Friedrich-Alexander-Universität
Erlangen-Nürnberg

Module description

for the degree programme

Master of Science Advanced Materials and Processes

(Version of examination regulation: 20242)

for the winter term 2026/2027

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1	**Module name** 42758	**Basics in Advanced Processes**	**5 ECTS**
2	Courses / lectures	Vorlesung: Basics in Advanced Processes 1 MAP (2 SWS) (WiSe 2026) Vorlesung: Basics in Advanced Processes 2: Chemical Analysis and Structure Determination (2 SWS) (SoSe 2026)	2,5 ECTS 2,5 ECTS
3	Lecturers	Prof. Dr. Marco Haumann Dr.-Ing. Detlef Freitag Dr. Peter Schulz Prof. Dr.-Ing. Malte Kaspereit Prof. Dr. Robin Klupp Taylor Dr. Florian Wisser	

4	**Module coordinator**	Prof. Dr. Robin Klupp Taylor
5	**Contents**	This module provides students with the fundamentals and examples of chemical processes along with an overview of analytical techniques which support modern process development and product design. Winter semester lecture course - Basics in Advanced Processes 1 The course commences with an introduction to chemical processes and their principal characteristics. An overview of practical and economic aspects of chemical process design is given. With case studies, the concepts of unit operations (especially mechanical processes of mixing and separation and thermal processes of separation including distillation and gas scrubbing) are introduced. Fundamental topics in heat and mass transport and chemical conversion are then presented before their application to chemical reactor design is considered. The lecture course ends with a series of case studies covering highly relevant chemical processes including ammonia synthesis, steam cracking and fluid catalytic cracking, silicon production and hydroformylation. Summer semester lecture course - Basics in Advanced Processes 2 (Chemical Analysis and Structure Determination) In this course the following analytical techniques are presented along with practical examples from industrial processes and the scientific literature: • Liquid and gas chromatography • Inverse gas chromatography (IGC) / headspace analysis (HS-GC) • X-ray diffraction • Gas adsorption/desorption and porosimetry • Thermal analysis • Mass spectrometry • Nuclear magnetic resonance (NMR) techniques incl. liquid state NMR, solid state NMR and magnetic resonance imaging (MRI)

		• Particle sizing techniques based on light scattering • Non-linear optical techniques for interfacial analysis
6	**Learning objectives and skills**	Students who successfully participate in this module can: • Identify the key characteristics of chemical processes and their design considerations • Classify different unit operations used in chemical processes • Use concepts from heat and mass transport and chemical conversion along with unit operations to design elementary chemical processes • Describe the operation of several key chemical processes used in industry • Explain the fundamental operating principles of a range of analytical techniques and identify their limitations • Select appropriate analytical techniques to determine the physical or chemical characteristics of an intermediate or product of a chemical process
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1;2
9	**Module compatibility**	Pflichtmodul Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (60 minutes) Written examination (60 minutes) Written examination (120 minutes)
11	**Grading procedure**	Written examination (50%) Written examination (50%) Written examination (100%)
12	**Module frequency**	Every semester
13	**Workload in clock hours**	Contact hours: 30 h Independent study: 120 h
14	**Module duration**	2 semester
15	**Teaching and examination language**	english
16	**Bibliography**	Winter semester lecture course - Basics in Advanced Processes 1 • A. Jess, P. Wasserscheid, Chemical Technology. Wiley, Weinheim, 2013 (First Ed.) / 2020 (Second Ed.). FAU library holdings: First Edition | Second Edition

- W.L. McCabe, J.C. Smith, P. Harriott, Unit operations of chemical engineering, seventh. ed., McGraw Hill Education, Boston [etc.], 2005. FAU Library holdings

Summer semester lecture course - Basics in Advanced Processes 2 (Chemical Analysis and Structure Determination)

- R.J. Anderson, D.J. Bendell, P.W. Groundwater, Organic Spectroscopic Analysis, Royal Society of Chemistry, Cambridge, 2004. Full Text
- M.E. Brown, Introduction to thermal analysis: Techniques and applications, Reprint, Kluwer academic publ, Dordrecht, London, Boston, 2001. FAU library holdings
- M. Che, J.C. Védrine (Eds.), Characterization of solid materials and heterogeneous catalysts: From structure to surface reactivity, Wiley -VCH Verlag, Weinheim, 2012. Full Text
- P. Haines, Principles of Thermal Analysis and Calorimetry, Royal Society of Chemistry, Cambridge, 2002. Full Text
- E. de Hoffmann, V. Stroobant, Mass spectrometry: Principles and applications third ed., Wiley; Chichester, 2007.FAU library holdings
- R. Jenkins, R.L. Snyder, Introduction to X-Ray Powder Diffractometry, first ed., John Wiley & Sons, New York, NY, 2012. Full Text
- J. Keeler, Understanding NMR spectroscopy, Reprinted, Wiley, 2007. FAU library holding (Online texts and resources from the same author here)
- S.M. Khopkar, Basic concepts of analytical chemistry, third ed., New Academic Science, Tunbridge Wells, 2012. Full Text
- J.M. Miller, Chromatography: Concepts and contrasts, second ed., Wiley, Hoboken, NJ, 2009. Full Text
- J.W. Niemantsverdriet, Spectroscopy in Catalysis: An Introduction, third ed., Wiley, Weinheim, 2007. Full Text
- S. Podzimek, Light scattering, size exclusion chromatography, and asymmetric flow field flow fractionation powerful tools for the characterization of polymers, proteins, and nanoparticles, first ed., Wiley, Hoboken, 2011. Full Text
- R. Xu, Particle Characterization: light scattering methods, first ed., Springer Netherlands, Dordrecht, 2000. FAU library holdings

1	**Module name** 42759	**Basics in Biomaterials and Bioprocessing**	**5 ECTS**
2	Courses / lectures	Vorlesung: Basics in Biomaterials and Bioprocessing 1 (2 SWS) (WiSe 2026) Vorlesung: Biomaterial Interfaces und Werkstoffoberflächen in der Medizin/Material surfaces in medicine (2 SWS) (SoSe 2027)	2,5 ECTS -
3	Lecturers	Prof. Dr.-Ing. Aldo Boccaccini Dr. Julia Will Prof. Dr. Kathrin Castiglione Dr.-Ing. Irem Ünalan	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	*Basics in Biomaterials and Bioprocessing 1*: This course gives a general introduction to Biomaterials and Bioprocessing. In the Biomaterials section, the processing, properties and application of the different material groups (Metals, ceramics, polymers and composite) used in medical applications are discussed. Different examples of biomaterials for orthopaedic devices are presented. Basics of materials for tissue engineering are given with emphasis on porous (scaffolds (processing, application and properties). In the Bioprocessing part, fundamental knowledge about biological macromolecules (polysaccharides, phospholipids, proteins, DNA, RNA) and biological membranes is given. Building on this, enzyme kinetics and enzyme immobilization, growth kinetics of cells, as well as mass balances in batch, fed-batch and continuous fermentation are presented. Finally, different types of bioreactors (stirred-tank, air-lift and bubble-columns, wave-bags, roller bottles) are introduced and exemplary bioprocesses are discussed. *Basics in Biomaterials and Bioprocessing 2: Biomaterial Interfaces and 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.

6	**Learning objectives and skills**	*Basics in Biomaterials and Bioprocessing 1:* The students • acquire basic knowledge on the processing, microstructure and properties of a wide range of biomaterials, e.g. materials for biomedical applications • appreciate the specific properties required for successful biomedical applications of materials and understand biocompatibility concepts • apply their knowledge in order to select biomaterials for specific biomedical applications, e.g. bone implants, stents, wound healing materials, tissue scaffolds • acquire fundamental knowledge about biological macromolecules, membranes and cells and are able to mathematically describe their behaviour • can select a suitable method for the immobilization of a given protein as well as a suitable reactor and process mode for a given biotechnological process. *Biomaterial Interfaces and Material Surfaces in Medicine*: The students -acquire basic knowledge on different aspects of biomaterial interfaces, in particular about the interaction between different biomaterials (polymers, metals, ceramics and composites) with the biological environment. • can apply their knowledge in order to judge the success of the different biomaterials • know and can explain methods of surface characterization
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1;2
9	**Module compatibility**	Pflichtmodul Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (60 minutes) Written examination (60 minutes) Written examination (120 minutes)
11	**Grading procedure**	Written examination (50%) Written examination (50%) 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**	*Basics in Biomaterials and Bioprocessing 1:*

		• Biomaterials Science, 2nd ed., B. D Ratner et al. (eds.), Elsevier, 2004. • Biomaterials Fabrication and Processing, P.K.Chu, X. Liu (eds.), CRR Press, 2008 • Tissue Engineering using Ceramics and Polymers, A. R. Boccaccini, J. E. Gough (Eds.), Woodhead Publ. Ltd., 2007 • Molecular Biology of the Cell, B. Alberts et al., 6th edition, Norton & Company, 2014 • K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, VCH, 2005 • Pauline M. Doran, Bioprocess Engineering Principles, Second Edition, Academic Press, 2013 *Biomaterial Interfaces and 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

1	**Module name** 42760	**Basics in Computational Materials Science and Process Simulation**	**5 ECTS**
2	Courses / lectures	Vorlesung: Basics in Computational Materials Science and Process Simulation 1 (2 SWS) Vorlesung: Basics in Computational Materials Science and Process Simulation 2 (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Prof. Dr. Michael Engel PD Dr. Frank Wendler Dr.-Ing. Manuel Münsch	

4	**Module coordinator**	Prof. Dr. Michael Engel
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**	semester: 1;2
9	**Module compatibility**	Pflichtmodul Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (60 minutes) Written examination (60 minutes) Written examination (120 minutes)
11	**Grading procedure**	Written examination (50%) Written examination (50%) Written examination (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** 42761	**Basics Nanomaterials and Nanotechnology**	**5 ECTS**
2	Courses / lectures	Vorlesung: Basics in Nanomaterials and Nanotechnology 1 - Mechanical and Optical Properties (2 SWS) Vorlesung mit Übung: Basics in Nanomaterials and Nanotechnology 2 - Nano Characterization (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lecturers	Prof. Dr. Peter Felfer Prof. Dr. Nicolas Vogel	

4	**Module coordinator**	Prof. Dr. Peter Felfer
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**	semester: 1;2
9	**Module compatibility**	Pflichtmodul Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (60 minutes) Written examination (60 minutes) Written examination (120 minutes)
11	**Grading procedure**	Written examination (50%) Written examination (50%) Written examination (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**	german
16	**Bibliography**	

1	**Module name** 1900	**Scientific Skills I** Scientific skills I	**2,5 ECTS**
2	Courses / lectures	Praktikum: Lab Course Fundamentals in Chemical and Bioengineering for MAP (2 SWS) Praktikum: Lab Course Material Science for MAP (2 SWS) Hauptseminar: HS "Sklaverei und (Un-)Freiheit im Mittelalter"	2,5 ECTS 2,5 ECTS -
3	Lecturers	Prof. Dr. Nicolas Vogel Dr. Anca Valentina Mazare PD Dr. Cornelia Scherer	

4	**Module coordinator**	Prof. Dr. Nicolas Vogel
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**	semester: 1
9	**Module compatibility**	Pflichtmodul Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Practical achievement
11	**Grading procedure**	Practical achievement (pass/fail)
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**	

Fundamentals

1	**Module name** 42750	**Chemical Reaction Engineering**	**5 ECTS**
2	Courses / lectures	Vorlesung: Chemical Reaction Engineering 1 MAP (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Marco Haumann	

4	**Module coordinator**	Prof. Dr. Marco Haumann
5	**Contents**	fundamental parameters micro-kinetics heterogeneous catalysis - reaction processes on surfaces macro-kinetics - inner and outer mass transfer: macro Kinetics - non isothermal conditions types of chemical reactors reactor modelling mass and heat reactors - stable operation points
6	**Learning objectives and skills**	Students who participate in this course will become familiar with basic concepts of chemical reaction engineering. Students who successfully participate in this module can describe complex reactions by kinetic rate expressions analyze reactions on solid surfaces of heterogeneous catalysts describe and quantify the interplay between reaction kinetics and mass transport describe and quantify mass and heat balances in catalyst particles classify chemical reactors based on reacting phases or mode of operation balance mass and heat flows in ideal reactors find stable and safe operation points for reactors
7	**Prerequisites**	To succeed in this course students will need to apply earlier acquired knowledge from e.g. physical chemistry, mathematics. A solid background in mathematics is required, since differential equations and integrals form the basis for the description of the chemical processes and their kinetics. Understanding of kinetics to describe the time dependent concentration changes in chemical reactions should be familiar from physical chemistry classes. Basic knowledge in thermodynamics and general chemistry is beneficial.
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Fundamentals Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (pass/fail)
12	**Module frequency**	Only in winter 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**	Jess and P. Wasserscheid, Chemical Technology, Wiley-VHC, Weinheim. O. Levenspiel, Chemical Reaction Engineering. John Wiley.

1	**Module name** 42751	**Interface Engineering and Particle Technology**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Introduction to Interface Engineering (3 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Robin Klupp Taylor	

4	**Module coordinator**	Prof. Dr. Robin Klupp Taylor
5	**Contents**	**Applicable to students who attended the module courses up until WS 2025/26 inclusive:** This module provides students with an overview of the following key concepts and practical aspects of the fields of interfacial engineering and particle technology: • Molecular interactions: Adsorption and adhesion • Particle nucleation and growth • Particle stabilization • Particle size and shape. • Particles in motion • Particle size distributions • Unit operations: separations, mixing, comminution • Packed and fluidized beds The associated exercises and homework cover all topics and allow students to develop their understanding independently with follow-up support from the course tutors. **Applicable to students who attend the module courses from WS 2026/27 onwards:** • Fundamentals of interfaces, including surface and interfacial energy, surface tension, interfacial area, and thermodynamic driving forces. • Molecular interactions, including electrostatic, van der Waals, repulsive, hydrogen-bonding, and specific chemical interactions. • Liquid interfaces, surfactants, curved interfaces, Laplace pressure, Kelvin effects, and capillary phenomena. • Phase transitions, supersaturation, homogeneous and heterogeneous nucleation, particle growth, ripening, and particle morphology. • Particle size and shape descriptors, equivalent diameters, form factors, dispersity, and particle size distributions. • Solid surfaces, crystalline facets, surface defects, surface chemistry, surface energy and adsorption. • Wetting of solid, rough, and porous surfaces, including contact angles, Wenzel and Cassie models and liquid invasion of porous structures. • Macroscopic surface forces, Hamaker and Lifshitz concepts, adhesion, disjoining pressure, capillary and liquid-bridge forces. • Colloidal systems, electrical double layers, zeta potential, DLVO theory, electrostatic stabilization, steric stabilization, and aggregation. • Applications in particle technology, clean energy processes, coatings, porous media, catalysis, and formulated disperse systems.

