TEM 1 lecture as part of the M1 Pflichtmodul) with the basic physics of fast electrons, their generation and guidance by electromagnetic fields and their interaction with matter in the specimen and the detector. Afterwards various imaging (BF, DF, HRTEM, STEM), diffraction (ED, CBED), spectroscopic (EDXS, EELS, EFTEM) and 3D (ET) techniques including their applications to current research topics will be introduced. The aim is always to give insight into both the contrast mechanisms and physics of as well as the achievable information delivered by the different techniques. The module furthermore focuses on the introduction to Scanning Electron Microscopy (SEM) in Materials Science and Nanotechnology. Amongst others, the following topics are addressed: Components of an SEM instrument Elastic/inelastic electron-probe/sample interactions, interaction volume, generation of secondary and backscattered electrons Contrast mechanisms of different detector systems Topographic und chemically-sensitive imaging Electron diffraction and its application in SEM Scanning Transmission Electron Microscopy (STEM) Quantitative X-ray spectroscopy Focused ion beams (Dual-Beam FIB, He-ion microscopy) Preparation-specific challenges Application examples.
6	**Learning objectives and skills**	**The students acquire specialist skills** • SEM lecture: • Introduction to the basic concepts of and physics behind SEM • TEM 1 & 2 exercise and TEM 2 lecture in addition to TEM 1 lecture (from M1 Pflichtmodul): • Basic concepts of the interaction of fast electrons with matter • Introduction of TEM components and their functionality • Knowledge about the application of high resolution techniques for nanomaterials

		• Verstehen • SEM lecture: • Overview over applications and deeper understanding of SEM and FIB techniques in materials science on the micro- and nanoscale • Enhancement of knowledge through teaching of current SEM applications and state-of-the-art developments in research • TEM 1 & 2 exercise and TEM 2 lecture in addition to TEM 1 lecture (from M1 Pflichtmodul): • In-depth understanding of microscopy techniques for micro- and nanostructure research • In-depth understanding of basic and advanced imaging, diffraction and spectroscopic TEM techniques and their application to material science **How to use** • TEM 1 & 2 exercise: • Hands-on-training on modern analysis software for EM applications • Each topic will be accompanied with suitable exercises • Analysieren • Insight into the structure property relationship of materials
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Micro- and Nanostructure Research Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (30 Min.) oral exam (30 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	TEM: • Goodhews, Humphreys and Beanland: Electron Microscopy and Analysis; • Williams & Carter: Transmission Electron Microscopy; • Reimer & Kohl: Transmission Electron Microscopy; • Fultz & Howe: Transmission Electron Microscopy and Diffractometry of Materials; • Reimer: Transmission Electron Microscopy; • De Graef: Introduction to Conventional Transmission Electron Microscopy; • Reimer: Scanning Electron Microscopy;

		• P. Haasen: Physikalische Metallkunde; • G. Gottstein: Physikalische Grundlagen der Materialkunde; • J. M. Cowley: Diffraction Physics • SEM: • Reimer, Scanning Electron Microscopy, Springer Verlag. Goodhews, Humphreys and Beanland: Electron Microscopy and Analysis Goldstein et al., Scanning Electron Microscopy and X-Ray Microanalysis (2003) N. Yao, Focused Ion Beam Systems, Basics and Applications, Cambridge University Press, 2010. L.A. Gianuzzi, F.A. Stevie, Introduction to Focused Ion Beams. Instrumentation, Theory, Techniques and Practice, Springer, 2005. J. Orloff, M. Utlaut, L. Swanson, High Resolution Focused Ion Beams: FIB and its Applications, Springer, 2003 Lecture notes.

1	**Module name** 46282	**Applied Micro- and Nanostructure Research** Applied micro- and nanostructure research	**5 ECTS**
2	Courses / lectures	Praktikum: Practical Course Electron Microscopy II (2 SWS, SoSe 2025)	3 ECTS
3	Lecturers	Dr. Johannes Will Prof. Dr. Erdmann Spiecker	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	Practical introduction, application and hands-on experience of TEM and SEM techniques for materials characterization. Recommended is the assignment to the module "Scanning Electron Microscopy in Materials Science and Nanotechnology. The practical courses is organized as follows: Practical Course Electron Microscopy I (WS): 3 days of practical course "as block during the first week of the semester break in February Practical Course Electron Microscopy II (SS): 4 days of practical course during the lecture period
6	**Learning objectives and skills**	**The studentswill gain** deeper knowledge and understanding of fundamentals of electron microscopy techniques **Applications** Hands-on experience on SEM and TEM instruments Application of advanced microcopy techniques Evaluieren (Beurteilen) Fundamentals of image and data analysis
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Micro- and Nanostructure Research Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Practical course descriptions

		Lecture notes Transmission Electron Microscopy in Material Science I & II Lecture notes Scanning Electron Microscopy in Materials Science and Nanotechnology

