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 summer term 2025

flat version (only modules, no levels (Konten)), in alphabetical order

Table of contents

1	**Module name** 45035	**Adsorption: Fundamentals and Applications** Adsorption: Fundamentals and applications	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

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: 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**	schriftlich oder mündlich Oral examination (30 min.)
11	**Grading procedure**	schriftlich oder mündlich (100%)
12	**Module frequency**	nur im Wintersemester
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** 46264	**Advanced Applications: Tissue Engineering** Advanced applications: Tissue engineering	**5 ECTS**
2	Courses / lectures	Praktikum: Lab Course "Tissue Engineering" (PktTE, SS2024) (2 SWS) Vorlesung: Biomaterials for Tissue Engineering (2 SWS)	2,5 ECTS 2,5 ECTS
3	Lehrende	Dr.-Ing. Gerhard Frank Prof. Dr.-Ing. Aldo Boccaccini Dr. Julia Will	

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

- mit der Bedeutung, Herstellung, Charakterisierung, Einsatz und Bewertung von Gerüststrukturen im Tissue Engineering vertraut sein.

Praktikum "Tissue Engineering"
|Versuch 1: Polymer-beschichtete bioaktive Scaffolds für Knochen Tissue Engineering|
Die Studenten

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

|Versuch 2: Elektrophoretische Abscheidung von Funktionsschichten auf Biomaterialien|
Die Studenten

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

|*Educational objectives and competences:*|
Biomaterials for Tissue Engineering
The students need to

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

Practical "Tissue engineering"
|Experiment 1:| Polymer coated bioactive scaffolds for bone tissue engineering
The students

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

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

- get to know: the requirements for biomaterials, the influence of the EPD-process parameters on the functionality of the coatings.

		• apply: the processes of EPD, contact angle measurements as a characterisation method for surfaces. • assess and discuss: functional coatings regarding their application as biomaterials, the results of the experiments and the process in general.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	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**	Variabel (45 Minuten) derzeit mündliche Prüfung (15 Minuten) currently taking an oral exam (15 minutes)
11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Sommersemester
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** 42762	**Advanced Processes: Catalysis**	**5 ECTS**
2	Courses / lectures	No teaching units are offered for the module in the current semester. For further information on teaching units please contact the module managers.	
3	Lehrende	-	

4	**Module coordinator**	apl. 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**	no Integration in curriculum available!
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**	Klausur Graded scientific presentation (30 minutes).
11	**Grading procedure**	Klausur (100%)
12	**Module frequency**	nur im Sommersemester
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** 46257	**Advanced Semiconductor Technologies - Photovoltaic Systems I - Fundamentals** Advanced semiconductor technologies - Photovoltaic systems I - Fundamentals	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

4	**Module coordinator**	Prof. Dr. Christoph Brabec Prof. Dr. Wolfgang Heiß
5	**Contents**	**Lecture / Exercise / Lab work** The lecture will introduce into the fundamentals of photovoltaic energy conversion. The conversion of light into electricity is one of the most efficient power technologies by today and is expected to transform our energy system towards a renewable scenario. The limits of photovoltaic energy conversion, the materials and architectures of major PV technologies and advanced characterization methods for modules as well as solar fields will be introduced theoretically and experimentally during the lecture, a seminar and the lab works.
6	**Learning objectives and skills**	• The students will learn the concept of black body radiation and the radiation laws and the limits of light energy conversion. The fundamental semiconductor junctions (p-n, M-i-M, Shottky and Hetero Junction are repeated. The one diode and two diodes replacement circuits are explained . Electrical, optical, recombination and extraction loss mechanisms are discussed separately and demonstrated at the hand of numerical drift-diffusion equation solvers. The most important solar cell concepts (Si, CIGS, CdTe, GaAs, Perovksites, Organics) are introduced, and the strengths and weaknesses of each technology are analysed. • Characterization of Photovoltaic Modules will trained by flashed measurements in the lab. Defect imaging methods like DLIT, EL or PL imaging will be trained at the hand of module installations in Erlangen.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering , or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	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**	Variabel Advanced Semiconductor Technologies – Photovoltaic Systems I - Fundamentals (Prüfungsnummer: 62571)