6	**Learning objectives and skills**	Applicable to students who attended the module courses up until WS 2025/26 inclusive: On completion of the module students will be able to: • understand the relevance of interfaces in the natural and artificial world. • master the fundamentals of interfaces and apply them to the specific case of wetting, particle nucleation, growth and stabilization • analyse interfacial-dependent processes in their connection with engineering challenges and develop solutions. • define the societal relevance of particle technology • give examples of unit operations of particle technology • differentiate between the various approaches for defining particle size and shape • analyze the motion of particles according to physical and engineering principles • analyze particle size distributions, distinguish between accepted norms for their presentation, and apply them for the analysis of separation equipment • describe the structure of packings and bulk materials and the perfusion of those • describe the fundamentals of the processes of separation, mixing, comminution and fluidization • apply their acquired knowledge and skills in the additional exercises and tutorials in order to solve independently problems from interfacial and mechanical processes engineering Applicable to students who attend the module courses from WS 2026/27 onwards: On completion of the module students will be able to: • Define key concepts of interface engineering, including surface energy, interfacial tension, wetting, adsorption, capillarity, and colloidal stability.• Explain how molecular interactions determine interfacial energies, surface forces, wetting behavior, adsorption, and colloidal phenomena. • Apply core equations and models of interface science to quantitative problems involving capillarity, curvature, wetting, adsorption, nucleation, and colloidal stability. • Analyze liquid interfaces, curved interfaces, and capillary phenomena using thermodynamic and mechanical arguments. • Explain how supersaturation, nucleation, growth, and ripening conditions influence particle size, morphology, and dispersity. • Characterize particles and particle ensembles using size, shape, equivalent diameter, form factor, and distribution descriptors. • Relate solid-surface structure, chemistry, defects, and porosity to surface energy, wetting and adsorption.

		• Analyze wetting phenomena on smooth, rough, structured, and porous surfaces. • Evaluate macroscopic surface forces, adhesion, capillary forces, and liquid-bridge interactions in interfacial systems. • Evaluate colloidal stability using electrostatic, van der Waals, DLVO, and steric-stabilization arguments. • Propose interface-engineering strategies for selected technical applications in particle technology, clean energy, coatings, porous media, catalysis, and formulated disperse systems.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Fundamentals Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (pass/fail)
12	**Module frequency**	Only in winter 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**	Unless stated, online texts are only available within the FAU network (or remotely via VPN) Interface Engineering • Adamson, A.W. and Gast, A.P. (1997) Physical chemistry of surfaces, 6th edn, Wiley, New York, Chichester. FAU library holdings • Berti, D. and Palazzo, G. (2014) Colloidal foundations of nanoscience, Elsevier, Amsterdam. Full Text • Butt, H.-J.B., Graf, K., Kappl, M. (2003) Physics and chemistry of interfaces, Wiley-VCH; Chichester : John Wiley, Weinheim. Full Text • Cosgrove, T. (2005) Colloid science: Principles, methods and applications / edited by Terence Cosgrove, Blackwell Pub, Oxford, Ames, Iowa. Full Text • Everett, D.H. (2007) Basic principles of colloid science, Royal Society of Chemistry, London. Full Text • Israelachvili, J.N. (2012) Intermolecular and surface forces, 3rd edn, Academic Press is an imprint of Elsevier, Amsterdam. Full Text • Kontogeorgis, G.M. and Kiil, S. (2016) Introduction to applied colloid and surface chemistry, Wiley, Chichester, UK. Full Text

- Lyklema, J. (2005) Fundamentals of interface and colloid science. Elsevier/Academic Press, Amsterdam, London. Full Text
- Mersmann, A. (2001) Crystallization Technology Handbook, CRC Press, Boca Raton FAU library holdings
- Stokes, R.J. and Evans, D.F. (1997) Fundamentals of interfacial engineering, Wiley-VCH, New York, Chichester. FAU library holdings
- Tadros, T.F. (2012) Dispersion of powders in liquids and stabilization of suspensions, Wiley-VCH, Weinheim, Germany. Full Text
- Tadros, T.F. (2015) Interfacial phenomena and colloid stability, De Gruyter, Berlin. Full Text
- Tadros, T.F. (2018) Formulation science and technology, De Gruyter, Berlin. Full Text
-
    - Volume 1 - Basic Theory of Interfacial Phenomena and Colloid Stability Full Text
    - Volume 2 - Basic Principles of Dispersions Full Text
    - Volume 3 - Industrial Applications I - Pharmaceuticals, Cosmetics and Personal Care Full Text
    - Volume 4 - Industrial Applications II - Agrochemicals, Paints, Coatings and Food Systems Full Text

Particle Technology

Peukert, W.: Lecture Script - available as copy-protected online viewable document or in printed form, obtainable for free on showing your FAU ID card at CopyArenA, Karlsbader Str. 13 (N.B. some chapters are not covered in the IEPT module)

German Books

- Bohnet, M. (2012) Mechanische Verfahrenstechnik, John Wiley & Sons, Hoboken. Full text
- Löffler, F. and Raasch, J. (1992) Grundlagen der mechanischen Verfahrenstechnik, Vieweg, Braunschweig, Wiesbaden. FAU library holdings
- Müller, W. (2014) Mechanische Verfahrenstechnik und Ihre Gesetzmässigkeiten, 2nd edn, De Gruyter Oldenbourg.Full text
- Rumpf, H. (1975) Mechanische Verfahrenstechnik, 3rd edn, Carl Hanser Verlag, S.l. FAU library holdings
- Schubert, H. (2008) Handbuch der mechanischen Verfahrenstechnik, 1st edn, Wiley-VCH, Weinheim. Full text
- Schulze, D. (2014) Pulver und Schüttgüter: Fließeigenschaften und Handhabung, 3rd edn, Springer Vieweg, Berlin. Full text

- Stiess, M. (2009) Mechanische verfahrenstechnik - Partikeltechnologie 1, 3rd edn, Springer, Berlin. Full text
- Zogg, M. (1993) Einführung in die mechanische Verfahrenstechnik, 3rd edn, B.G. Teubner, Stuttgart. Full text (free)

English Books

- Allen, T. (ed) (2003) Powder Sampling and Particle Size Determination, Elsevier, Amsterdam. Full text
- Fayed, M.E. and Otten, L. (1997) Handbook of powder science & technology, 2nd edn, Chapman & Hall, New York, London. FAU library holdings
- Higashitani, K., Makino, H., Matsusaka, S. (2019) Powder technology handbook, CRC Press, Boca Raton. Full text
- Kaye, B.H. (1999) Characterization of powders and aerosols, Wiley-VCH, Weinheim, Chichester. Full text
- Ortega-Rivas, E. (2012) Unit Operations of Particulate Solids, CRC Press, Boca Raton. Full text
- Richardson, J.F., Harker, J.H., Backhurst, J.R. (eds) (2013) Coulson and Richardson's Chemical Engineering. Volume 2, Particle Technology and Separation Processes: Solutions to the problems in Chemical engineering, Butterworth-Heinemann, Oxford. Full text
- Rhodes, M.J. (2008) Introduction to Particle Technology, 2nd edn, Wiley, Chichester, UK. Full text
- Rumpf, H. (1990) Particle Technology, Chapman and Hall, London. FAU library holdings
- Seville, J. and Wu, C.-Y. (eds) (2016) Particle Technology and Engineering, Elsevier. Full text
- Svarovsky, L. (2001) Solid-Liquid Separation, 4th edn, Elsevier, Burlington. Full text

1	**Module name** 42752	**Fluid Mechanics**	**5 ECTS**
2	Courses / lectures	Vorlesung: Fluid Dynamics / Fluid Mechanics (2 SWS)	-
3	Lecturers	Felix Czwielong Dr.-Ing. Manuel Münsch Prof. Dr. Philipp Schlatter	

4	**Module coordinator**	Dr.-Ing. Manuel Münsch
5	**Contents**	motivation, history organization of the lecture introduction, continuum, pressure, surface tension scalars, vectors and tensors fluid statics and buoyancy governing equations: Integral analysis of fluid flow governing equations: Differential analysis of fluid flow special forms of governing equations similitude, dimensional analysis, and modeling solutions of basic internal and external flows applied examples of the course material
6	**Learning objectives and skills**	The Students will learn the mathematical fundamentals of integral and differential modeling fluid flows can classify different types of fluid flow phenomena and derive the necessary non-dimensional parameters can simplify and utilize mathematical models for the solution of different types of flows have the chance to see the direct application of the content in the research and development work conducted at LSTM-Erlangen
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Fundamentals Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (pass/fail)
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**	• Munson, Yound and Okiishi: Fundamentals of Fluid Mechanics. John Willey and Sons • Fox and McDonald: Introduction to Fluid Mechanics. John Willey and Sons • White: Fluid Mechanics. McGraw Hill • Durst: Grundlagen der Strömungsmechanik: Eine Einführung in die Theorie der Strömung von Fluiden. Springer

1	**Module name** 42753	**Chemical Thermodynamics**	**5 ECTS**
2	Courses / lectures	Vorlesung: Chemical Thermodynamics (CT) (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Matthias Thommes	

4	**Module coordinator**	Prof. Dr. Matthias Thommes
5	**Contents**	Thermodynamic description of multiphase mixtures containing one, two or more substances: • vapor-liquid equilibria • gas-liquid equilibria • liquid-liquid equilibria • reaction equilibria under consideration of phase equilibria • modelling and prediction of fluid phase equilibria based on activity and fugacity • equations of state • activity coeffitient/gE models
6	**Learning objectives and skills**	The students who successfully participate in this module can • understand the driving forces and thermodynamic limitations of processes containing mixed phases • understand the phase change and phase equilibria from an intermolecular and energetic viewpoint as a key to understanding thermal separation processes • understand the thermodynamics behind equilibria of two and more phases as well as the equilibria of chemical reactions • learn how to calculate these equilibria based on pure substance properties, without equilibrium data
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Fundamentals Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (pass/fail)
12	**Module frequency**	Only in winter 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**	• Gmehling, J.; Kolbe, B.; Kleiber, M.; Rarev, J. Chemical Thermodynamics for Process Simulation • Smith, J. M.; Van Ness, H. C.; Abbott, M. Introduction to Chemical Engineering Thermodynamics • Prausnitz, J. M.; Lichtenthaler, R.N.; de Azevedo, E.G. Molecular Thermodynamics of Fluid-Phase Equilibria • Any other book on Chemical Thermodynamics

1	**Module name** 42754	**Thermodynamics and Mechanics of Materials**	**5 ECTS**
2	Courses / lectures	Vorlesung: Thermodynamics and Mechanics of Materials (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Michael Zaiser	

4	**Module coordinator**	Prof. Dr. Peter Felfer
5	**Contents**	Thermodynamics in Materials Science: Recap of thermodynamic principles and basics Thermodynamics of solid solutions Derivation of phase diagrams Mechanical Properties of Materials: Continuum mechanical background: tensors, stress, strain, elastic constants Continuum mechanical modeling of plasticity Linear elastic fracture mechanics Deformation mechanisms and crystal defects Fatigue Creep
6	**Learning objectives and skills**	The lecture enables students to apply the principles of thermodynamics in the context of materials science. In particular, they students will be able to derive and explain phase diagrams and their significance for alloy development. The students will furthermore be able to use the framework of continuum mechanics to describe and model elastic and plastic deformation as well as fracture. Furthermore, students will be able to explain macroscopic deformation and failure on the basis of microscopic and atomistic deformation mechanisms and relate the mechanical properties of materials to their microstructure.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Fundamentals Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (pass/fail)
12	**Module frequency**	Only in winter 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**	• Gaskell: Introduction to the Thermodynamics of Materials • Roesler, Harders, Baeker: Mechanical Behaviour of Engineering Materials

1	**Module name** 42755	**Polymer Materials**	**5 ECTS**
2	Courses / lectures	Vorlesung: Polymer Materials (2 SWS)	5 ECTS
3	Lecturers	Michael Redel Prof. Dr. Dirk Schubert Prof. Dr. Nicolas Vogel	

4	**Module coordinator**	Prof. Dr. Dirk Schubert
5	**Contents**	The lecture provides an introduction into Polymer Science and Engineering and broad overview of the field. The following topics will be introduced: • Macromolecules: Definition and special characteristics of macromolecules; types of polymers and classifications, special polymer classes • Polymer synthesis: step and chain growth, living polymerization, network formation, ionic polymerization • Polymer thermodynamics: conformation of macromolecules in dissolved state and melt; thermodynamics of mixing, phase separation • Characterization of polymers: Determination of molecular weight, rheological properties and chemical functionalities • Polymers in solid state: semicrystalline materials, amorphous materials, elastomers • Polymer processing: Introduction in relevant fabrication processes (extrusion, injection moulding,)
6	**Learning objectives and skills**	Students who successfully participate in this module: • Understand fundamental structure-property relations of macromolecules and polymeric materials • Are able to deduce and predict macroscopic material properties from the molecular structure of the polymer • Develop the ability to modify the macroscopic properties via the molecular structure • Learn fundamental competences for the synthesis, characterization and processing of macromolecular materials • Are able to choose a polymeric material for a desired application • Receive an overview of current research topics and activities in the area of polymer sciences.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Fundamentals Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (pass/fail)
12	**Module frequency**	Only in winter 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**	R. J. Young, P. A. Lovell, Introduction to Polymers, 3rd Edition. CRC Press 2011

1	**Module name** 42756	**Materials and Structure**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Materials and Structure (Werkstoffe und ihre Struktur) (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Philipp Pelz	