1	**Module name** 46284	**3D Characterization in Materials Science** 3D characterization in materials science	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: 3D Characterization in Materials Science (2 SWS) Praktikum: Practical Course to 3D Characterization in Materials Science (2 SWS)	3 ECTS 2 ECTS
3	Lecturers	Dr.-Ing. Benjamin Apeleo Zubiri Prof. Dr. Erdmann Spiecker	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	The module focuses on the application of 3D characterization methods in materials science. Techniques on different length scales (meters down to angstroms) using different probes (e.g. visible light, X-rays, electrons) are covered. The aim of this module is to give an overview over available techniques, to teach the underlying physical principles and to point out specific advantages, challenges and limits, demonstrated on recent research examples. Focal topics are transmission tomography methods on the nano- and microscale, namely high-resolution X-ray computed tomography (Nano-CT) and electron tomography. Sample preparation, data acquisition, 3D reconstruction, data handling and analysis are taught in both the lecture and the practical course. The theoretical background of 3D reconstruction techniques for transmission tomography is also part of the lecture.
6	**Learning objectives and skills**	**Professional competence** **Knowledge** Overview over 3D characterization techniques on different length scales using different probes, demonstrated on recent research examples **Understanding** Understand the underlying physical principles and specific advantages, challenges and limits of different 3D techniques in materials science **Analyzing** Learn theoretical and practical aspects of sample preparation, data acquisition, 3D reconstruction and analysis of transmission tomography on the nanoscale
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Micro- and Nanostructure Research Master of Science Nanotechnology 20232
10	**Method of examination**	Oral derzeit mündliche Prüfung (15 Minuten) --- currently taking an oral exam (15 minutes)

11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	• G. Hübschen, I. Altpeter, ... H.-G. Herrmann: Materials Characterization Using Nondestructive Evaluation (NDE) Methods. Elsevier. • J. Frank: Electron Tomography - Methods For Three-Dimensional Visualization of Structures in the Cell. Springer. • T. M. Buzug: Computed Tomography. Springer. • Burnett et al. 2014, Correlative Tomography, Scientific Reports 4, 4711. • Hauser et al. 2017, Correlative Super-Resolution Microscopy: New Dimensions and New Opportunities, Chem. Rev. 117, 7428-7456. • Lecture notes.

1	**Module name** 46285	**Scattering Methods for Nanostructured Materials** Scattering methods for nanostructured materials	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lecturers	-	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	The module focuses on the application of scattering methods for crystal structure determination in general (diffraction), the investigation of supported nanostructures and thin films (grazing incidence diffraction and reflectometry) and for the size and shape analysis of nanostructures in solution (small-angle scattering). Basic concepts of Fourier transforms will be applied to the interaction of a primary probe with a periodically ordered object. Moreover, the impact of multiple scattering events on the diffracted intensity and its angular dependence will be discussed in a unified model for neutrons, x-rays and electrons. Those theoretical considerations will built the basis for the understanding of the methods named above. For all methods, current published research examples will be showcased.
6	**Learning objectives and skills**	**The students** Unterstanding professional competences Basics of Fourier transform and convolution Understanding of the interaction of neutrons, x-rays and electrons with atoms and their arrays Physical principles of the interaction of a scattering probe with an extended crystalline lattice Understanding how scattering methods contribute and which kind of information can be extracted for todays challenges in material science **Appliation** Each topic will be accompanied with suitable exercises
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Micro- and Nanostructure Research Master of Science Nanotechnology 20232
10	**Method of examination**	Oral
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester

15	**Teaching and examination language**	english
16	**Bibliography**	• D.S. Sivia: Elementary Scattering Theory • B.E. Warren: X-ray Diffraction • J. M. Cowley: Diffraction Physics • A. Authier: Dynamical Scattering Theory • Als-Nielsen & McMorrow: Elements of modern X-ray physics • J. Daillant and A. Gibaud: X.ray and Neutron Reflectivity: Principles and Applications • Renaud et al. 2009, Probing surface and interface morphology with Grazing Incidence Small Angle X-ray Scattering, Surface Science Reports 64, 255-380. • Rivnay et al. 2012, Quantitative Determination of Organic Semiconductor Microstructure from the Molecular to Device Scale, Chem. Rev. 112, 5488-5519.

1	**Module name** 46239	**Data Science for Electron Microscopy & Machine Learning in Microscopy** Data science for electron microscopy and machine learning in microscopy	**5 ECTS**
2	Courses / lectures	Vorlesung: Data Science for Electron Microscopy (2 SWS) Seminar: Machine Learning in Microscopy	2,5 ECTS -
3	Lecturers		

4	**Module coordinator**	Prof. Dr. Philipp Pelz
5	**Contents**	Introduction to Data Science & Machine Learning Topics in Microscopy, specifically Electron Microscopy
6	**Learning objectives and skills**	• know different data types in microscopy and basic data processing methods • know essential applications and development fields from the mentioned subject areas • classify their own results. • have gained an understanding of industry-relevant work methods
7	**Prerequisites**	- basic programming skills in Python
8	**Integration in curriculum**	semester: 8
9	**Module compatibility**	Micro- and Nanostructure Research Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination (60 minutes) Seminar achievement (30 minutes) derzeit mündliche Prüfung (15 Min.) currently taking an oral exam (15 min.)
11	**Grading procedure**	Written examination (50%) Seminar achievement (50%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 60 h Independent study: 90 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Surface Science and Corrosion