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

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

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

		calculation of resistance losses in transparent electrodes, of the viscosities and surface tensions of inks as well as of the water vapor transmission rates of barriers. • Deposition and patterning of electrodes, active layers, and barriers for organic or perovskite solar cells will be trained in the lab work.
7	**Prerequisites**	Bachelor in Material Science, Nanotechnology, Energy Technology, Electronic Engineering, Computer Science, Physics, Chemistry, Chemical Engineering, Nanotechnologie, Energietechnik, Elektrotechnik, Physik, Chemie or comparable
8	**Integration in curriculum**	semester: 1
9	**Module compatibility**	Elective Course Master of Science Advanced Materials and Processes 20242 Focal Subject Advanced Processes Master of Science Advanced Materials and Processes 20242 Usability of the module / integration into the sample curriculum: 1) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 1 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) 2) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | Kernfach 2 und 3 | Materialien der Elektronik und der Energietechnologie | weitere Wahlmodule | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) 3) Materialwissenschaft und Werkstofftechnik (Master of Science) (Po-Vers. 2020w | TechFak | Materialwissenschaft und Werkstofftechnik (Master of Science) | 1. und 2. Wahlfach | Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing) This module can also be used in the subjects "Nanotechnology (Master of Science)".
10	**Method of examination**	Variabel Advanced Semiconductor Technologies – Solution Processed Semiconductors II - Processing (examination number: 62551) • in semesters where the lecture takes place: no more than two weeks after lecture start in the lecture and in the StudOn group

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

1	**Module name** 42767	**Advanced Structural Materials and Nanomechanical Testing** Focal subject Biomaterials and bioprocessing	**5 ECTS**
2	Courses / lectures	Zu diesem Modul sind keine Lehrveranstaltungen oder Lehrveranstaltungsgruppen hinterlegt!	
3	Lehrende	No lecturers available since there are no courses / lectures for this module!	

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**	no Integration in curriculum available!
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**	Klausur (90 Minuten)
11	**Grading procedure**	Klausur (100%)
12	**Module frequency**	nur im Wintersemester
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** 94475	**Application of Cell Technology and Biofarbication** Application of Cell Technology and Biofarbication (AppCT+BioFab)	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

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: 1
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**	Variabel (60 Minuten)
11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Wintersemester
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** 42765	**Atomistic Methods: phase diagrams and processes** Focal subject Biomaterials and bioprocessing	**5 ECTS**
2	Courses / lectures	Vorlesung mit Übung: Atomistic Methods: phase diagrams and processes (SoSe 2025)	-
3	Lehrende	Prof. Dr. Luca Ghiringhelli	

4	**Module coordinator**	Prof. Dr. Luca Ghiringhelli
5	**Contents**	1. Theoretical foundations of atomistic models 2. Coarse graining and formulation of continuum theories 3. Generalized continuum theories
6	**Learning objectives and skills**	students learn the theoretical foundations of the models behind current state-of-the-art simulation techniques • develop a critical understanding of current modeling tools and approximation methods • develop a critical understandingof relevance both for atomistic modeling and for continuum approaches
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!
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**	Klausur (90 Minuten)
11	**Grading procedure**	Klausur (100%)
12	**Module frequency**	keine Angaben zum Turnus des Angebots hinterlegt!
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** 42758	**Basics in Advanced Processes**	**5 ECTS**
2	Courses / lectures	Vorlesung: Basics in Advanced Processes 2: Chemical Analysis and Structure Determination (2 SWS, SoSe 2025)	2,5 ECTS
3	Lehrende	Dr. Peter Schulz Prof. Dr. Robin Klupp Taylor	

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**	no Integration in curriculum available!
9	**Module compatibility**	Pflichtmodul Master of Science Advanced Materials and Processes 20242
10	**Method of examination**	Klausur (60 Minuten) Klausur (60 Minuten) Klausur (120 Minuten)
11	**Grading procedure**	Klausur (50%) Klausur (50%) Klausur (100%)
12	**Module frequency**	keine Angaben zum Turnus des Angebots hinterlegt!
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** 42763	**Biomimetic Synthesis of Materials** Focal Subject Advanced Processes	**5 ECTS**
2	Courses / lectures	Zu diesem Modul sind keine Lehrveranstaltungen oder Lehrveranstaltungsgruppen hinterlegt!	
3	Lehrende	No lecturers available since there are no courses / lectures for this module!	