4	**Module coordinator**	Prof. Dr. Erdmann Spiecker
5	**Contents**	The content of the module gives an overview of different fields of materials science and engineering. The following topics are included in the module: • atomic structure and interatomic bonding • structure of crystalline solids • structure determination by X-ray diffraction • imperfections in solids • microscopic characterization of crystal defects • mechanical properties of metals • dislocations and strengthening mechanisms • phase diagrams of binary alloys • phase diagrams of metals: development of microstructure • kinetics of phase transformations • structure and properties of ceramics
6	**Learning objectives and skills**	The course enables the students • to classify the different types of bonding that occur in materials • to understand the relationship between bonding, structure and fundamental materials properties • to describe crystalline materials with basic concepts of crystallography • to classify crystal defects with respect to their dimensionality • to describe the importance of dislocations and interfaces for the mechanical properties of metals • to understand the development of microstructure based on phase diagrams and the kinetics of phase transformation • to describe basic crystal structures of ceramics • The course forms the basis for advanced lectures in the field of materials science.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Fundamentals Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (pass/fail)
12	**Module frequency**	Only in winter 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**	William D. Callister, Jr., "Materials Science and Engineering: An Introduction", John Wiley & Sons, Inc., 7th edition (or later)

1	**Module name** 42757	**Electronic Materials**	**5 ECTS**
2	Courses / lectures	Vorlesung: Electronic Materials (VL und Seminar) (3 SWS)	5 ECTS
3	Lecturers	PD Dr.-Ing. Miroslaw Batentschuk Prof. Dr. Christoph Brabec	

4	**Module coordinator**	Prof. Dr. Christoph Brabec
5	**Contents**	• semiconductor materials, elementary, binary, ternary and quaternary semiconductors, crystal structures • formation of band structures, direct and indirect semiconductors, bandgap, effective mass of carriers • carrier statistics, Ohms low, Fermi-distribution, density of states, carrier densities • intrinsic and extrinsic (doped) semiconductors, mechanisms of doping and limitations, carrier concentration and position of Fermi energy versus temperature, temperature dependence of carrier density and conductivity, degenerate semiconductors • epitaxy of semiconductors, quantum wells and quantum dots, characterization of epitaxial layers • patterning of semiconductors, lithography, etching and material deposition • carrier transport, Drude model, scattering processes, thermal and drift velocity, mobility, conductivity • principles, processing and application of ohmic contacts (Peltier), Shottky contacts • diffusion, band structure in electric field • pn-junction, doping concentration, carrier densities, depletion region, electric field and potential • biased pn-junction, carrier transport and current-voltage characteristic • photovoltaics, kinds of solar cells, their limits and materials demands • organic semiconductors and their applications
6	**Learning objectives and skills**	The lecture enables the students to understand the basic physical properties of semiconductors. The fundamentals of semiconductor devices are introduced based on a discussion of the pn-junction diode. The lecture also covers technological aspects such as growth and processing of semiconductors. The seminar enables the student to amplify their knowledge about the topics of the lectures, especially on materials demands for electronic devices, first of all for solar cells. Every student should prepare at least one talk to the selected topic.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Fundamentals Master of Science Advanced Materials and Processes 20242

10	**Method of examination**	Written examination (90 minutes) Prüfungsform: Seminar und Hausarbeit (ca. 20 Seiten). Alternative Prüfungsform: Klausur, 45 Minuten
11	**Grading procedure**	Written examination (pass/fail) The exam counts 100%
12	**Module frequency**	Only in winter 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**	• Simon M. Sze, "Semiconductor Devices: Physics and Technology", John Wiley & Sons • S.O. Kasap, Principles of Electronic Materials and Devices (Mc Graw Hill, 3rd Edition) • W. Callister, Materials Science and Engineering (esp. chapter 12, Wiley, 2nd Edition)

Focal Subject: Advanced Processes

1	**Module name** 42762	**Advanced Processes: Catalysis**	**5 ECTS**
2	Courses / lectures	Vorlesung: Catalysis (2 SWS)	5 ECTS
3	Lecturers	Dr. Friederike Agel	

4	**Module coordinator**	Dr. Friederike Agel Prof. Dr. Marco Haumann
5	**Contents**	Basics of Sustainability and Catalysis Heterogeneous catalysis: • Adsorption (bonds and models) • Microkinetics: Mechanisms of surface reactions • Deriving reaction rate approaches for surface catalyzed reactions • Macrokinetics: Influence of mass transfer in porous materials • Mass transfer influences on selectivity • Selectivity and stability of heterogenous catalysts • Catalyst characterization Homogeneous catalysis: • Ligand influence on selectivity/activity/stability • Fluid/fluid biphasic catalysis • Hatta number and enhancement Special catalyst materials
6	**Learning objectives and skills**	Students will be able to • formulate the basic principles of sustainable chemistry (atom economy, energy efficiency, recycling, avoidance of hazardous substances) and discuss the role of catalysis in achieving these goals. • distinguish between essential classes of catalysts (heterogeneous, homogeneous) and compare their advantages and disadvantages in the context of sustainable processes. • define physical and chemical adsorption, molecular and dissociative adsorption, and explain them using typical examples. • apply common adsorption models (e.g., Langmuir isotherms, multilayer adsorption) qualitatively. • derive rate laws for surface-catalyzed reactions (e.g., Langmuir-Hinshelwood, Eley-Rideal) assuming rate-determining steps and steady-state approximations. • use simple material and energy balances to show how catalysts influence yield, energy requirements, and by-product formation in processes. • use dimensionless parameters (e.g., effectiveness factor, Thiele modulus) to assess the influence of mass transport on the observed kinetics and identify transport limitations. • explain how diffusion limitations influence selectivity (e.g., preference for fast or rapidly diffusing reactants) and graphically represent simple scenarios.

		• define the terms activity, selectivity, and deactivation (sintering, coking, poisoning) and discuss strategies for increasing selectivity and long-term stability. • name essential characterization methods for heterogeneous catalysts (e.g., BET surface area, porosimetry, temperature-programmed methods, spectroscopic methods) and explain their information content. • formulate structure-property relationships, e.g., how surface area, pore structure, metal dispersion, or support material influence activity and selectivity. • for organometallic catalysts, explain the influence of ligands on electronic, steric properties of the catalyst, and thus on activity, selectivity, and stability in qualitative terms and discuss this using simple substrate examples. • explain the concept of fluid/fluid two-phase catalysis (phase separation, catalyst recovery, mass transport across the phase boundary) and name the advantages and disadvantages compared to single-phase systems. • qualitatively describe the significance of the Hatta number concept and mass transfer coefficients for gas/liquid or liquid/liquid-catalyzed reactions and distinguish between reaction-controlled and transport-controlled regimes.
7	**Prerequisites**	No preliminary knowledge is needed for a successful participation. However, basic knowledge of kinetics, thermodynamics and reaction engineering can make it easier to get started.
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Oral (30 minutes)
11	**Grading procedure**	Oral (100%) Oral examination (100 %)
12	**Module frequency**	Only in winter semester The lecture is offered only during the winter semester. The oral exam can be taken in either the winter or 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**	Slides and all further material will be uploaded on StudOn.

1	**Module name** 42918	**Fuel cells and electrolysers**	**5 ECTS**
2	Courses / lectures	Vorlesung: Fuel cells and electrolysers (2 SWS) Übung: Fuel cells and electrolysers (3 SWS)	- -
3	Lecturers	Prof. Dr.-Ing. Simon Thiele	

4	**Module coordinator**	Prof. Dr.-Ing. Simon Thiele
5	**Contents**	Fuel cell (FC) and electrolysis cell (ECs) • Application areas • Thermodynamic boundary conditions • Electrochemical basics • Kinetics • Transport processes • State of the art • Characterisation techniques • Open questions and scientific challenges
6	**Learning objectives and skills**	Students • are able to apply acquired knowledge from e.g. physical chemistry, mathematics and basic electrochemistry • understand kinetics to describe the time dependent concentration changes in chemical reactions • apply basic knowledge in thermodynamics and general chemistry • are familiar with basic concepts of electrochemical engineering for fuel cells and electrolysers • can describe thermodynamics, kinetic effects and electrochemical foundations • understand limitations such as kinetic, ohmic or mass transport limitions • have a solid knowledge on the state of the art • know how to experimentally characterize cells • are able to deduce methods to improve cell technologies by analyzing experimental data
7	**Prerequisites**	To succeed in this course, students will need to apply acquired knowledge from e.g. physical chemistry, mathematics and basic electrochemistry. Understanding of kinetics to describe the time dependent concentration changes in chemical reactions should be familiar from physical chemistry classes. Basic knowledge in thermodynamics and general chemistry is beneficial.
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable (120 minutes)

		written exam (120 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**	• O'hayre, Ryan; Cha, Suk-Won; Prinz, Fritz B.; Colella, Whitney (2016): Fuel cell fundamentals: John Wiley & Sons.

1	**Module name** 42939	**Chemical Technologies for the Energy Transition**	**5 ECTS**
2	Courses / lectures	Übung: Chemical technologies for energy transition - Seminar (2 SWS) (SoSe 2027) Vorlesung: Chemical technologies for energy transition (2 SWS) (SoSe 2027)	- -
3	Lecturers		

4	**Module coordinator**	Prof. Dr. Marco Haumann
5	**Contents**	• Definition of sustainability and measures • Current and future Energy mix • Concepts of Catalysis • Exhaust Gas Catalysis • Sustainable Feedstocks • Biorefinery • Carbon capture and storage • Closing the C cycle: CO2 as C1 Source • Alternative fuels • Chemical energy storage vs electrical storage
6	**Learning objectives and skills**	The students • learn important processes that contribute to the sustainability of the chemical industry, apart from energy processes. • learn what sustainability means • understand aspects of sustainability and are able to transfer it to future processes • understand the functionality and theory of common analysis tools for the characterization of catalytic systems • are able to show the advantages and disadvantages and the potentials of the reviewed applications
7	**Prerequisites**	No preliminary knowledge is needed for a successful participation. However, basic knowledge of catalysis, energy efficiency, thermodynamics, or reaction engineering can make it easier to get started.
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable Graded scientific presentation (30 minutes).
11	**Grading procedure**	Variable (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**	
16	**Bibliography**	• Slides and all further material will be uploaded on StudOn.

1	**Module name** 42940	**Recycling of Electronic Wastes**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Recycling of Electronic Wastes (Lecture and Exercises) (4 SWS)	5 ECTS
3	Lecturers	Dr. Monica Distaso	

4	**Module coordinator**	Dr. Monica Distaso
5	**Contents**	• Definition of sustainability and measures • Current and future Energy mix • Concepts of Catalysis • Exhaust Gas Catalysis • Sustainable Feedstocks • Biorefinery • Carbon capture and storage • Closing the C cycle: CO2 as C1 Source • Alternative fuels • Chemical energy storage vs electrical storage
6	**Learning objectives and skills**	The students • learn important processes that contribute to the sustainability of the chemical industry, apart from energy processes. • learn what sustainability means • understand aspects of sustainability and are able to transfer it to future processes • understand the functionality and theory of common analysis tools for the characterization of catalytic systems • are able to show the advantages and disadvantages and the potentials of the reviewed applications
7	**Prerequisites**	No preliminary knowledge is needed for a successful participation. However, basic knowledge of catalysis, energy efficiency, thermodynamics, or reaction engineering can make it easier to get started.
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable (30 minutes) Graded scientific presentation (30 minutes).
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**	• Slides and all further material will be uploaded on StudOn.

1	**Module name** 45035	**Adsorption: Fundamentals and Applications** Adsorption: Fundamentals and applications	**5 ECTS**
2	Courses / lectures	Übung: Übung Adsorption: Fundamentals and Applications (0 SWS) Vorlesung: Adsorption: Fundamentals and Applications (2 SWS)	- 5 ECTS
3	Lecturers	Dr.-Ing. Carola Vorndran Prof. Dr. Matthias Thommes	

4	**Module coordinator**	Prof. Dr. Matthias Thommes
5	**Contents**	1. Introduction and terminology 2. Gas adsorptions basics and adsorbent materials 3. Physisorption mechanisms 4. Surface area determination 5. Porosity and pore structure analysis of nanoporous materials 5.1 Micropore analysis 5.2Mesopore analysis 5.3 Macropore analysis : adsorption and liquid intrusion methods 5.4. Characterization of hierarchically structured porous materials 6. High pressure adsorption 7. Surface chemistry effects on adsorption 8. Adsorption and characterization in the liquid phase 9. Adsorption of mixtures 10. Adsorption applications in gas storage and separation
6	**Learning objectives and skills**	The students will achieve a deep understanding of the underlying mechanisms for the adsorption of fluids on powders and nanoporous materials know adsorption-based and complimentary techniques/methodologies for a reliable characterization of adsorbents for applications in separation, heterogeneous catalysis etc. understand the basics of high pressure adsorption and corresponding applications in gas storage know selected, important principles of adsorption-based separation processes
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written or oral Oral examination (30 min.)
11	**Grading procedure**	Written or oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 30 h

		Independent study: 105 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46257	**Advanced Semiconductor Technologies - Photovoltaic Systems I - Fundamentals** Advanced semiconductor technologies - Photovoltaic systems I - Fundamentals	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Advanced Semiconductor Technologies - Photovoltaic Systems for Power Generation - Design Implementation and Characterization (2 SWS) Tutorium: Questionaire PV Systems 1	3 ECTS -
3	Lecturers	Prof. Dr. Christoph Brabec Dr. Larry Lüer	

4	**Module coordinator**	Prof. Dr. Christoph Brabec Prof. Dr. Wolfgang Heiß
5	**Contents**	VHB Digital Lecture "PV Systems" • This lecture is provided by Virtuelle Hochschule Bayern. It is a virtual lecture composed and realized by leading experts in Bavaria and Germany (with contributions from FAU lecturers) in the field of semiconductors and photovoltaics. • Students are free to work with the lectures according to their own schedule. At the end of each lecture, one or two exercises will be presented which must be accomplished in order to get access to the subsequent lecture. • Within each semester, there will be at least two online appointments where all course authors will be available for a Q&A session. These sessions obviously occur at a fixed time, which will be announced at the beginning of the semester on Studon and in Campo under the event "Questionnaire". • The lecture will introduce 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.
6	**Learning objectives and skills**	VHB Digital Lecture "Photovoltaic Systems" • The virtual lecture consists of 10 individual lectures. Each lecture ends with a set of exercises to be accomplished. • Lecture 1: Introduction & History. This lecture sets the stage. We start with the question "how much energy does mankind use?" Then, we outline potential (renewable and non-renewable) energy sources, before we focus on photovoltaics. We outline PV applications, and show the evolution of production volume and cost, the so-called "learning curve". We

present projections into the future and their relation to policy decisions.