1	**Module name** 46234	**Oberflächentechnik und Elektrochemie** Surface technology and electrochemistry	**10 ECTS**
2	Courses / lectures	Vorlesung: Advanced Corrosion Science (2 SWS, WiSe 2025) Vorlesung: Basics Electrochemistry II (2 SWS, SoSe 2025) Vorlesung: Basics Electrochemistry I (2 SWS, WiSe 2025) Vorlesung: Surface Modification techniques (2 SWS, SoSe 2025) Seminar: Seminar Surface Science and Corrosion (2 SWS, WiSe 2025)	3 ECTS 3 ECTS 3 ECTS 3 ECTS 1 ECTS
3	Lecturers	Prof. Dr. Sannakaisa Virtanen Karthikeyan Hariharan Prof. Dr. Patrik Schmuki Michael Strebl Dr.-Ing. Michael Höhlinger	

4	**Module coordinator**	Prof. Dr. Sannakaisa Virtanen
5	**Contents**	*Advanced Corrosion Science* Recap of fundamental background in electrochemistry and corrosion Introduction to advanced methods in corrosion science: Electrochemical methods (Polarization curve, EIS, EC noise) Local techniques (SVET, SKP, SIET, LEIS) Non electrochemical techniques: Respirometry, mass loss, solution analysis, resitance method Surface analysis (SEM, TEM, EDX, XPS, Auger, ToF SIMS, GDOES, atom probe analysis) Discussion of current issues in corrosion science: Biodegradable metals Passive films und localized corrosion Atmospheric corrosion Corrosion in nuclear waste repositories Corrosion of advanced materials: AM, BMG, high entropy alloys und ultrafine-grained materials Drinking water corrosion, microbially induced corrosion, cathodic protection Inhibitors und smart coatings Mg und Al corrosion Corrosion Modelling, DFT (Corrosion in) Electrochemical energy storage and conversion Corrosion failure case studies and analysis: Discussion of the conditions and mechanisms that led to corrosion failure based on observations and experimental evidence and derivation of a solution to the problem. *Surface Modification Techniques*

Innerhalb der Materialwissenschaften kommt der Oberflächenmodifikation entscheidende Bedeutung zu.
Neben der Verbesserung der Korrosionsbeständigkeit sowie der tribologischen Eigenschaften können dadurch auch gänzlich neue Eigenschaften generiert werden. Im Zuge dieser Lehrveranstaltung werden diverse Methoden der Oberflächenmodifikation und Oberflächenfunktionalisierung beleuchtet. Es werden die Grundlagen aber auch Fallbeispiele derartiger Verfahren erläutert und deren Rolle im Alltäglichen Leben ebenso wie in industriellen Anwendungen Rechnung getragen. Neben den etablierten Methoden werden auch neuartige Ansätze aus den aktuellen Forschungsgebieten des Lehrstuhls erläutert.
The tailored modification of surfaces plays an important role in material science. Besides improving e.g. the corrosion- and tribological-properties of material-surfaces by specific methods and approaches, furthermore completely new properties can be achieved. In this course common methods of surface modification and surface functionalization are elucidated. The theoretical background and examples, indicating the relevance of these methods in everyday life as well as for industrial applications, are presented. In addition to the common methods new highly promising approaches are introduced and discussed.

Berechnung von Korrosionsproblemen
Die World Corrosion Organization (WCO) schätzte 2009 die wirtschaftlichen Schäden durch Korrosion auf weltweit 1,8 Billionen US-Dollar. In Industriestaaten belaufen sich die jährlichen Kosten durch Korrosion auf bis zu 4 Prozent des Bruttoinlandsproduktes, in Deutschland also auf bis zu 104 Milliarden Euro" [Deutsches Lackinstitut]. Die hier angeführten Zahlen zeigen, dass Korrosion ein wirtschaftlich sehr bedeutendes Problem darstellt, dem große Beachtung beigemessen werden muss. Das Lernziel der Vorlesung Berechnung von Korrosionsproblemen" ist es, mittels im Bachelorstudium erworbenen Kenntnissen, Fallbeispiele typischer Korrosionsprobleme fachlich tiefgehend verstehen und beurteilen zu können. Hierfür werden zum einen häufige grundlegende praxisnahe Probleme definiert und beschrieben.
Zum anderen werden durch Abstraktion komplexe Beispiele und Anwendungen auf bekannte Grundlagen heruntergebrochen, quantitativ beschrieben und somit fassbar gemacht.
Basics Electrochemistry
Der Elektrochemie kommt große Bedeutung sowohl im wissenschaftlichen als auch technologischen Kontext zu. Heutige Forschungsarbeiten konzentrieren sich hauptsächlich (aber nicht ausschließlich) auf die Themengebiete Nanotechnologie und Anwendungen der Energietechnik wie Brennstoffzellen, Batteriesysteme und Solarzellen. Prinzipiell widmet sich die Elektrochemie dem Zusammenspiel von Elektrizität und chemischen Reaktionensabläufen in der Art, dass freie chemische Energie, die mit einer Reaktion einhergeht, in elektrische Energie konvertiert wird (z.B. Brennstoffzellen) oder aber elektrische Energie Verwendung findet um beispielsweise