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**	no Integration in curriculum available!
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**	Klausur (90 Minuten)
11	**Grading procedure**	Klausur (100%)
12	**Module frequency**	keine Angaben zum Turnus des Angebots hinterlegt!
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** 42939	**Chemical Technologies for the Energy Transition**	**5 ECTS**
2	Courses / lectures	Übung: Chemical technologies for energy transition - Seminar (2 SWS) Vorlesung: Chemical technologies for energy transition (1 SWS)	- 1,5 ECTS
3	Lehrende	apl. Prof. Dr. Marco Haumann	

4	**Module coordinator**	apl. 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: 1;2;3;4
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**	Variabel Graded scientific presentation (30 minutes).
11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Sommersemester
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** 45471	**Computational Fluid Dynamics 1**	**5 ECTS**
2	Courses / lectures	Zu diesem Modul sind keine Lehrveranstaltungen oder Lehrveranstaltungsgruppen hinterlegt!	
3	Lehrende	No lecturers available since there are no courses / lectures for this module!	

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 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**	The students 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 negelcted • formulate a FDM for the solution of unsteady transport equations • asess 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 • implmement 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 team
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
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**	mündlich (30 Minuten)
11	**Grading procedure**	mündlich (100%)
12	**Module frequency**	nur im Wintersemester
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**	• J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Spinger, 2008 • R.J. Leveque, Finite Difference Methods for Ordinary and Partial Differential Equations, SIAM, 2007

1	**Module name** 42918	**Fuel cells and electrolysers**	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

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: 1;2;3;4
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**	Variabel (120 Minuten) written exam (120 min.)

11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Wintersemester
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** 42764	**Multi-scale Simulation Methods** Focal Subject Advanced Processes	**5 ECTS**
2	Courses / lectures	Zu diesem Modul sind keine Lehrveranstaltungen oder Lehrveranstaltungsgruppen hinterlegt!	
3	Lehrende	No lecturers available since there are no courses / lectures for this module!	

4	**Module coordinator**	PD Dr. Paolo Moretti
5	**Contents**	no content description available!
6	**Learning objectives and skills**	no learning objectives and skills description available!
7	**Prerequisites**	None
8	**Integration in curriculum**	no Integration in curriculum available!
9	**Module compatibility**	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**	Klausur (90 Minuten)
11	**Grading procedure**	Klausur (100%)
12	**Module frequency**	keine Angaben zum Turnus des Angebots hinterlegt!
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** 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	Lehrende	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: 1

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**	mündlich (30 Minuten)
11	**Grading procedure**	mündlich (100%)
12	**Module frequency**	in jedem 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** 45045	**Porous Materials: Preparation principles, production processes and spectroscopic characterization** Porous materials: Preparation principles, production processes and spectroscopic characterization	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

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**	no Integration in curriculum available!
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**	schriftlich oder mündlich
11	**Grading procedure**	schriftlich oder mündlich (100%)
12	**Module frequency**	nur im Wintersemester
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** 42915	**Process simulation**	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

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**	no Integration in curriculum available!
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**	Variabel (120 Minuten) Klausur/written exam (120 min.)
11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Wintersemester
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** 94351	**Process Technologies** Process technologies	**5 ECTS**
2	Courses / lectures	Vorlesung: Process Technologies (2 SWS) Übung: Process Technologies Exercises (1 SWS)	5 ECTS -
3	Lehrende	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: 1
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**	Studienleistung

11	**Grading procedure**	Studienleistung (bestanden/nicht bestanden)
12	**Module frequency**	nur im Sommersemester
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** 42940	**Recycling of Electronic Wastes**	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