- Lecture 2: Semiconductor Physics. We start with a minimal introduction to quantum mechanics, needed to understand how energy bands are formed in a crystalline semiconductor. This leads us to direct and indirect semiconductors and the contribution of phonons to optical absorption. We discuss the density of states and the Fermi - Dirac distribution. We discuss the resulting conductivity of semiconductors and what we can learn from its temperature dependence. We introduce the highly important and useful concept of quasi-Fermi levels. We conclude the lecture by discussion extrinsic semiconductors; these are the basis to observe a photovoltaic effect by forming a p-n junction.
- Lecture 3: Efficiency limits and black body radiation. The sun is a broad band emitter while a single junction solar cell has a single fixed bandgap energy. This lecture discusses the drastic consequence from this mismatch, namely that a single junction solar cell can never reach 100% power conversion efficiency. Quantifying efficiency limits requires the understanding of the thermodynamics of the system. We distinguish losses we cannot avoid from those which may be avoided by improving the technology. We calculate the current-voltage curve of an ideal solar cell and discuss the types of losses and how to quantify them by experiment. Finally, we show recent progress how the efficieny limit of single junction solar cells can be overcome by forming tandem solar cells
- Lecture 4. Loss mechanisms. In this lecture, we discuss losses that keep realistic solar cells from reaching the theoretical efficiency limit. We discuss optical losses and how to handle them using antireflection coatings, pyramids, and the control of interference in thin film solar cells. Then we discuss nonradiative recombination, distinguishing the Shockley-Read-Hall and Auger mechanisms. Further, we discuss resistive losses, and we discuss how these losses can be distinguished in experiments.
- Lecture 5: Junctions. A fundamental understanding is essential to predict the properties of semiconductors. We start with a historic overview and present a short recap of the quantum mechanics. The discussion of metal-metal junctions is followed by Shottky junctions and the derivation of the current-voltage curve. Important cases beyond Shottky are discussed such as mirror charges and Fermi-level pinning, that often govern the properties of real-world junctions. Then we take a closer look at p-n junctions in silicon, and finish by considering heterojunctions.
- Lecture 6. Silicon Technology. History an market share; production of pure silicon material and silicon wafers, technologies for the processing of silicon solar cells:

		BSF / PERC, TOPcon and SHJ, and finally IBC. All these technologies solve problems in performance and production complexity, which are compared. Finally, the production of modules from single silicon solar cells is discussed. • Lecture 7. CIGS technology. This is a thin film technology. First, we introduce the band structure and how the energies can be tuned. Then we discuss the cell architecture and how the layers are produced technically. Then we discuss defects and metastable performance (light induced healing) and how to passivate defects. Finally, efficiency limits, and the industrial realisation are discussed. • Lecture 8 . GaAs multijunctions. We start with a discussion on defects and defect passivation for III/V semiconductors. Then we introduce into multijunctions and why their efficiency goes beyong the single junction detailed balance limit. We discuss the concept of solar concentration and the application of GaAs tandems, especially in space. • Lecture 9. Solution processing and morphology. In solution processed solar cells, morphology control is decisive for device performance as well as stability. This lecture introduces into the basic concepts of morphology optimization by controlling the processing conditions. • Lecture 10: Organic photovoltaics. We introduce into organic semiconductors and their electronic properties. Then we present device structures, distinguishing monolayer, bilayer, and bulk heterojunction structures. We compare different ways to process devices in the lab. Then we focus on the special photophysics of OPV system where the primary photoexcitation is a bound electron hole pair. This directly links to current research directions to overcome the connected efficiency losses. Finally, device degradation mechniams are discussed.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
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 (45 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: 45 h Independent study: 105 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 94351	**Process Technologies** Process technologies	**5 ECTS**
2	Courses / lectures	Vorlesung: Process Technologies (2 SWS) (SoSe 2026) Übung: Process Technologies Exercises (1 SWS) (SoSe 2026)	5 ECTS -
3	Lecturers	Prof. Dr.-Ing. Bastian Etzold	

4	**Module coordinator**	Prof. Dr.-Ing. Bastian Etzold
5	**Contents**	The Module "Process Technologies gives an overview on important processes in the chemical process industries. The processes are treated in a holistic approach and the interaction of individual process steps and their feedback to the overall process are discussed in more detail. In particular, the relationship between the physical/chemical basics of the processes, process development and process design are discussed. The presented processes are selected based on their importance in the fields of raw materials, intermediates and consumer products of the chemical process industries. In the sense of process engineering, apart from the reaction steps, the separation operations are also part of the considerations. The evaluation of the methods with regard to their cost-effectiveness and sustainability complete the description of the processes. In detail, the following aspects are treated: • Raw materials (crude oil, fuels, natural gas, technical gases) • Organic base chemicals (syngas, alkanes, alkenes, aromatics) • Organic intermediates (C1-C4 alcohols, cyclic alcohols, ether, epoxides, organic acids) • Renewable raw materials • Organic end products (surfactants, pigments, polymers) • Inorganic base chemicals and intermediates (sulfuric acid, ammonia, sodium hydroxide) • Inorganic end products (fertilizers, ceramics, glass) • Process development (technologies, economic evaluation)
6	**Learning objectives and skills**	The students • know the important processes in the chemical process industries • describe the interaction of individual process steps and their feedback to the overall process • discuss the relationship between the physical/chemical basics of the processes, process development and process design • evaluate the processes und methods with regard to their cost-effectiveness and sustainability
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242

10	**Method of examination**	Course achievement
11	**Grading procedure**	Course achievement (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**	Textbooks and compendia on Technical Chemistry, e.g. • Baerns, et al., Technische Chemie, Wiley-VCH • Jess, Wasserscheid, Chemical Technology, Wiley-VCH • Ullmann's Encyclopedia of Industrial Chemistry

1	**Module name** 46298	**Advanced Semiconductor Technologies - Photovoltaic Systems I - Practical Work**	**5 ECTS**
2	Courses / lectures	Übung: Excercises Photovoltaic systems - Fundamentals (3 SWS) Praktikum: Lab Work Characterization and Advanced Defect Imaging of PV Modules and Systems (3 SWS)	2 ECTS 2 ECTS
3	Lecturers	Dr.-Ing. Thomas Heumüller	

4	**Module coordinator**	Prof. Dr. Christoph Brabec Prof. Dr. Wolfgang Heiß
5	**Contents**	This module provides hands-on experience with the characterization and simulation of solar cells and photovoltaic modules. It is especially suited for students who wish to focus on photovoltaics or optoelectronics in general for their Master thesis. It consists of a practical course where solar cells and modules are characterized with state of the art laboratory techniques, and a short lecture with exercises, introducing into simulations of current-voltage traces and other characterization techniques. If both measurements and simulations are available, then comparison can give access to model parameters. Identifying the dominant loss mechanism helps finding targeted strategies for device optimization.
6	**Learning objectives and skills**	The module consists of two parts: • Practical course "Solar Cell Characterization": Individual Solar Cells and larger Modules will be characterized under different illumination conditions. The measured IV curves are fitted by drift diffusion simulations. EQE measurements will be performed as well as photo luminescence imaging. • Lecture and exercises: Students will learn about simulation methods for current-voltage traces: using the diode model and using drift-diffusion simulations. Open source tool swill be used that the students can also use for their homework. The effect of model parameters on the shape of the current-voltage curves is discussed, which allows identifying dominant loss mechanisms. Both practical course and lecture/exercises are compulsory; a written report must be submitted.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Practical achievement (120 minutes)

		Tutorial achievement Both practical course and lecture/exercises are compulsory; a written report must be submitted for both
11	**Grading procedure**	Practical achievement (50%) Tutorial achievement (50%) Both practical course and lecture/exercises are compulsory; a written report must be submitted for both. exam type: pass/fail (no grades). Both practical course and lecture/ exercises must be passed to accomplish the module.
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**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Focal Subject: Biomaterials and Bioprocessing

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) (SoSe 2027) Vorlesung: Biomaterials for Tissue Engineering (2 SWS) (SoSe 2027)	2,5 ECTS 2,5 ECTS
3	Lecturers		

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: 2;2;3;4
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
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** 94475	**Application of Cell Technology and Biofarbication** Application of Cell Technology and Biofarbication (AppCT+BioFab)	**5 ECTS**
2	Courses / lectures	Vorlesung: Application of Cell Technology (2 SWS)	-
3	Lecturers	Dr.-Ing. Rainer Detsch Prof. Dr.-Ing. Aldo Boccaccini	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	This course introduces the basics of biochemistry, cells and cell culture technique. Based on this knowledge, the students will learn how cells interact with biomaterials and how material parameters are influencing protein adsorption, cell adhesion, proliferation and differentiation. Also techniques to study these interactions are discussed in this course. With regards to biomedical engineering, characteristics of cell lines, primary and stem cells are further focal points. To understand the different approaches of tissue engineering, materials, growth factors and bioreactors will be discussed. Based on different hard and soft tissue examples, angiogenesis and tissue regeneration will be focused. Furthermore, students will learn basics about additive manufacturing, hydrogels and cellprinting. This leads to the field of biofabrication.
6	**Learning objectives and skills**	The students have the knowledge of the application of cell tissue technologies for tissue engineering in medicine and biomedicine. The students can apply basic research methods e.g. application of cell based interdisciplinary research topics. As the students will discuss current research projects, students are able to interpret and evaluate in vitro data from several biomedical research studies.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable (60 minutes) Klausur, 60 Min.
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter 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**	• Di Silvio (ed.): Cellular Response to Biomaterials; Cambridge u.a., 2009 • KC Dee, DA Puleo and R Bizios: Tissue-Biomaterial-Interaction; Wiley-Liss New Jersey, ISBN 0-471-25394-4

		• B. D. Ratner et al. (eds.): Biomaterials Science, 2nd Ed., Elsevier, 2004. • Detsch R, Will J, Hum J, Roether JA, Boccaccini AR. Biomaterials. In 2018. p. 91105. Available from: http://link.springer.com/10.1007/978-3-319-74854-2_6 • Ovsianikov, Aleksandr, Yoo, James, Mironov, Vladimir (Eds.)3D Printing and Biofabrication, ISBN 978-3-319-45445-0

1	**Module name** 42768	**Bioinspired Design**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Bioinspired Design (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Nicolas Vogel PD Dr. Stephan Wolf	

4	**Module coordinator**	PD Dr. Stephan Wolf
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**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
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** 45730	**Optical Technologies in Life Science** Optical technologies in life science	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Optical Technologies in Life Science (4 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Dr. Oliver Friedrich PD Dr. Sebastian Schürmann	

4	**Module coordinator**	PD Dr. Sebastian Schürmann
5	**Contents**	Inhalte • Anwendungen optischer Messmethoden im Bereich der Zellbiologie und Medizin • Mikroskopie: Grundlegende Konzepte und Kontrastverfahren, Auflösungsvermögen und Grenzen, Aufbau und Komponenten von Lichtmikroskopen, Fluoreszenz-Mikroskopie • Anwendungen von Fluoreszenz-Mikroskopie im Life Science Bereich, Verfahren zur Markierung biologischer Strukturen und Vorgänge in Zellen • Epifluoreszenz-, Konfokal-, Multiphotonen-Mikroskopie, Konzepte und Anwendungsbeispiele • Optische Endoskopie und Endomikroskopie in Forschung und Klinik • Super-Resolution Mikroskopie, Konzepte und Anwendungsbeispiele für optische Bildgebung jenseits der beugungsbedingten Auflösungsgrenze Content • Application of optical methods in the field of cell biology and medicine • Microscopy: Basic concepts, methods to enhance contrast, optical resolution and limits, components and setup of light microscopes, fluorescence microscopy • Applications of fluorescence microscopy in life sciences, methods for labeling of biological structures and cellular processes´ • Epi-fluorescence, confocal and multiphoton microscopy, concepts and application examples • Optical endoscopy and endomicroscopy in research and clinics • Super-resolution microscopy, concepts and applications for optical Imaging beyond the diffraction Limit of Resolution
6	**Learning objectives and skills**	Lernziele und Kompetenzen Die Studierenden • verstehen die grundlegenden Konzepte und technische Umsetzung optischer Technologien im Bereich Life Sciences und kennen typische Anwendungsbeispiele • können verschiedene technische Ansätze im Hinblick auf wissenschaftlich Fragestellungen vergleichen und bewerten

		• können Vor- und Nachteile verschiedener Technologien, sowie konzeptionelle und praktische Limitationen einschätzen und bei der Analyse wissenschaftlicher Ansätze und Ergebnisse berücksichtigen • können selbstständig vertiefende Informationen zu technischen Lösungen, Materialien und Methoden im Bereich der Mikroskopie und Spektroskopie sammeln, strukturieren, und für die zielgerichtete Planung wissenschaftlicher Experimente auswählen • können wissenschaftliche Fragestellungen und technische Ansätze in Kleingruppen kritisch diskutieren und gemeinschaftlich Ansätze zur Beantwortung von Forschungsfragen mit Hilfe optischer Technologien entwickeln Learning objectives and competences: Students • understand the basic concepts and specific technical approaches to optical technologies in life sciences and identify typical applications examples. • can analyze and compare different technical approaches to scientific research questions. • can summarize advantages and disadvantages of different technologies and assess theoretical and practical limitations with regard to experimental approaches and results. • can find, collect and structure in-depth information on technical solutions, materials and methods in the areas of microscopy and spectroscopy, in order to plan scientific experiments.
7	**Prerequisites**	• Grundkenntnisse im Bereich Optik und Zellbiologie • Basic knowledge in the fields of optics and cell biology is required
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written or oral
11	**Grading procedure**	Written or 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**	• Michael W. Davidson et al: Microscopy Primer, http://micro.magnet.fsu.edu, umfassendes Online-Lehrwerk über grundlegende Mikroskopieverfahren und neuesten technischen Entwicklungen

		• Bruce Alberts: Molecular Biology of the Cell, 4th Edition, New York, Garland Science Publisher. Standardlehrwerk für die Zellbiologie. • Ulrich Kubitschek: Fluorescence Microscopy: from Principles to Biological Applications, Wiley-VCH Verlag. • Douglas Chandler & Robert Roberson: Bioimaging: Current Concepts in Light and Electron Microscopy, Jones and Bartlett Publishers.