		stabile Verbindungen zu zersetzen (z.B. Chlorgaserzeugung). Die Lehrveranstaltung leitet die Studierenden an, die Grundlagen der Elektrochemie zu verstehen und erläutert grundlegende Methoden und Arbeitsweisen um elektrochemische Reaktionen und darauf basierende Anwendungen zu verstehen. Electrochemistry plays an important role in scientific and technological fields. Nowadays, the research areas are focused, but not limited, on nanotechnology and energy devices, i.e. fuel cells, battery systems and solar cells. In principle, the electrochemistry involves the study of relationship between electricity and chemical reactions, such that chemical free energy associated with a reaction is converted into electrical energy (e.g. fuel cells) or conversely, electricity is used to decompose stable chemical systems (e.g. production of chlorine). The lecture program provides an opportunity for students to understand the basics of electrochemistry and provide the fundamental tools for understanding electrochemical-reactions and electrochemical-devices.
6	**Learning objectives and skills**	***Advanced Corrosion Science*** **The students are able to:** • Identify, distinguish, and explain corrosion mechanism and different forms of corrosion. • Illustrate and explain electrochemical, local, non-electrochemical and surface analysis methods that are used in corrosion science. • Interpret results of the characterisation methods described above • Explain the different concepts of smart coatings and self-healing coatings including triggers and release mechanisms of inhibitors. • Present the details that play a role atmospheric corrosion processes like salts, relative humidity, electrolyte film thickness, time of wetness, influence of gases, wet dry cycling and corrosion product formation. • Explain different test methods for atmospheric corrosion, like lab exposure, accelerated corrosion tests and field exposure tests. • Discuss special features in the corrosion mechanisms of Mg and Al alloys (anomalous H2 evolution). • Review different mechanisms of localized corrosion and explain the significance of pit initiation and pit growth, critical pitting potential, critical pitting temperature and repassivation in localized corrosion. • Explain cathodic and anodic paint disbonding or delamination and how it can be studied using SKP. • Assess findings of scientific investigations of corrosion failure, determine corrosion mechanisms that lead to the corrosion issue and develop a concept for solving the corrosion problem. • Explain mechanisms of different types of corrosion inhibitors.

- Summarize corrosion properties of advanced materials like high entropy alloys, bulk metallic glasses, additive manufactured materials or ultrafine-grained materials.
- Describe corrosion related aspects of nuclear waste storage and the influence of radiation on corrosion.
- Compare different types of metals in their applicability as a biodegradable metal and explain surface treatments to control the degradation behavior.
- Understand the complexity of simulated body fluids and possible discrepancy between in vitro and in vivo experiments.
- Describe mechanisms of microbially induced corrosion, dezincification.
- Explain cathodic protection strategies by sacrificial anodes and impressed current cathodic protection.

Surface Modification Techniques
Die Studierenden

- können die Grundlagen von Korrosionsmechanismen und -arten wiedergeben.
- lernen verschiedene Methoden der Oberflächenvorbehandlung kennen.
- können abschätzen, welche Oberflächenvorbehandlung für die Entfernung verschiedener Verunreinigungen eingesetzt werden können.
- können den zugrundeliegenden Mechanismus einer Konversionsbeschichtung am Beispiel der Phosphatierung und Chromatierung beschreiben.
- erklären die Mechanismen von elektrochemischer Abscheidung und elektrophoretischer Beschichtung
- erkennen den Zusammenhang verschiedener Schritte und Parameter der Oberflächenvorbereitung auf die finale Oberflächenqualität einer Beschichtung.
- lernen die Bestandteile und Wirkungsweise einer Reinigungslösung kennen
- Die Studierenden werden auf Besonderheiten hinsichtlich des Umweltschutzes bei der Oberflächentechnik sensibilisiert.
- Erklären die verschiedene Verfahren und Beschichtungsmechanismen von PVD und CVD Prozessen.
- Erklären von Verfahren des thermischen Spritzens und von Sol-Gel Beschichtungen
- können chemische und elektrochemische Konversionsschichten (Phosphatierung, Chromierung, Anodisierung)
- Erläutern Besonderheiten verschiedener organischer Beschichtungen (Lacke).
- Erklären selbstorganisierender Monolagen und Konzepte zur Erzeugung superhydrophober Oberflächen
- Beschreiben den Mechanismus der Ausbildung von selbstorganisierenden anodische Oxidschichten (Nanoporen und Nanoröhren).

- Illustrating the mode of action of chemical mechanical pretreatment.
- Describing plasma aided methods, Laser and electron beam methods as well as ion implantation.
- Illustrating the mode of action of chemical conversion layers (phosphatization, chromating), electrodeposition, electrophoresis, electrochemical conversion layers (anodizing) and CVD/PVD techniques.
- Understanding the basics of organic coatings (paints and lacquers), self-assembled monolayers, self-organized anodic oxide layers (Nanopores, Nanotubes).

Berechnung von Korrosionsproblemen
Die Studierenden sind in der Lage:

- den Wirkzusammenhang von Kinetik und Potential bei Korrosionsreaktionen quantitativ zu erfassen.
- Den Unterschied und die Einflüsse auf Diffusions- und Aktivierungskontrolle zu erklären
- Korrosionsvorgänge anhand schematischer Stromdichte-Potential Kurven zu veranschaulichen
- Pourbaix-Diagramme zu erstellen zu verstehen und anzuwenden.
- die Nernst Gleichung anzuwenden und leiten sie her.
- Fragestellungen der Hochtemperaturoxidation zu bewerten.
- Möglichkeiten des Korrosionsschutzes zu beurteilen.