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: 1
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**	Variabel (30 Minuten) Graded scientific presentation (30 minutes).
11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Wintersemester
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** 42766	**Self Assembly on Surfaces** Focal subject Biomaterials and bioprocessing	**5 ECTS**
2	Courses / lectures	Vorlesung: Self-assembly at surface (2 SWS)	-
3	Lehrende	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**	no Integration in curriculum available!
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**	Klausur (90 Minuten)
11	**Grading procedure**	Klausur (100%)
12	**Module frequency**	keine Angaben zum Turnus des Angebots hinterlegt!
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** 42936	**Self-organisation processes** Self-organization processes	**5 ECTS**
2	Courses / lectures	Vorlesung: Self-organization Processes (2 SWS) Übung: Self-Organisation Processes (Exercise) (3 SWS)	5 ECTS 5 ECTS
3	Lehrende	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. • Theory 1 (introduction): the idea of building blocks, thermodynamic principles • Theory 2 (continuum): spinodal decomposition, reaction diffusion, phase field model, feedback • Theory 3 (particles): entropy maximization, interface minimization • Molecules 1 (basics): molecular interactions, role of shape • Molecules 2 (liquid crystals): topological order, defects • Molecules 3 (interfaces): surfactants, micelles, emulsions, foams, vesicles • Molecules 4 (beyond): block copolymers, membranes, proteins, metal organic frameworks • Colloids 1: Methods for the synthesis of colloidal building blocks for self-organization • Colloids 2: Bulk crystallization, assembly by depletion, electrostatics, confinement by solid-fluid interfaces, opals • Colloids 3: Assembly at planar and curved fluid-fluid interfaces, pickering emulsions • Colloids 4: Convective assembly, film formation techniques and defects, coffee ring effect, templating • Bioinspired 1 (dynamic self-assembly): active matter, bacteria, swarms, robots • Bioinspired 2 (design): programmable assembly, DNA nanotechnology, inverse problems
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: 1;2;3;4
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**	Variabel oral exam (30 min.)
11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Sommersemester
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** 42922	**Thin-film processing**	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

4	**Module coordinator**	Prof. Dr. Nicolas Vogel
5	**Contents**	Students who participate in this course will learn principles of the different process steps involved in the formation of thin films on solid substrates, both from liquid- and from gas phases. Individual lectures of the course involve the following topics: • Drying Technology: Transformation of liquid precursors and dispersions into solid films • Self-organisation processes occurring during the film formation • Industrial coating processes and technologies • Characterisation of thin-films • Properties of thin films
6	**Learning objectives and skills**	Students who participate in this course will become familiar with the different aspects of thin films, from physical principles governing the formation of thin films to their resulting properties. Students who successfully participate in this module can: • Understand the physical principles of thin film formation • Correlate the properties of colloidal dispersions and liquid interfaces with the resulting film formation properties • Control the film structure via the evaporation profile • Select and explain different industrial coating processes to control film formation • Assess and explain the optical, electronic and mechanical properties of thin films
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: 1;2;3;4
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**	Variabel
11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Wintersemester
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** 45335	**Trocknungstechnik** Drying technology	**5 ECTS**
2	Courses / lectures	The teaching units in the module are only offered in the winter semester.	
3	Lehrende	-	

4	**Module coordinator**	Prof. Dr.-Ing. Andreas Bück
5	**Contents**	• Grundlagen und Ziele der Trocknungstechnik • Zusammenspiel Materialeigenschaften, Prozessbedingungen, Produkteigenschaften • Mechanische Trocknungsverfahren (Filtration, Sedimentation) • Diffusionskontrollierte Trocknungsverfahren • Konvektive Trocknungsverfahren: Grundlagen • Sprühtrocknung • Wirbelschichttrocknung • Modellierung von Trocknungsprozessen und Apparateauslegung
6	**Learning objectives and skills**	Die Studierenden: • sind mit den Grundlagen der diffusionslimitierten und konvektiven Trocknung vertraut; • können anhand von Materialeigenschaften kinetische und kapazitive Prozessgrenzen ableiten; • können verschiedene Trocknungsverfahren klassifizieren und den Anwendungsbereich beurteilen; • sind fähig, verschiedene Prozessvarianten vergleichend gegenüberzustellen; • können mit Hilfe vorgestellter Prozessmodelle, Trocknungsprozesse beschreiben und auslegen; • können das erlernte Wissen an Hand ausgewählter Beispiele praktisch umsetzen.
7	**Prerequisites**	None
8	**Integration in curriculum**	semester: 1
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**	Variabel Mündliche Prüfung (30 Min)
11	**Grading procedure**	Variabel (100%)
12	**Module frequency**	nur im Wintersemester
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. O. Krischer, W. Kast: Trocknungstechnik: Die wissenschaftlichen Grundlagen der Trocknungstechnik, Springer-Verlag, 2014 2. A.S. Mujumdar (Ed.): Handbook of Industrial Drying, CRC Press, 2013 Gehrmann, Esper, Schuchmann: Trocknungstechnik in der Lebensmittelindustrie, Behrs G mbH, 2009.