1	**Module name** 45731	**Composites and Nanomaterials in Medical technology / Biomaterials for Implants**	**5 ECTS**
2	Courses / lectures	Vorlesung: Biomaterials (Materials for implants) (2 SWS) (WiSe 2026)	2,5 ECTS
3	Lecturers	Dr.-Ing. Irem Ünalan Prof. Dr.-Ing. Aldo Boccaccini Dr. Julia Will	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini Dr. Julia Will
5	**Contents**	**Verbundwerkstoffe und Nanomaterialien in derMedizintechnik** • 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. **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 ***Content*** **Composite materials and nanomaterials in medicaltechnology** • 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 **Biomaterials for Implants** • 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
6	**Learning objectives and skills**	**Verbundwerkstoffe und Nanomaterialien in derMedizintechnik** 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. **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 ***<u>Educationalobjectives and competences</u>*** **Composite Materials and Nanomaterials inMedical 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

		Biomaterialsfor Implants 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.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written or oral schriftliche Prüfung / written exam (60 min)
11	**Grading procedure**	Written or oral (100%)
12	**Module frequency**	Every semester Es handelt sich um ein zweisemestriges Modul. Im einen Semester wird "Composites and Nanomaterials in Medical technology" gelesen, im anderen Semester "Biomaterials for Implants". Die Prüfung kann in jedem Semester abgelegt werden unabhängig davon, welche Vorlesung zuerst gehört wurde. This is a two-semester module. In one semester, students take the course “Composites and Nanomaterials in Medical Technology,” and in the other semester, “Biomaterials for Implants.” The exam can be taken in either semester, regardless of which course was taken first.
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**	**Verbundwerkstoffe und Nanomaterialien in der Medizintechnik/Composites and nanomaterials in medical technology** • Ambrosio (ed.): Biomedical composites; Oxford, 2010 • Wintermantel, Suk-Woo: Medizintechnik; Berlin, 2009 **Biomaterialien (Implantatwerkstoffe) /Biomaterials for Implants**

		• 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

1	**Module name** 94473	**Polymerwerkstoffe in der Medizin (MAP)**	**5 ECTS**
2	Courses / lectures	Vorlesung: Polymer Materials for Medical Applications (2 SWS)	3 ECTS
3	Lecturers	Michael Redel Prof. Dr. Dirk Schubert	

4	**Module coordinator**	Prof. Dr. Dirk Schubert
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**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
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: ?? h (keine Angaben zum Arbeitsaufwand in Präsenzzeit hinterlegt) Independent study: ?? h (keine Angaben zum Arbeitsaufwand im Eigenstudium hinterlegt)
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

Focal Subject: Computational Materials Science and Process Simulation

1	**Module name** 45471	**Computational Fluid Dynamics 1**	**5 ECTS**
2	Courses / lectures	Vorlesung: Computational Fluid Dynamics (2 SWS) Übung: Computational Fluid Dynamics - Exercise (1 SWS)	- 5 ECTS
3	Lecturers	Dr.-Ing. Manuel Münsch Prof. Dr. Philipp Schlatter	

4	**Module coordinator**	Dr.-Ing. Manuel Münsch
5	**Contents**	• Governing equations and models in fluid mechanics • Steady problems: the Finite-Difference Method (FDM) • Unsteady problems: methods of time integration • Advection-diffusion problems • The Finite-Volume Method • Solution of the incompressible Navier-Stokes equations • Grids and their properties • Boundary conditions • Conservation laws The theory given in the lectures is extended and applied to several transport problems in this exercise class: • discretization of the Blasius similarity equations • parabolization and discretization of the boundary layer equations • finite-Difference discretization of heat-transfer problems • approximation of boundary conditions • finite-Volume discretization of heat-transfer problems • discretization and time-stepping of the Navier-Stokes equations • projections methods: the SIMPLE and PISO Methods
6	**Learning objectives and skills**	Thestudents who successfully take this module should: • understand the physical meaning and mathematical character of the terms in advection-diffusion equations and the Navier-Stokes equations • assess under what circumstances some terms in these equations can be neglected • formulate a FDM for the solution of unsteady transport equations • assess the convergence, consistency and stability of a FDM • formulate a FVM for the solution of unsteady transport equations • know how to solve the Navier-Stokes equation with the FVM • implement programs in matlab/octave to simulate fluid flow • assess the quality and validity of a fluid flow simulation • work in team and write a report describing the results and significance of a simulation

		• know the different types of grids and when to use them The students who successfully solve the exercises should: • be able to discretize transport problems with the finite-difference and the finite-volume methods • discretize several type of boundary conditions (no-slip, flux, mixed) • understand how the implementation of projection methods to solve the Navier-Stokes equation is done • work in a team
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Computational Materials Science and Process Simulation Master of Science Advanced Materials and Processes 20242 Compulsoryelective module 1-3 Master of Science Clean Energy Processes 20212
10	**Method of examination**	Oral (30 minutes) Oral(30 minutes)
11	**Grading procedure**	Oral (100%) Oral(100%)
12	**Module frequency**	Only in winter 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**	

1	**Module name** 42915	**Process simulation**	**5 ECTS**
2	Courses / lectures	Tutorium: Process Simulation (Tutorial) (1 SWS) Vorlesung: Process Simulation (2 SWS) Übung: Process Simulation (Exercise) (2 SWS)	- - -
3	Lecturers	Prof. Dr.-Ing. Bastian Etzold	

4	**Module coordinator**	Prof. Dr.-Ing. Bastian Etzold
5	**Contents**	Content: • Introduction to industrial process development • Aspects of process intensification • Introduction to the Aspen Plus simulator for process simulation • Equipment modeling: chem. reactors (detailed), separators, heat exchangers, mixers, pumps, compressors • recirculation, separation sequences, interconnection to the overall process • Short-cut methods for single apparatuses and for process synthesis • Flow sheet simulation of selected sample processes in Aspen Plus • Heat integration (pinch analysis) • Economic feasibility studies: Cost structure, cost models, plant capacity utilization, economic measures of quality.
6	**Learning objectives and skills**	The students: • are familiar with the systematic approach to conceptual process design • are familiar with the individual steps of modeling chemical reactors, separators, heat exchangers, mixers, pumps and compressors • are able to independently carry out the modeling and simulation of chemical engineering processes using industry-relevant commercial simulation tools (in particular Aspen Plus) • are able to practically apply and expand their basic knowledge of reaction engineering and thermal process engineering in the simulation of process engineering processes • are able to classify different models of basic operations and assess the scope of application • are capable of comparing different process variants • are able to apply the acquired knowledge practically on the basis of selected examples, taking into account economic aspects (cost structure, cost models, plant capacity utilization, economic measures of quality)
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242

		Focal Subject: Computational Materials Science and Process Simulation Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable (120 minutes) Klausur/written exam (120 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter 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**	• Bearns, Behr, Brehm, Gmehling, Hofmann, Onken, Renken: Technische Chemie, Wiley-VCH, Weinheim, 2006. • Biegler, Grossmann, Westerberg: Systematic Methods of Chemical Process

1	**Module name** 42765	**Atomistic Methods: phase diagrams and processes**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Atomistic Methods: phase diagrams and processes (SoSe 2026)	-
3	Lecturers	PD Dr. Paolo Moretti	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	Thermodynamics, equilibrium statistical mechanics, molecular simulation
6	**Learning objectives and skills**	The students develop an understanding of the connection between the atomistic description of a system, and its macroscopic observables.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Computational Materials Science and Process Simulation Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written or oral Mündliche Prüfung, 30 Minuten
11	**Grading procedure**	Written or oral (100%)
12	**Module frequency**	no Module frequency information available!
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**	

Focal Subject: Nanomaterials and Nanotechnology

1	**Module name** 45350	**Nanotechnology of Disperse Systems** Nanotechnology of disperse systems	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Nanotechnology of Disperse Systems (3 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Robin Klupp Taylor Dr. Monica Distaso	

4	**Module coordinator**	Prof. Dr. Robin Klupp Taylor
5	**Contents**	• Introduction to nanodisperse systems and their broad fields of application and research • Summer semester only: Parallel lecture blocks (Block 1 (non-MAP) - Optoelectronic properties of nanodisperse systems, Block 2 (MAP) - Synthesis, properties and applications of mesocrystals) • Winter semester only: 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
6	**Learning objectives and skills**	On completion of the lecture course students will be able to: • 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
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3

9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Oral (30 minutes)
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**	1 semester
15	**Teaching and examination language**	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** 42936	**Self-organisation processes** Self-organization processes	**5 ECTS**
2	Courses / lectures	Vorlesung: Self-organization Processes (2 SWS) (SoSe 2026) Übung: Self-Organisation Processes (Exercise) (3 SWS) (SoSe 2026)	5 ECTS 5 ECTS
3	Lecturers	Prof. Dr. Michael Engel Prof. Dr. Robin Klupp Taylor Dr. Giulia Magnabosco	

4	**Module coordinator**	Prof. Dr. Michael Engel
5	**Contents**	Structure formation with elementary building blocks in molecular, particulate, soft, and biological systems. Theoretical aspects, experimental realizations, and applications are discussed. • introduction (Overview): the idea of building blocks, thermodynamic principles, near and far from equilibrium • Molecules 1 (Surfactants): molecular interaction, hydrophobicity, micellation • Molecules 2 (Mesophases): packing parameter, applications, self-assembled monolayers, membranes • Molecules 3 (Block co-polymers): Flory-Huggins theory, microphase separation, recent research • Molecules 4 (Liquid crystals): phases, role of anisotropy, order parameter, thermodynamics, properties • Theory 1 (Pattern formation): phase diagrams, phase field model, spinodal decomposition • Theory 2 (Particle self-assembly): nanoparticle self-assembly, (nano)crystal shapes, hard vs. soft spheres, entropy maximization vs. interface minimization • Theory 3 (Dynamic self-assembly): oscillatory chemical reactions, reaction diffusion, active matter • Theory 4 (Programmable assembly): DNA nanotechnology, future challenges • Colloids 1 (Synthesis): methods for synthesis of isotropic colloids, bulk crystallization • Colloids 2 (Sedimentation): Assembly by depletion, electrostatics, confinement by solid-fluid interfaces, opals • Colloids 3 (Assembly at fluid-fluid interfaces): techniques, Pickering emulsions, evaporation • Colloids 4 (Convective assembly): film formation and defects, coffee ring effect, templating
6	**Learning objectives and skills**	Successful completion of this module confirms students are able to • describe complex self-organization processes with the help of simple model systems • apply this knowledge to physical, chemical, and bioinspired systems

		• develop an advanced understanding of the self-organization of (macro)molecules and colloids • understand processes to direct and influence self-organization processes • judge the relevance of self-organization for the processing and synthesis of materials • gain insight into current research in the field of the lecture
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable Oral exam (30 min.)
11	**Grading procedure**	Variable (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**	• Ian W. Hamley, “Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials”, Wiley, 2007. • Yoon S. Lee, „Self-Assembly and Nanotechnology Systems”, Wiley, 2011. • Scott Camazine, Jean-Louis Deneubourg, Nigel R. Franks, „Self-Organization in Biological Systems“, Princeton University Press, 2003. • John A. Pelesko, „Self Assembly: The Science of Things That Put Themselves Together“, Chapman and Hall/CRC, 2007. • Jacob N. Israelachvili, „Intermolecular and Surface Forces”, Academic Press, 2011.

1	**Module name** 42766	**Self Assembly on Surfaces**	**5 ECTS**
2	Courses / lectures	Vorlesung: Self-assembly at surface (2 SWS)	-
3	Lecturers	Prof. Dr. Marcus Halik	

4	**Module coordinator**	Prof. Dr. Marcus Halik
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**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (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** 42767	**Advanced Structural Materials and Nanomechanical Testing**	**5 ECTS**
2	Courses / lectures	Vorlesung: Scanning Probe Microscopy and Nanomechanics (2 SWS) Übung: Scanning Probe Microscopy and Nanomechanics - Exercises (1 SWS) Vorlesung: Advanced Structural Materials (1 SWS)	3 ECTS - -
3	Lecturers	Dr. Michael Wurmshuber Matthias Glosemeyer PD Dr.-Ing. Steffen Neumeier Prof. Dr. Mathias Göken	

4	**Module coordinator**	Prof. Dr. Mathias Göken
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**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
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: ?? 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** 45045	**Porous Materials: Preparation principles, production processes and spectroscopic characterization** Porous materials: Preparation principles, production processes and spectroscopic characterization	**5 ECTS**
2	Courses / lectures	Vorlesung: Porous Materials: Preparation principles, production processes and spectroscopic characterization (2 SWS) Übung: Tutorial Porous Materials: Preparation principles, production processes and spectroscopic characterization (1 SWS) Übung: Übung Porous Materials: Preparation principles, production processes and spectroscopic characterization (1 SWS)	5 ECTS - -
3	Lecturers	Prof. Dr. Martin Hartmann Dr. Florian Wisser Dr. Dorothea Wisser	

4	**Module coordinator**	Prof. Dr. Martin Hartmann
5	**Contents**	In diesem Modul sollen wichtige spektroskopische Verfahren und ihre Anwendungsbereiche vorgestellt werden. Im ersten Teil der Veranstaltung wird eine kurze Einführung in die molekularen Grundlagen sowie der Eigenschaften elektromagnetischer Strahlung gegeben. Zunächst werden die Prinzipien der Methoden zur Strukturaufklärung auf molekularer Ebene besprochen, insbesondere der Resonanzmethoden wie Kernresonanz- (NMR-), Elektronenspinresonanz- (ESR-) Ultraviolett- (UV-), Infrarot- (IR-) und Raman-Spektroskopie. Im zweiten Teil der Veranstaltung wird die Charakterisierung von technischen Katalysatoren und Adsorbenten vorwiegend mittels Festkörper-NMR-Spektroskopie und ESR-Spektroskopie (unter Einbeziehung von IR- und UV-Spektroskopie) anhand verschiedener Beispiele konkret geübt. Dabei werden neben den Grundlagen der Spektroskopie von Feststoffen auch die verschiedenen Aspekte der In-situ-(Operando)-Spektroskopie und der Prozessanalytik mittels spektroskopischer Methoden konkreter vorgestellt. Die Lehrveranstaltungen dieses Moduls sind Vorlesungen, Übungen und ein Praktikum. In den Vorlesungen werden die erforderlichen theoretischen Grundlagen für das Verständnis spektroskopischer Methoden vermittelt. Eng mit dem Vorlesungsstoff verzahnt werden in den Übungsgruppen und im Praktikum die Fähigkeit zur Aufnahme und Interpretation realer Spektren an Hand von Beispielen aus der Technik (z.B. Zeolithe, geträgerte Metallkatalysatoren, immobilisierte Enzyme) geübt.
6	**Learning objectives and skills**	Die Studierenden: • verstehen die molekularen Grundlagen sowie der Eigenschaften elektromagnetischer Strahlung • kennen die wichtigsten spektroskopischen Methoden und ihre Anwendung zur Charakterisierung von technischen