Quantitative elucidation of the cause-effect relationship between kinetics and potential, Construction of Pourbaix diagrams, applying nernst equation, Assessment of high-temperature oxidation behaviors of metals and alloys, Evaluation of corrosion-protection approaches

Basics Electrochemistry

Die Studierenden

- definieren und beherrschen rechnerisches Anwenden thermodynamischer Grundbegriffe und Modelle (Enthalpie, Entropie, Gibbs-Energie, chemische Gleichgewichte).
- vergleichen von Elektrolyten (Wässrige Lösungen, Organische Lösungen, Festphasenelektrolyte.
- vergleichen verschiedener Elektrodenarten und deren Elektrodenpotential.
- wenden die Nernst-Gleichung an.
- definieren elektrochemischer Systeme (Elektrolysezellen, Galvanische Zellen).
- verstehen Elektroden/Elektrolyt-Grenzflächen (elektrochemische Doppelschicht).
- können die Zusammenhanges von Reaktionsrate und Stromstärke diskutieren.

		• bewerten die Kinetik von Elektrodenreaktionen (stofftrans portkontrolliert, ladungsdurchtrittskontrolliert, reaktionskontrolliert). • können die Butler-Volmer-Gleichung herleiten. • verstehen die theoretischen Grundlagen instrumenteller Techniken und technologischer Anwendungen (Brennstoffzellen, Batteriesysteme, elektrochemische Bauteile und Anwendungen). **The students** • Defining and operating with fundamental thermodynamic concepts and models (enthalpy, entropy, free energy, chemical equilibrium). • Comparing of Electrolytes (aqueous solutions, organic solutions, solid phase electrolytes. • Comparing different types of electrodes and their electrode potential. Applying the Nernst equation. • Defining electrochemical systems (electrolytic cells and galvanic cells). • Elucidating Electrode-solution interfaces (electric double layer). • Discussing the relationship between electrochemical reaction rate and current. • Assessing electrode kinetics (mass transport control, charge transfer control, reaction control). • Deriving the Butler-Volmer equation. • Describing the theoretical background of instrumental techniques and technologies (fuel cells, battery systems, electrochemical devices).
7	**Prerequisites**	Immatrikulation im MA-Studium
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Oral mündliche Prüfung (30 Min.) oral exam (30 min.)
11	**Grading procedure**	Oral (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 120 h Independent study: 180 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Vorbereitende LiteraturWird im Zuge der Lehrveranstaltungen vorgestellt.

1	**Module name** 46235	**Praktikum zur Korrosion und Oberflächenanalyse** Laboratory course: Corrosion and surface analysis	**5 ECTS**
2	Courses / lectures	Praktikum: Praktikum zur Korrosion und Oberflächenanalyse (3 SWS)	5 ECTS
3	Lecturers	Dr. Anca Valentina Mazare	

4	**Module coordinator**	Prof. Dr. Sannakaisa Virtanen
5	**Contents**	Im Ergänzungsmodul Praktikum zur Korrosion und Oberflächenanalyse werden unter Anleitung von Betreuern im Rahmen eines Praktikums Versuche aus den Bereichen Korrosion und Oberflächentechnik abgehandelt. Das Modul besteht aus 4 einzelnen Versuchen. Die Studierenden erlernen im Zuge dieser Lehrveranstaltung neben dem selbstständigen Durchführen elektrochemischer Messungen, dem Anodisieren sowie der Charakterisierung der Hochtemperaturoxidationsbeständigkeit von Metallen und Legierungen, die Anwendung verschiedener Verfahren der Oberflächenanalyse. Neben diesen genannten methodischen Lernzielen wird fachliches Wissen über eine Auswahl besonders wichtiger Werkstoffe im Kontext der Korrosion und Oberflächentechnik vermittelt, wobei die Studierenden lernen Messergebnisse zu evaluieren und qualitative sowie quantitative Urteile über das Werkstoffverhalten zu fällen. **English version** Within the practical lab course students absolve experiments belonging to the field of Surface Science & Electrochemistry & Corrosion guided by experienced supervisors. The practical course is subdivided in 4 single experiments. The students learn the practical knowledge about conducting electrochemical measurements, anodization, and characterizing the high-temperature oxidation behavior of metals and alloys. Therefore a variety of surface-sensitive characterization techniques are introduced. Beside the latter methodical issues, furthermore expertise knowledge for a selection of especially important materials that are typically important in the context of corrosion and surface science is taught along the way. The students learn to evaluate measurement data and to interpret qualitative- and quantitatively the measured material behavior.
6	**Learning objectives and skills**	Die Studierenden • bewerten den Einfluss von Legierungselementen und Beschichtungen auf das Degradationsverhalten von Implantatwerkstoffen (Magnesium), Implantatwerkstoffe • kennen und verstehen die Herausforderungen im Legierungsdesign, • bewerten den Einfluss verschiedener Oberflächenvorbehandlungen sowie Oxidationsparameter auf die Ausbildung schützender Oxidschichten im Zuge der Hochtemperaturoxidation,

		• verstehen die Vorrausetzungen und Mechanismen die der Ausbildung schützender Oxidschichten (Hochtemperaturoxidation) zu Grunde liegen, • erzeugen anodisierten Bauteiloberflächen, • bewertuen Tof-SIMS Daten, • wenden Rasterelektronenmikroskopie (REM) an **English version** Evaluation of the influence of alloying elements and coatings on the degradation behavior of implant materials, Implants elucidation of the challenges in alloy design, Assessment of the influence of different surface modification techniques and oxidation parameters on the formation of protective oxide scales during high temperature oxidation, Creating anodized components surfaces, Evaluation and interpretation of Tof-SIMS data, Application of Scanning Electron Microscopy (SEM)
7	**Prerequisites**	Voraussetzungen für die TeilnahmeFundierte Kenntnisse in der Elektrochemie und Hochtemperaturoxidation. Vorlesungen vom LS LKO/ WW4 im Bachelorstudium oder äquivalente Kenntnisse. Immatrikulation im MA-Studium.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Variable Hausarbeit (=Praktikumsprotokolle; Leistungsnachweis) und schriftliche Prüfung nach Beendigung des Praktikums Homework (=internship protocols; proof of performance) and written examination after completion of the internship
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 70 h Independent study: 80 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Vorbereitende LiteraturWird im Zuge der Lehrveranstaltung vorgestellt.