		Feststoffen, insbesondere Resonanzmethoden wie Kernresonanz- (NMR-), Elektronenspinresonanz- (ESR-) Ultraviolett- (UV-), Infrarot- (IR-) und Raman-Spektroskopie • wenden die theoretischen Aspekte in vielfältigen spezielleren, aber auch kombinierten Übungen zur Charakterisierung von technischen Katalysatoren und Adsorbenten mittels Festkörper-NMR-Spektroskopie und ESR-Spektroskopie (unter Einbeziehung von IR- und UV-Spektroskopie) an • können Spektren selbsständig aufnehmen und an Hand von Beispielen aus der Technik (z.B. Zeolithe, geträgerte Metallkatalysatoren, immobilisierte Enzyme) interpretieren und die Ergebnisse kritisch bewerten
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written or oral
11	**Grading procedure**	Written or oral (100%)
12	**Module frequency**	Only in winter 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**	• Spectroscopy in Catalysis An Introduction, J. Niemantsverdriet, 2007 • Characterization of Solid Materials and Heterogeneous Catalysts, M. Che, J.C. Vedrine (Eds.), Wiley-VCH 2012

1	**Module name** 42922	**Thin-film processing**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Thin-Film Processing (5 SWS)	-
3	Lecturers	Prof. Dr. Robin Klupp Taylor Dr. Giulia Magnabosco	

4	**Module coordinator**	Prof. Dr. Nicolas Vogel
5	**Contents**	This course surveys the full workflow of modern thin-film processing, moving from fabrication routes to in-depth characterisation: • Thin solid films - thermodynamic and kinetic principles of Physical- and Chemical-Vapour Deposition (evaporation, sputtering, ion-beam & laser methods; thermal, plasma-assisted and photon-stimulated CVD, precursor handling). • Solution- and electro-based coatings - electroplating, electroless deposition, sol-gel, chemical-bath and SILAR techniques. • Soft and molecular films - surfactant and self-assembled monolayers, Langmuir-Blodgett transfer, stimulus-responsive surface coatings. • Polymer and particulate films - solution-processed polymers, dispersion paints, layer-by-layer assemblies, nano/micro-structured and porous architectures; electrophoretic deposition, evaporative drying phenomena and methods (coffee-ring effect, mitigation, colloidal crystals). • Characterisation toolbox - thickness, morphology, roughness, phase, composition, mechanical response and in-situ monitoring; selection of suitable techniques and instrumentation for each property.
6	**Learning objectives and skills**	After successful completion, students will be able to: • Explain the physicochemical foundations governing vapour-, solution- and electro-based thin-film deposition processes. • Compare and evaluate PVD, CVD and wet-chemical routes with respect to kinetics, throughput, sustainability and application domain. • Apply interfacial and drying principles to design soft, polymeric or particulate films with targeted micro-/nano-structure. • Select and justify appropriate industrial coating or self-assembly strategies for a specified substrate, material and property requirement.
7	**Prerequisites**	Prerequisites: Basics of Materials Science, Physics (I+II), Fundamentals of Electrical Engineering, Measurement systems, Interface Engineering and Particle Technology
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242

		Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable
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**	• F.-W. Bach, A. Laarmann, T. Wenz (Eds.), Modern Surface Technology, Wiley, Weinheim, FRG, 2006.[Full Text] • J. Bachmann, Atomic Layer Deposition in Energy Conversion Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2017.[Full Text] • Cohen, E.D. and Gutoff, E.B. (1992) Modern coating and drying technology, VCH, New York, NY. • Frey, H. and Khan, H.R. (2015) Handbook of Thin-Film Technology, Springer Berlin Heidelberg, Berlin, Heidelberg. • Y. Lin, X. Chen (Eds.), Advanced Nano Deposition Methods, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2016.[Full Text] • Martin, P.M. (2010) Handbook of deposition technologies for films and coatings: Science, applications and technology, 3rd edn, Elsevier, Amsterdam, Boston. • M. Ohring, Materials science of thin films: Deposition and structure / Milton Ohring, 2nd ed., Academic Press, San Diego, CA, 2002. [Full Text]

Elective course

1	**Module name** 42765	**Atomistic Methods: phase diagrams and processes**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Atomistic Methods: phase diagrams and processes (SoSe 2026)	-
3	Lecturers	PD Dr. Paolo Moretti	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	Thermodynamics, equilibrium statistical mechanics, molecular simulation
6	**Learning objectives and skills**	The students develop an understanding of the connection between the atomistic description of a system, and its macroscopic observables.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Computational Materials Science and Process Simulation Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written or oral Mündliche Prüfung, 30 Minuten
11	**Grading procedure**	Written or oral (100%)
12	**Module frequency**	no Module frequency information available!
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** 42766	**Self Assembly on Surfaces**	**5 ECTS**
2	Courses / lectures	Vorlesung: Self-assembly at surface (2 SWS)	-
3	Lecturers	Prof. Dr. Marcus Halik	

4	**Module coordinator**	Prof. Dr. Marcus Halik
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**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written examination (90 minutes)
11	**Grading procedure**	Written examination (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** 42767	**Advanced Structural Materials and Nanomechanical Testing**	**5 ECTS**
2	Courses / lectures	Vorlesung: Scanning Probe Microscopy and Nanomechanics (2 SWS) Übung: Scanning Probe Microscopy and Nanomechanics - Exercises (1 SWS) Vorlesung: Advanced Structural Materials (1 SWS)	3 ECTS - -
3	Lecturers	Dr. Michael Wurmshuber Matthias Glosemeyer PD Dr.-Ing. Steffen Neumeier Prof. Dr. Mathias Göken	

4	**Module coordinator**	Prof. Dr. Mathias Göken
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**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
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: ?? 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** 42762	**Advanced Processes: Catalysis**	**5 ECTS**
2	Courses / lectures	Vorlesung: Catalysis (2 SWS)	5 ECTS
3	Lecturers	Dr. Friederike Agel	

4	**Module coordinator**	Dr. Friederike Agel Prof. Dr. Marco Haumann
5	**Contents**	Basics of Sustainability and Catalysis Heterogeneous catalysis: • Adsorption (bonds and models) • Microkinetics: Mechanisms of surface reactions • Deriving reaction rate approaches for surface catalyzed reactions • Macrokinetics: Influence of mass transfer in porous materials • Mass transfer influences on selectivity • Selectivity and stability of heterogenous catalysts • Catalyst characterization Homogeneous catalysis: • Ligand influence on selectivity/activity/stability • Fluid/fluid biphasic catalysis • Hatta number and enhancement Special catalyst materials
6	**Learning objectives and skills**	Students will be able to • formulate the basic principles of sustainable chemistry (atom economy, energy efficiency, recycling, avoidance of hazardous substances) and discuss the role of catalysis in achieving these goals. • distinguish between essential classes of catalysts (heterogeneous, homogeneous) and compare their advantages and disadvantages in the context of sustainable processes. • define physical and chemical adsorption, molecular and dissociative adsorption, and explain them using typical examples. • apply common adsorption models (e.g., Langmuir isotherms, multilayer adsorption) qualitatively. • derive rate laws for surface-catalyzed reactions (e.g., Langmuir-Hinshelwood, Eley-Rideal) assuming rate-determining steps and steady-state approximations. • use simple material and energy balances to show how catalysts influence yield, energy requirements, and by-product formation in processes. • use dimensionless parameters (e.g., effectiveness factor, Thiele modulus) to assess the influence of mass transport on the observed kinetics and identify transport limitations. • explain how diffusion limitations influence selectivity (e.g., preference for fast or rapidly diffusing reactants) and graphically represent simple scenarios.

		• define the terms activity, selectivity, and deactivation (sintering, coking, poisoning) and discuss strategies for increasing selectivity and long-term stability. • name essential characterization methods for heterogeneous catalysts (e.g., BET surface area, porosimetry, temperature-programmed methods, spectroscopic methods) and explain their information content. • formulate structure-property relationships, e.g., how surface area, pore structure, metal dispersion, or support material influence activity and selectivity. • for organometallic catalysts, explain the influence of ligands on electronic, steric properties of the catalyst, and thus on activity, selectivity, and stability in qualitative terms and discuss this using simple substrate examples. • explain the concept of fluid/fluid two-phase catalysis (phase separation, catalyst recovery, mass transport across the phase boundary) and name the advantages and disadvantages compared to single-phase systems. • qualitatively describe the significance of the Hatta number concept and mass transfer coefficients for gas/liquid or liquid/liquid-catalyzed reactions and distinguish between reaction-controlled and transport-controlled regimes.
7	**Prerequisites**	No preliminary knowledge is needed for a successful participation. However, basic knowledge of kinetics, thermodynamics and reaction engineering can make it easier to get started.
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Oral (30 minutes)
11	**Grading procedure**	Oral (100%) Oral examination (100 %)
12	**Module frequency**	Only in winter semester The lecture is offered only during the winter semester. The oral exam can be taken in either the winter or 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**	Slides and all further material will be uploaded on StudOn.

1	**Module name** 42918	**Fuel cells and electrolysers**	**5 ECTS**
2	Courses / lectures	Vorlesung: Fuel cells and electrolysers (2 SWS) Übung: Fuel cells and electrolysers (3 SWS)	- -
3	Lecturers	Prof. Dr.-Ing. Simon Thiele	

4	**Module coordinator**	Prof. Dr.-Ing. Simon Thiele
5	**Contents**	Fuel cell (FC) and electrolysis cell (ECs) • Application areas • Thermodynamic boundary conditions • Electrochemical basics • Kinetics • Transport processes • State of the art • Characterisation techniques • Open questions and scientific challenges
6	**Learning objectives and skills**	Students • are able to apply acquired knowledge from e.g. physical chemistry, mathematics and basic electrochemistry • understand kinetics to describe the time dependent concentration changes in chemical reactions • apply basic knowledge in thermodynamics and general chemistry • are familiar with basic concepts of electrochemical engineering for fuel cells and electrolysers • can describe thermodynamics, kinetic effects and electrochemical foundations • understand limitations such as kinetic, ohmic or mass transport limitions • have a solid knowledge on the state of the art • know how to experimentally characterize cells • are able to deduce methods to improve cell technologies by analyzing experimental data
7	**Prerequisites**	To succeed in this course, students will need to apply acquired knowledge from e.g. physical chemistry, mathematics and basic electrochemistry. Understanding of kinetics to describe the time dependent concentration changes in chemical reactions should be familiar from physical chemistry classes. Basic knowledge in thermodynamics and general chemistry is beneficial.
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable (120 minutes)

		written exam (120 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**	• O'hayre, Ryan; Cha, Suk-Won; Prinz, Fritz B.; Colella, Whitney (2016): Fuel cell fundamentals: John Wiley & Sons.

1	**Module name** 42939	**Chemical Technologies for the Energy Transition**	**5 ECTS**
2	Courses / lectures	Übung: Chemical technologies for energy transition - Seminar (2 SWS) (SoSe 2027) Vorlesung: Chemical technologies for energy transition (2 SWS) (SoSe 2027)	- -
3	Lecturers		

4	**Module coordinator**	Prof. Dr. Marco Haumann
5	**Contents**	• Definition of sustainability and measures • Current and future Energy mix • Concepts of Catalysis • Exhaust Gas Catalysis • Sustainable Feedstocks • Biorefinery • Carbon capture and storage • Closing the C cycle: CO2 as C1 Source • Alternative fuels • Chemical energy storage vs electrical storage
6	**Learning objectives and skills**	The students • learn important processes that contribute to the sustainability of the chemical industry, apart from energy processes. • learn what sustainability means • understand aspects of sustainability and are able to transfer it to future processes • understand the functionality and theory of common analysis tools for the characterization of catalytic systems • are able to show the advantages and disadvantages and the potentials of the reviewed applications
7	**Prerequisites**	No preliminary knowledge is needed for a successful participation. However, basic knowledge of catalysis, energy efficiency, thermodynamics, or reaction engineering can make it easier to get started.
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable Graded scientific presentation (30 minutes).
11	**Grading procedure**	Variable (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**	
16	**Bibliography**	• Slides and all further material will be uploaded on StudOn.

1	**Module name** 42940	**Recycling of Electronic Wastes**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Recycling of Electronic Wastes (Lecture and Exercises) (4 SWS)	5 ECTS
3	Lecturers	Dr. Monica Distaso	

4	**Module coordinator**	Dr. Monica Distaso
5	**Contents**	• Definition of sustainability and measures • Current and future Energy mix • Concepts of Catalysis • Exhaust Gas Catalysis • Sustainable Feedstocks • Biorefinery • Carbon capture and storage • Closing the C cycle: CO2 as C1 Source • Alternative fuels • Chemical energy storage vs electrical storage
6	**Learning objectives and skills**	The students • learn important processes that contribute to the sustainability of the chemical industry, apart from energy processes. • learn what sustainability means • understand aspects of sustainability and are able to transfer it to future processes • understand the functionality and theory of common analysis tools for the characterization of catalytic systems • are able to show the advantages and disadvantages and the potentials of the reviewed applications
7	**Prerequisites**	No preliminary knowledge is needed for a successful participation. However, basic knowledge of catalysis, energy efficiency, thermodynamics, or reaction engineering can make it easier to get started.
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable (30 minutes) Graded scientific presentation (30 minutes).
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**	• Slides and all further material will be uploaded on StudOn.