1	**Module name** 46236	**Grundlagen der Elektrochemie - Vertiefung** Fundamentals of electrochemistry - Advanced	**5 ECTS**
2	Courses / lectures	Übung: Exercise Basic electrochemistry II (2 SWS) Vorlesung: Basic Electrochemistry II (2 SWS)	2 ECTS 3 ECTS
3	Lecturers	Prof. Dr. Sannakaisa Virtanen Prof. Dr. Patrik Schmuki	

4	**Module coordinator**	Prof. Dr. Patrik Schmuki
5	**Contents**	Der Elektrochemie kommt große Bedeutung sowohl im wissenschaftlichen als auch technologischen Kontext zu. Heutige Forschungsarbeiten konzentrieren sich hauptsächlich (aber nicht ausschließlich) auf die Themengebiete Nanotechnologie und Anwendungen der Energietechnik wie Brennstoffzellen, Batteriesysteme und Solarzellen. Prinzipiell widmet sich die Elektrochemie dem Zusammenspiel von Elektrizität und chemischen Reaktionensabläufen in der Art, dass freie chemische Energie, die mit einer Reaktion einhergeht, in elektrische Energie konvertiert wird (z.B. Brennstoffzellen) oder aber elektrische Energie Verwendung findet um beispielsweise stabile Verbindungen zu zersetzen (z.B. Chlorgaserzeugung). Die Lehrveranstaltung leitet die Studierenden an, die Grundlagen der Elektrochemie zu verstehen und erläutert grundlegende Methoden und Arbeitsweisen um elektrochemische Reaktionen und darauf basierende Anwendungen zu verstehen. ---------- Electrochemistry plays an important role in scientific and technological fields. Nowadays, the research areas are focused, but not limited, on nanotechnology and energy devices, i.e. fuel cells, battery systems and solar cells. In principle, the electrochemistry involves the study of relationship between electricity and chemical reactions, such that chemical free energy associated with a reaction is converted into electrical energy (e.g. fuel cells) or conversely, electricity is used to decompose stable chemical systems (e.g. production of chlorine). The lecture program provides an opportunity for students to understand the basics of electrochemistry and provide the fundamental tools for understanding electrochemical-reactions and electrochemical-devices.

6	**Learning objectives and skills**	Die Studierenden können
		•
		  ◦ die Grundlagen der Elektrochemie anwenden (Thermodynamik, Kinetik)
		  ◦ beschreiben wie Elektrochemie angewandt werden kann um dringende Probleme zu lösen im Hinblick auf eine nachhaltigere Gesellschaft
		  ◦ die Funktionsprinzipien von elektrochemischen Energiespeichersystemen wie Batterien, Brennstoffzellen/ Elektrolyseuren und Superkondensatoren beschreiben
		  ◦ die Funktionsprinzipien und aktuelle Herausforderungen in der Forschung bezogen auf Photokatalyse und Elektrokatalyse erklären

		○ elektrochemische Methoden kennen und elektrochemische Messdaten lesen und verstehen ○ die elektrochemischen Reaktionen beim Galvanisieren beschreiben • ○ den Kontext verstehen Elektrochemie auf reale Probleme anzuwenden ○ Daten aus der Elektrochemie lesen und verstehen ○ Informationen aus Veröffentlichungen ziehen ○ Ergebnisse zusammenfassen und präsentieren ---------- The students are able to: • ○ Apply the fundamentals of electrochemistry (thermodynamics, kinetics) ○ Describe how electrochemistry can be applied to solve pressing issues towards a more sustainable society ○ Describe the working principles of electrochemical energy storage systems such as batteries, fuel cells/electrolyzers and supercapacitors ○ Explain the the working principle and current research challenges associated with photocatalysis and electrocatalysis ○ Know about electrochemical methods and are able to read and understand electrochemical measurement data ○ Describe the electrochemical reactions that take place during electroplating • ○ Understand the context of applying electrochemistry to real-world problems ○ Read and interpret electrochemical data ○ Extract information from published articles ○ Summarize and present the results
7	**Prerequisites**	Belegung der Module M1, M6 oder M8. Immatrikulation im MA-Studium. Assignment of the modules M1, M6 or M8. Enrollment in the MA course.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination Klausur (45 Min.) ---------- written exam (45 min.)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 45 h Independent study: 105 h

14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Vorbereitende LiteraturWird im Zuge der Lehrveranstaltung vorgestellt.

1	**Module name** 46237	**Oberflächenanalyse I** Surface analysis I	**5 ECTS**
2	Courses / lectures	Seminar: Seminar Surface Science and Corrosion (2 SWS)	1 ECTS
3	Lecturers	Prof. Dr. Patrik Schmuki	

4	**Module coordinator**	Prof. Dr. Patrik Schmuki
5	**Contents**	*Surface Analysis I + II (Vl+Ü)* The generation of nanostructured materials gained relevance in the recent years and efficient characterization methods were developed, permitting insight into the topographical and chemical nanostructure of materials. The scope of this course covers a range of surface analytical instruments, discussing their principle mode of operation, application and data interpretation. All discussed instruments are also available at the chair and tutorials at the machines are a part of the lecture. The fabrication of nanostructured materials from particles to complex 3 dimensional structures is the topic of the second part of this lecture. Die Strukturierung von Werkstoffoberflächen auf der Nanoskala erlangte in jüngster Vergangenheit große Bedeutung was nicht zuletzt auf der Entwicklung hocheffizienter Charakterisierungsmethoden fußt. Diese erlauben eine hochauflösende Analyse der topografischen sowie chemischen Natur der Oberfläche. Im Zuge dieser Lehrveranstaltung (Teil I) werden eine Vielzahl Oberflächenanalytischer Verfahren und Instrumente erläutert und deren Funktionsprinzip und etwaige Betriebsmodi besprochen, wobei auch auf die Messdateninterpretation Wert gelegt wird. Für die am LS vorhandenen Verfahren erfolgt außerdem eine Begehung der Labore wobei die Studierenden einen konkreten Eindruck der diversen Techniken erhalten können. Im zweiten Teil der Lehrveranstaltung (Teil II) wird die Darstellung nanostrukturierter Werkstoffe besprochen. Hierbei wird auf Partikel bis hin zu komplexen dreidimensionalen Strukturen eine große Bandbreite der Oberflächenmodifikation abgedeckt. *Seminar Surface Science and Corrosion* Das Seminar Surface Science and Corrosion bietet die Gelegenheit Einblicke in den aktuellen Stand der Forschungsfelder des Lehrstuhls zu erlangen. Hierbei werden Fallbeispiele präsentiert und diskutiert und so ein tiefgehendes Verständnis der Messmethoden, welche in der VL Surface Analysis vermittelt werden, ermöglicht. Neben dieser inhaltlichen Komponente der Art eines Frontalunterrichtes, ist es möglich und sehr erwünscht die Thematiken zu diskutieren. Den Studierenden ist es hierbei neben dem Erwerb von Fachwissen möglich, einen ersten Eindruck vom Ablauf wissenschaftlicher Konferenzen bzw. Tagungen zu erhalten. The seminar Surface science and Corrosion offers the opportunity to gather insights into the current research areas of the chair. In the course of the seminar results are presented and discussed what enables a profound understanding of the techniques that are taught within the lecture Surface Analysis. Besides this factual part, the students have furthermore the chance (and are supposed) to ask questions to

		the speakers. This is an important insight into the academic working environment that might be especially relevant for prospective PhD-students.
6	**Learning objectives and skills**	Surface Analysis I + II (Vl+Ü): **Die Studierenden** • verstehen fundamentaler Konzepte im Bereich Kristallographie • können Vor- und Nachteile verschiedener Verfahren der Oberflächencharakterisierung kritisch diskutieren • verstehen die theoretischen Grundlagen von STM/AFM, SEM/EDX, XPS/Auger, XRD, ToF-SIMS • kennen verschiedener Herstellungsmethoden für Nanostrukturen und Anwendung von CVD. • verstehen das Prinzip des Sol-Gel Prozesses • kennen die Anwendungen nanostrukturierter Oberflächen • kennen und verstehen Verfahren zur Oberflächenanalyse bei Nanomaterialien **The students:** • Describing of basic concepts in crystallography. • Evaluating different kinds of surface characterization techniques (pros and cons). • Elucidating the theoretical background of STM/AFM, SEM/EDX, XPS/Auger, XRD, ToF-SIMS. • Defining fabrication methods of nanostructures and elucidation of nanostructured CVD. • Describing the sol-gel process. • Reporting applications of nanostructured surfaces. • Elucidation of surface analytical techniques for nanomaterial characterization. **Seminar Surface Science and Corrosion** **Die Studierenden** • wenden wissenschaftlicher Verfahren und Techniken in der Forschung (Beispiele)an • haben Erfahrung bezüglich des Ablaufs und der Gepflogenheiten im wissenschaftlichen Arbeitsumfeld durch aktive Teilnahme an Diskussionen. • besitzen Softskills als Vorbereitung auf eine wissenschaftliche Karriere **The students** • Appliance of scientific techniques in research (discussion of examples). • Generating experience in scientific community. • Participation in scientific discussions. • Acquiring of soft-skills for futural scientific careers.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232

		Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination schriftliche Prüfung (45 Min.) written exam (45 min.)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Vorbereitende LiteraturWird im Zuge der Lehrveranstaltung bekannt gegeben.