1	**Module name** 45035	**Adsorption: Fundamentals and Applications** Adsorption: Fundamentals and applications	**5 ECTS**
2	Courses / lectures	Übung: Übung Adsorption: Fundamentals and Applications (0 SWS) Vorlesung: Adsorption: Fundamentals and Applications (2 SWS)	- 5 ECTS
3	Lecturers	Dr.-Ing. Carola Vorndran Prof. Dr. Matthias Thommes	

4	**Module coordinator**	Prof. Dr. Matthias Thommes
5	**Contents**	1. Introduction and terminology 2. Gas adsorptions basics and adsorbent materials 3. Physisorption mechanisms 4. Surface area determination 5. Porosity and pore structure analysis of nanoporous materials 5.1 Micropore analysis 5.2Mesopore analysis 5.3 Macropore analysis : adsorption and liquid intrusion methods 5.4. Characterization of hierarchically structured porous materials 6. High pressure adsorption 7. Surface chemistry effects on adsorption 8. Adsorption and characterization in the liquid phase 9. Adsorption of mixtures 10. Adsorption applications in gas storage and separation
6	**Learning objectives and skills**	The students will achieve a deep understanding of the underlying mechanisms for the adsorption of fluids on powders and nanoporous materials know adsorption-based and complimentary techniques/methodologies for a reliable characterization of adsorbents for applications in separation, heterogeneous catalysis etc. understand the basics of high pressure adsorption and corresponding applications in gas storage know selected, important principles of adsorption-based separation processes
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written or oral Oral examination (30 min.)
11	**Grading procedure**	Written or oral (100%)
12	**Module frequency**	Only in winter semester
13	**Workload in clock hours**	Contact hours: 30 h

		Independent study: 105 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46257	**Advanced Semiconductor Technologies - Photovoltaic Systems I - Fundamentals** Advanced semiconductor technologies - Photovoltaic systems I - Fundamentals	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Advanced Semiconductor Technologies - Photovoltaic Systems for Power Generation - Design Implementation and Characterization (2 SWS) Tutorium: Questionaire PV Systems 1	3 ECTS -
3	Lecturers	Prof. Dr. Christoph Brabec Dr. Larry Lüer	

4	**Module coordinator**	Prof. Dr. Christoph Brabec Prof. Dr. Wolfgang Heiß
5	**Contents**	VHB Digital Lecture "PV Systems" • This lecture is provided by Virtuelle Hochschule Bayern. It is a virtual lecture composed and realized by leading experts in Bavaria and Germany (with contributions from FAU lecturers) in the field of semiconductors and photovoltaics. • Students are free to work with the lectures according to their own schedule. At the end of each lecture, one or two exercises will be presented which must be accomplished in order to get access to the subsequent lecture. • Within each semester, there will be at least two online appointments where all course authors will be available for a Q&A session. These sessions obviously occur at a fixed time, which will be announced at the beginning of the semester on Studon and in Campo under the event "Questionnaire". • The lecture will introduce 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.
6	**Learning objectives and skills**	VHB Digital Lecture "Photovoltaic Systems" • The virtual lecture consists of 10 individual lectures. Each lecture ends with a set of exercises to be accomplished. • Lecture 1: Introduction & History. This lecture sets the stage. We start with the question "how much energy does mankind use?" Then, we outline potential (renewable and non-renewable) energy sources, before we focus on photovoltaics. We outline PV applications, and show the evolution of production volume and cost, the so-called "learning curve". We

present projections into the future and their relation to policy decisions.

- Lecture 2: Semiconductor Physics. We start with a minimal introduction to quantum mechanics, needed to understand how energy bands are formed in a crystalline semiconductor. This leads us to direct and indirect semiconductors and the contribution of phonons to optical absorption. We discuss the density of states and the Fermi - Dirac distribution. We discuss the resulting conductivity of semiconductors and what we can learn from its temperature dependence. We introduce the highly important and useful concept of quasi-Fermi levels. We conclude the lecture by discussion extrinsic semiconductors; these are the basis to observe a photovoltaic effect by forming a p-n junction.
- Lecture 3: Efficiency limits and black body radiation. The sun is a broad band emitter while a single junction solar cell has a single fixed bandgap energy. This lecture discusses the drastic consequence from this mismatch, namely that a single junction solar cell can never reach 100% power conversion efficiency. Quantifying efficiency limits requires the understanding of the thermodynamics of the system. We distinguish losses we cannot avoid from those which may be avoided by improving the technology. We calculate the current-voltage curve of an ideal solar cell and discuss the types of losses and how to quantify them by experiment. Finally, we show recent progress how the efficieny limit of single junction solar cells can be overcome by forming tandem solar cells
- Lecture 4. Loss mechanisms. In this lecture, we discuss losses that keep realistic solar cells from reaching the theoretical efficiency limit. We discuss optical losses and how to handle them using antireflection coatings, pyramids, and the control of interference in thin film solar cells. Then we discuss nonradiative recombination, distinguishing the Shockley-Read-Hall and Auger mechanisms. Further, we discuss resistive losses, and we discuss how these losses can be distinguished in experiments.
- Lecture 5: Junctions. A fundamental understanding is essential to predict the properties of semiconductors. We start with a historic overview and present a short recap of the quantum mechanics. The discussion of metal-metal junctions is followed by Shottky junctions and the derivation of the current-voltage curve. Important cases beyond Shottky are discussed such as mirror charges and Fermi-level pinning, that often govern the properties of real-world junctions. Then we take a closer look at p-n junctions in silicon, and finish by considering heterojunctions.
- Lecture 6. Silicon Technology. History an market share; production of pure silicon material and silicon wafers, technologies for the processing of silicon solar cells:

		BSF / PERC, TOPcon and SHJ, and finally IBC. All these technologies solve problems in performance and production complexity, which are compared. Finally, the production of modules from single silicon solar cells is discussed. • Lecture 7. CIGS technology. This is a thin film technology. First, we introduce the band structure and how the energies can be tuned. Then we discuss the cell architecture and how the layers are produced technically. Then we discuss defects and metastable performance (light induced healing) and how to passivate defects. Finally, efficiency limits, and the industrial realisation are discussed. • Lecture 8 . GaAs multijunctions. We start with a discussion on defects and defect passivation for III/V semiconductors. Then we introduce into multijunctions and why their efficiency goes beyong the single junction detailed balance limit. We discuss the concept of solar concentration and the application of GaAs tandems, especially in space. • Lecture 9. Solution processing and morphology. In solution processed solar cells, morphology control is decisive for device performance as well as stability. This lecture introduces into the basic concepts of morphology optimization by controlling the processing conditions. • Lecture 10: Organic photovoltaics. We introduce into organic semiconductors and their electronic properties. Then we present device structures, distinguishing monolayer, bilayer, and bulk heterojunction structures. We compare different ways to process devices in the lab. Then we focus on the special photophysics of OPV system where the primary photoexcitation is a bound electron hole pair. This directly links to current research directions to overcome the connected efficiency losses. Finally, device degradation mechniams are discussed.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
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 (45 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: 45 h Independent study: 105 h
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 94351	**Process Technologies** Process technologies	**5 ECTS**
2	Courses / lectures	Vorlesung: Process Technologies (2 SWS) (SoSe 2026) Übung: Process Technologies Exercises (1 SWS) (SoSe 2026)	5 ECTS -
3	Lecturers	Prof. Dr.-Ing. Bastian Etzold	

4	**Module coordinator**	Prof. Dr.-Ing. Bastian Etzold
5	**Contents**	The Module "Process Technologies gives an overview on important processes in the chemical process industries. The processes are treated in a holistic approach and the interaction of individual process steps and their feedback to the overall process are discussed in more detail. In particular, the relationship between the physical/chemical basics of the processes, process development and process design are discussed. The presented processes are selected based on their importance in the fields of raw materials, intermediates and consumer products of the chemical process industries. In the sense of process engineering, apart from the reaction steps, the separation operations are also part of the considerations. The evaluation of the methods with regard to their cost-effectiveness and sustainability complete the description of the processes. In detail, the following aspects are treated: • Raw materials (crude oil, fuels, natural gas, technical gases) • Organic base chemicals (syngas, alkanes, alkenes, aromatics) • Organic intermediates (C1-C4 alcohols, cyclic alcohols, ether, epoxides, organic acids) • Renewable raw materials • Organic end products (surfactants, pigments, polymers) • Inorganic base chemicals and intermediates (sulfuric acid, ammonia, sodium hydroxide) • Inorganic end products (fertilizers, ceramics, glass) • Process development (technologies, economic evaluation)
6	**Learning objectives and skills**	The students • know the important processes in the chemical process industries • describe the interaction of individual process steps and their feedback to the overall process • discuss the relationship between the physical/chemical basics of the processes, process development and process design • evaluate the processes und methods with regard to their cost-effectiveness and sustainability
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242

10	**Method of examination**	Course achievement
11	**Grading procedure**	Course achievement (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**	Textbooks and compendia on Technical Chemistry, e.g. • Baerns, et al., Technische Chemie, Wiley-VCH • Jess, Wasserscheid, Chemical Technology, Wiley-VCH • Ullmann's Encyclopedia of Industrial Chemistry

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) (SoSe 2027) Vorlesung: Biomaterials for Tissue Engineering (2 SWS) (SoSe 2027)	2,5 ECTS 2,5 ECTS
3	Lecturers		

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: 2;2;3;4
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
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** 94475	**Application of Cell Technology and Biofarbication** Application of Cell Technology and Biofarbication (AppCT+BioFab)	**5 ECTS**
2	Courses / lectures	Vorlesung: Application of Cell Technology (2 SWS)	-
3	Lecturers	Dr.-Ing. Rainer Detsch Prof. Dr.-Ing. Aldo Boccaccini	

4	**Module coordinator**	Prof. Dr.-Ing. Aldo Boccaccini
5	**Contents**	This course introduces the basics of biochemistry, cells and cell culture technique. Based on this knowledge, the students will learn how cells interact with biomaterials and how material parameters are influencing protein adsorption, cell adhesion, proliferation and differentiation. Also techniques to study these interactions are discussed in this course. With regards to biomedical engineering, characteristics of cell lines, primary and stem cells are further focal points. To understand the different approaches of tissue engineering, materials, growth factors and bioreactors will be discussed. Based on different hard and soft tissue examples, angiogenesis and tissue regeneration will be focused. Furthermore, students will learn basics about additive manufacturing, hydrogels and cellprinting. This leads to the field of biofabrication.
6	**Learning objectives and skills**	The students have the knowledge of the application of cell tissue technologies for tissue engineering in medicine and biomedicine. The students can apply basic research methods e.g. application of cell based interdisciplinary research topics. As the students will discuss current research projects, students are able to interpret and evaluate in vitro data from several biomedical research studies.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable (60 minutes) Klausur, 60 Min.
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter 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**	• Di Silvio (ed.): Cellular Response to Biomaterials; Cambridge u.a., 2009 • KC Dee, DA Puleo and R Bizios: Tissue-Biomaterial-Interaction; Wiley-Liss New Jersey, ISBN 0-471-25394-4

		• B. D. Ratner et al. (eds.): Biomaterials Science, 2nd Ed., Elsevier, 2004. • Detsch R, Will J, Hum J, Roether JA, Boccaccini AR. Biomaterials. In 2018. p. 91105. Available from: http://link.springer.com/10.1007/978-3-319-74854-2_6 • Ovsianikov, Aleksandr, Yoo, James, Mironov, Vladimir (Eds.)3D Printing and Biofabrication, ISBN 978-3-319-45445-0

1	**Module name** 45471	**Computational Fluid Dynamics 1**	**5 ECTS**
2	Courses / lectures	Vorlesung: Computational Fluid Dynamics (2 SWS) Übung: Computational Fluid Dynamics - Exercise (1 SWS)	- 5 ECTS
3	Lecturers	Dr.-Ing. Manuel Münsch Prof. Dr. Philipp Schlatter	

4	**Module coordinator**	Dr.-Ing. Manuel Münsch
5	**Contents**	• Governing equations and models in fluid mechanics • Steady problems: the Finite-Difference Method (FDM) • Unsteady problems: methods of time integration • Advection-diffusion problems • The Finite-Volume Method • Solution of the incompressible Navier-Stokes equations • Grids and their properties • Boundary conditions • Conservation laws The theory given in the lectures is extended and applied to several transport problems in this exercise class: • discretization of the Blasius similarity equations • parabolization and discretization of the boundary layer equations • finite-Difference discretization of heat-transfer problems • approximation of boundary conditions • finite-Volume discretization of heat-transfer problems • discretization and time-stepping of the Navier-Stokes equations • projections methods: the SIMPLE and PISO Methods
6	**Learning objectives and skills**	Thestudents who successfully take this module should: • understand the physical meaning and mathematical character of the terms in advection-diffusion equations and the Navier-Stokes equations • assess under what circumstances some terms in these equations can be neglected • formulate a FDM for the solution of unsteady transport equations • assess the convergence, consistency and stability of a FDM • formulate a FVM for the solution of unsteady transport equations • know how to solve the Navier-Stokes equation with the FVM • implement programs in matlab/octave to simulate fluid flow • assess the quality and validity of a fluid flow simulation • work in team and write a report describing the results and significance of a simulation

		• know the different types of grids and when to use them The students who successfully solve the exercises should: • be able to discretize transport problems with the finite-difference and the finite-volume methods • discretize several type of boundary conditions (no-slip, flux, mixed) • understand how the implementation of projection methods to solve the Navier-Stokes equation is done • work in a team
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Computational Materials Science and Process Simulation Master of Science Advanced Materials and Processes 20242 Compulsoryelective module 1-3 Master of Science Clean Energy Processes 20212
10	**Method of examination**	Oral (30 minutes) Oral(30 minutes)
11	**Grading procedure**	Oral (100%) Oral(100%)
12	**Module frequency**	Only in winter 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**	

1	**Module name** 42915	**Process simulation**	**5 ECTS**
2	Courses / lectures	Tutorium: Process Simulation (Tutorial) (1 SWS) Vorlesung: Process Simulation (2 SWS) Übung: Process Simulation (Exercise) (2 SWS)	- - -
3	Lecturers	Prof. Dr.-Ing. Bastian Etzold	

4	**Module coordinator**	Prof. Dr.-Ing. Bastian Etzold
5	**Contents**	Content: • Introduction to industrial process development • Aspects of process intensification • Introduction to the Aspen Plus simulator for process simulation • Equipment modeling: chem. reactors (detailed), separators, heat exchangers, mixers, pumps, compressors • recirculation, separation sequences, interconnection to the overall process • Short-cut methods for single apparatuses and for process synthesis • Flow sheet simulation of selected sample processes in Aspen Plus • Heat integration (pinch analysis) • Economic feasibility studies: Cost structure, cost models, plant capacity utilization, economic measures of quality.
6	**Learning objectives and skills**	The students: • are familiar with the systematic approach to conceptual process design • are familiar with the individual steps of modeling chemical reactors, separators, heat exchangers, mixers, pumps and compressors • are able to independently carry out the modeling and simulation of chemical engineering processes using industry-relevant commercial simulation tools (in particular Aspen Plus) • are able to practically apply and expand their basic knowledge of reaction engineering and thermal process engineering in the simulation of process engineering processes • are able to classify different models of basic operations and assess the scope of application • are capable of comparing different process variants • are able to apply the acquired knowledge practically on the basis of selected examples, taking into account economic aspects (cost structure, cost models, plant capacity utilization, economic measures of quality)
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242