1	**Module name** 46238	**Oberflächenanalyse II** Surface analysis II	**5 ECTS**
2	Courses / lectures	Seminar: Seminar Surface Science and Corrosion (2 SWS) Übung: Übung Surface Analysis II (1 SWS) Vorlesung: Surface Analysis II (2 SWS)	1 ECTS 1 ECTS 3 ECTS
3	Lecturers	Prof. Dr. Sannakaisa Virtanen Dr. Anca Valentina Mazare	

4	**Module coordinator**	Prof. Dr. Patrik Schmuki
5	**Contents**	***Surface Analysis I + II (Vl+Ü)*** The generation of nanostructured materials gained relevance in the recent years and efficient characterization methods were developed, permitting insight into the topographical and chemical nanostructure of materials. The scope of this course covers a range of surface analytical instruments, discussing their principle mode of operation, application and data interpretation. All discussed instruments are also available at the chair and tutorials at the machines are a part of the lecture. The fabrication of nanostructured materials from particles to complex 3 dimensional structures is the topic of the second part of this lecture. Die Strukturierung von Werkstoffoberflächen auf der Nanoskala erlangte in jüngster Vergangenheit große Bedeutung was nicht zuletzt auf der Entwicklung hocheffizienter Charakterisierungsmethoden fußt. Diese erlauben eine hochauflösende Analyse der topografischen sowie chemischen Natur der Oberfläche. Im Zuge dieser Lehrveranstaltung (Teil I) werden eine Vielzahl Oberflächenanalytischer Verfahren und Instrumente erläutert und deren Funktionsprinzip und etwaige Betriebsmodi besprochen, wobei auch auf die Messdateninterpretation Wert gelegt wird. Für die am LS vorhandenen Verfahren erfolgt außerdem eine Begehung der Labore wobei die Studierenden einen konkreten Eindruck der diversen Techniken erhalten können. Im zweiten Teil der Lehrveranstaltung (Teil II) wird die Darstellung nanostrukturierter Werkstoffe besprochen. Hierbei wird auf Partikel bis hin zu komplexen dreidimensionalen Strukturen eine große Bandbreite der Oberflächenmodifikation abgedeckt. ***Seminar Surface Science and Corrosion*** Das Seminar Surface Science and Corrosion bietet die Gelegenheit Einblicke in den aktuellen Stand der Forschungsfelder des Lehrstuhls zu erlangen. Hierbei werden Fallbeispiele präsentiert und diskutiert und so ein tiefgehendes Verständnis der Messmethoden, welche in der VL Surface Analysis vermittelt werden, ermöglicht. Neben dieser inhaltlichen Komponente der Art eines Frontalunterrichtes, ist es möglich und sehr erwünscht die Thematiken zu diskutieren. Den Studierenden ist es hierbei neben dem Erwerb von Fachwissen möglich, einen ersten Eindruck vom Ablauf wissenschaftlicher Konferenzen bzw. Tagungen zu erhalten.

		The seminar Surface science and Corrosion offers the opportunity to gather insights into the current research areas of the chair. In the course of the seminar results are presented and discussed what enables a profound understanding of the techniques that are taught within the lecture Surface Analysis. Besides this factual part, the students have furthermore the chance (and are supposed) to ask questions to the speakers. This is an important insight into the academic working environment that might be especially relevant for prospective PhD-students.
6	**Learning objectives and skills**	**Surface Analysis I + II (Vl+Ü):** **Die Studierenden** • beschreiben fundamentale Konzepte im Bereich Kristallographie. • diskutieren die Vor- und Nachteile verschiedener Verfahren der Oberflächencharakterisierung. • verstehen die theoretischen Grundlagen von STM/AFM, SEM/EDX, XPS/Auger, XRD, ToF-SIMS. • kennen verschiedene Herstellungsmethoden für Nanostrukturen und Anwendung von CVD. • verstehen den sol-gel Prozesses und könnenihn wiedergeben. • kennen versiedene Anwendungen nanostrukturierter Oberflächen. • können Verfahren zur Oberflächenanalyse bei Nanomaterialien kritisch diskutieren. **The students** • Describing of basic concepts in crystallography. • Evaluating different kinds of surface characterization techniques (pros and cons). • Elucidating the theoretical background of STM/AFM, SEM/EDX, XPS/Auger, XRD, ToF-SIMS. • Defining fabrication methods of nanostructures and elucidation of nanostructured CVD. • Describing the sol-gel process. • Reporting applications of nanostructured surfaces. • Elucidation of surface analytical techniques for nanomaterial characterization. **Seminar Surface Science and Corrosion** **Die Studierenden:** • wenden wissenschaftliche Verfahren und Techniken in der Forschung (Beispiele) an. • haben Erfahrung in Bezug auf Ablauf und Gepflogenheiten im wissenschaftlichen Arbeitsumfeld durch aktive Teilnahme an Diskussionen. • erwerben Softskills (VortraDarstellung / Diskussion) zur Vorbereitung auf eine wissenschaftliche Karriere. **The students**

		• Appliance of scientific techniques in research (discussion of examples). Generating experience in scientific community. Participation in scientific discussions. • Acquiring of soft-skills for futural scientific careers.
7	**Prerequisites**	Belegung des Wahlmoduls 2: Oberflächenanalyse I Immatrikulation im MA-Studium --- Enrollment in elective module 2: Surface Analysis I Enrollment in the MA program
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	1. and 2. Scientific-technical elective module Master of Science Nanotechnology 20232 Surface Science and Corrosion Master of Science Nanotechnology 20232
10	**Method of examination**	Written examination schriftliche Prüfung (45 Min.) written exam (45 min.)
11	**Grading procedure**	Written examination (100%)
12	**Module frequency**	Only in summer semester
13	**Workload in clock hours**	Contact hours: 75 h Independent study: 75 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Wird im Zuge der Lehrveranstaltung bekannt gegeben.