		Focal Subject: Computational Materials Science and Process Simulation Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable (120 minutes) Klausur/written exam (120 min.)
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter 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**	• Bearns, Behr, Brehm, Gmehling, Hofmann, Onken, Renken: Technische Chemie, Wiley-VCH, Weinheim, 2006. • Biegler, Grossmann, Westerberg: Systematic Methods of Chemical Process

1	**Module name** 45350	**Nanotechnology of Disperse Systems** Nanotechnology of disperse systems	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Nanotechnology of Disperse Systems (3 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Robin Klupp Taylor Dr. Monica Distaso	

4	**Module coordinator**	Prof. Dr. Robin Klupp Taylor
5	**Contents**	• Introduction to nanodisperse systems and their broad fields of application and research • Summer semester only: Parallel lecture blocks (Block 1 (non-MAP) - Optoelectronic properties of nanodisperse systems, Block 2 (MAP) - Synthesis, properties and applications of mesocrystals) • Winter semester only: 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
6	**Learning objectives and skills**	On completion of the lecture course students will be able to: • 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
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3

9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Oral (30 minutes)
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**	1 semester
15	**Teaching and examination language**	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** 42936	**Self-organisation processes** Self-organization processes	**5 ECTS**
2	Courses / lectures	Vorlesung: Self-organization Processes (2 SWS) (SoSe 2026) Übung: Self-Organisation Processes (Exercise) (3 SWS) (SoSe 2026)	5 ECTS 5 ECTS
3	Lecturers	Prof. Dr. Michael Engel Prof. Dr. Robin Klupp Taylor Dr. Giulia Magnabosco	

4	**Module coordinator**	Prof. Dr. Michael Engel
5	**Contents**	Structure formation with elementary building blocks in molecular, particulate, soft, and biological systems. Theoretical aspects, experimental realizations, and applications are discussed. • introduction (Overview): the idea of building blocks, thermodynamic principles, near and far from equilibrium • Molecules 1 (Surfactants): molecular interaction, hydrophobicity, micellation • Molecules 2 (Mesophases): packing parameter, applications, self-assembled monolayers, membranes • Molecules 3 (Block co-polymers): Flory-Huggins theory, microphase separation, recent research • Molecules 4 (Liquid crystals): phases, role of anisotropy, order parameter, thermodynamics, properties • Theory 1 (Pattern formation): phase diagrams, phase field model, spinodal decomposition • Theory 2 (Particle self-assembly): nanoparticle self-assembly, (nano)crystal shapes, hard vs. soft spheres, entropy maximization vs. interface minimization • Theory 3 (Dynamic self-assembly): oscillatory chemical reactions, reaction diffusion, active matter • Theory 4 (Programmable assembly): DNA nanotechnology, future challenges • Colloids 1 (Synthesis): methods for synthesis of isotropic colloids, bulk crystallization • Colloids 2 (Sedimentation): Assembly by depletion, electrostatics, confinement by solid-fluid interfaces, opals • Colloids 3 (Assembly at fluid-fluid interfaces): techniques, Pickering emulsions, evaporation • Colloids 4 (Convective assembly): film formation and defects, coffee ring effect, templating
6	**Learning objectives and skills**	Successful completion of this module confirms students are able to • describe complex self-organization processes with the help of simple model systems • apply this knowledge to physical, chemical, and bioinspired systems

		• develop an advanced understanding of the self-organization of (macro)molecules and colloids • understand processes to direct and influence self-organization processes • judge the relevance of self-organization for the processing and synthesis of materials • gain insight into current research in the field of the lecture
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable Oral exam (30 min.)
11	**Grading procedure**	Variable (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**	• Ian W. Hamley, “Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials”, Wiley, 2007. • Yoon S. Lee, „Self-Assembly and Nanotechnology Systems”, Wiley, 2011. • Scott Camazine, Jean-Louis Deneubourg, Nigel R. Franks, „Self-Organization in Biological Systems“, Princeton University Press, 2003. • John A. Pelesko, „Self Assembly: The Science of Things That Put Themselves Together“, Chapman and Hall/CRC, 2007. • Jacob N. Israelachvili, „Intermolecular and Surface Forces”, Academic Press, 2011.

1	**Module name** 45045	**Porous Materials: Preparation principles, production processes and spectroscopic characterization** Porous materials: Preparation principles, production processes and spectroscopic characterization	**5 ECTS**
2	Courses / lectures	Vorlesung: Porous Materials: Preparation principles, production processes and spectroscopic characterization (2 SWS) Übung: Tutorial Porous Materials: Preparation principles, production processes and spectroscopic characterization (1 SWS) Übung: Übung Porous Materials: Preparation principles, production processes and spectroscopic characterization (1 SWS)	5 ECTS - -
3	Lecturers	Prof. Dr. Martin Hartmann Dr. Florian Wisser Dr. Dorothea Wisser	

4	**Module coordinator**	Prof. Dr. Martin Hartmann
5	**Contents**	In diesem Modul sollen wichtige spektroskopische Verfahren und ihre Anwendungsbereiche vorgestellt werden. Im ersten Teil der Veranstaltung wird eine kurze Einführung in die molekularen Grundlagen sowie der Eigenschaften elektromagnetischer Strahlung gegeben. Zunächst werden die Prinzipien der Methoden zur Strukturaufklärung auf molekularer Ebene besprochen, insbesondere der Resonanzmethoden wie Kernresonanz- (NMR-), Elektronenspinresonanz- (ESR-) Ultraviolett- (UV-), Infrarot- (IR-) und Raman-Spektroskopie. Im zweiten Teil der Veranstaltung wird die Charakterisierung von technischen Katalysatoren und Adsorbenten vorwiegend mittels Festkörper-NMR-Spektroskopie und ESR-Spektroskopie (unter Einbeziehung von IR- und UV-Spektroskopie) anhand verschiedener Beispiele konkret geübt. Dabei werden neben den Grundlagen der Spektroskopie von Feststoffen auch die verschiedenen Aspekte der In-situ-(Operando)-Spektroskopie und der Prozessanalytik mittels spektroskopischer Methoden konkreter vorgestellt. Die Lehrveranstaltungen dieses Moduls sind Vorlesungen, Übungen und ein Praktikum. In den Vorlesungen werden die erforderlichen theoretischen Grundlagen für das Verständnis spektroskopischer Methoden vermittelt. Eng mit dem Vorlesungsstoff verzahnt werden in den Übungsgruppen und im Praktikum die Fähigkeit zur Aufnahme und Interpretation realer Spektren an Hand von Beispielen aus der Technik (z.B. Zeolithe, geträgerte Metallkatalysatoren, immobilisierte Enzyme) geübt.
6	**Learning objectives and skills**	Die Studierenden: • verstehen die molekularen Grundlagen sowie der Eigenschaften elektromagnetischer Strahlung • kennen die wichtigsten spektroskopischen Methoden und ihre Anwendung zur Charakterisierung von technischen

		Feststoffen, insbesondere Resonanzmethoden wie Kernresonanz- (NMR-), Elektronenspinresonanz- (ESR-) Ultraviolett- (UV-), Infrarot- (IR-) und Raman-Spektroskopie • wenden die theoretischen Aspekte in vielfältigen spezielleren, aber auch kombinierten Übungen zur Charakterisierung von technischen Katalysatoren und Adsorbenten mittels Festkörper-NMR-Spektroskopie und ESR-Spektroskopie (unter Einbeziehung von IR- und UV-Spektroskopie) an • können Spektren selbsständig aufnehmen und an Hand von Beispielen aus der Technik (z.B. Zeolithe, geträgerte Metallkatalysatoren, immobilisierte Enzyme) interpretieren und die Ergebnisse kritisch bewerten
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Written or oral
11	**Grading procedure**	Written or oral (100%)
12	**Module frequency**	Only in winter 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**	• Spectroscopy in Catalysis An Introduction, J. Niemantsverdriet, 2007 • Characterization of Solid Materials and Heterogeneous Catalysts, M. Che, J.C. Vedrine (Eds.), Wiley-VCH 2012

1	**Module name** 42922	**Thin-film processing**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Thin-Film Processing (5 SWS)	-
3	Lecturers	Prof. Dr. Robin Klupp Taylor Dr. Giulia Magnabosco	

4	**Module coordinator**	Prof. Dr. Nicolas Vogel
5	**Contents**	This course surveys the full workflow of modern thin-film processing, moving from fabrication routes to in-depth characterisation: • Thin solid films - thermodynamic and kinetic principles of Physical- and Chemical-Vapour Deposition (evaporation, sputtering, ion-beam & laser methods; thermal, plasma-assisted and photon-stimulated CVD, precursor handling). • Solution- and electro-based coatings - electroplating, electroless deposition, sol-gel, chemical-bath and SILAR techniques. • Soft and molecular films - surfactant and self-assembled monolayers, Langmuir-Blodgett transfer, stimulus-responsive surface coatings. • Polymer and particulate films - solution-processed polymers, dispersion paints, layer-by-layer assemblies, nano/micro-structured and porous architectures; electrophoretic deposition, evaporative drying phenomena and methods (coffee-ring effect, mitigation, colloidal crystals). • Characterisation toolbox - thickness, morphology, roughness, phase, composition, mechanical response and in-situ monitoring; selection of suitable techniques and instrumentation for each property.
6	**Learning objectives and skills**	After successful completion, students will be able to: • Explain the physicochemical foundations governing vapour-, solution- and electro-based thin-film deposition processes. • Compare and evaluate PVD, CVD and wet-chemical routes with respect to kinetics, throughput, sustainability and application domain. • Apply interfacial and drying principles to design soft, polymeric or particulate films with targeted micro-/nano-structure. • Select and justify appropriate industrial coating or self-assembly strategies for a specified substrate, material and property requirement.
7	**Prerequisites**	Prerequisites: Basics of Materials Science, Physics (I+II), Fundamentals of Electrical Engineering, Measurement systems, Interface Engineering and Particle Technology
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242

		Focal Subject: Nanomaterials and Nanotechnology Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable
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**	• F.-W. Bach, A. Laarmann, T. Wenz (Eds.), Modern Surface Technology, Wiley, Weinheim, FRG, 2006.[Full Text] • J. Bachmann, Atomic Layer Deposition in Energy Conversion Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2017.[Full Text] • Cohen, E.D. and Gutoff, E.B. (1992) Modern coating and drying technology, VCH, New York, NY. • Frey, H. and Khan, H.R. (2015) Handbook of Thin-Film Technology, Springer Berlin Heidelberg, Berlin, Heidelberg. • Y. Lin, X. Chen (Eds.), Advanced Nano Deposition Methods, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2016.[Full Text] • Martin, P.M. (2010) Handbook of deposition technologies for films and coatings: Science, applications and technology, 3rd edn, Elsevier, Amsterdam, Boston. • M. Ohring, Materials science of thin films: Deposition and structure / Milton Ohring, 2nd ed., Academic Press, San Diego, CA, 2002. [Full Text]

1	**Module name** 42768	**Bioinspired Design**	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Bioinspired Design (2 SWS)	5 ECTS
3	Lecturers	Prof. Dr. Nicolas Vogel PD Dr. Stephan Wolf	

4	**Module coordinator**	PD Dr. Stephan Wolf
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**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Variable
11	**Grading procedure**	Variable (100%)
12	**Module frequency**	Only in winter semester
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** 94473	**Polymerwerkstoffe in der Medizin (MAP)**	**5 ECTS**
2	Courses / lectures	Vorlesung: Polymer Materials for Medical Applications (2 SWS)	3 ECTS
3	Lecturers	Michael Redel Prof. Dr. Dirk Schubert	

4	**Module coordinator**	Prof. Dr. Dirk Schubert
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**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Biomaterials and Bioprocessing Master of Science Advanced Materials and Processes 20242
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: ?? h (keine Angaben zum Arbeitsaufwand in Präsenzzeit hinterlegt) Independent study: ?? h (keine Angaben zum Arbeitsaufwand im Eigenstudium hinterlegt)
14	**Module duration**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	

1	**Module name** 46298	**Advanced Semiconductor Technologies - Photovoltaic Systems I - Practical Work**	**5 ECTS**
2	Courses / lectures	Übung: Excercises Photovoltaic systems - Fundamentals (3 SWS) Praktikum: Lab Work Characterization and Advanced Defect Imaging of PV Modules and Systems (3 SWS)	2 ECTS 2 ECTS
3	Lecturers	Dr.-Ing. Thomas Heumüller	

4	**Module coordinator**	Prof. Dr. Christoph Brabec Prof. Dr. Wolfgang Heiß
5	**Contents**	This module provides hands-on experience with the characterization and simulation of solar cells and photovoltaic modules. It is especially suited for students who wish to focus on photovoltaics or optoelectronics in general for their Master thesis. It consists of a practical course where solar cells and modules are characterized with state of the art laboratory techniques, and a short lecture with exercises, introducing into simulations of current-voltage traces and other characterization techniques. If both measurements and simulations are available, then comparison can give access to model parameters. Identifying the dominant loss mechanism helps finding targeted strategies for device optimization.
6	**Learning objectives and skills**	The module consists of two parts: • Practical course "Solar Cell Characterization": Individual Solar Cells and larger Modules will be characterized under different illumination conditions. The measured IV curves are fitted by drift diffusion simulations. EQE measurements will be performed as well as photo luminescence imaging. • Lecture and exercises: Students will learn about simulation methods for current-voltage traces: using the diode model and using drift-diffusion simulations. Open source tool swill be used that the students can also use for their homework. The effect of model parameters on the shape of the current-voltage curves is discussed, which allows identifying dominant loss mechanisms. Both practical course and lecture/exercises are compulsory; a written report must be submitted.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 2;3
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject: Advanced Processes Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Practical achievement (120 minutes)

		Tutorial achievement Both practical course and lecture/exercises are compulsory; a written report must be submitted for both
11	**Grading procedure**	Practical achievement (50%) Tutorial achievement (50%) Both practical course and lecture/exercises are compulsory; a written report must be submitted for both. exam type: pass/fail (no grades). Both practical course and lecture/ exercises must be passed to accomplish the module.
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**	1 semester
15	**Teaching and examination language**	english
16	**Bibliography**	