Modulbezeichnung:	**Schwerpunkt Nanomaterials and Nanotechnology (Nano focal)** (Focal Subject Nanomaterials and Nanotechnology)	**15.0 ECTS**
Modulverantwortliche/r:	Mathias Göken	
Lehrende:	Mathias Göken, Robin N. Klupp Taylor, Steffen Neumeier, Alexandra Inayat, Marcus Halik, Volker Altstädt	

Startsemester: SS 2020	Dauer: 2 Semester	Turnus: halbjährlich (WS+SS)
Präsenzzeit: 180 Std.	Eigenstudium: 270 Std.	Sprache: Englisch

Lehrveranstaltungen:

Nanotechnology of Disperse Systems (SS 2020, Vorlesung, 2 SWS, Robin N. Klupp Taylor et al.)
Selbstorganisation an Oberflächen (SS 2020, Vorlesung, 2 SWS, Marcus Halik)
Übung zu Nanotechnology of Disperse Systems (SS 2020, Übung, 1 SWS, Robin N. Klupp Taylor et al.)
Nanopolymers (WS 2020/2021, Vorlesung, 1 SWS, Volker Altstädt)
Mechanical Properties and Structures of Advanced Materials (WS 2020/2021, Vorlesung, 2 SWS, Mathias Göken et al.)
Porous Materials: Preparation principles, production processes and spectroscopic characterization (WS 2020/2021, Vorlesung, 2 SWS, Alexandra Inayat et al.)

Inhalt:

Nanotechnology of Disperse Systems: This lecture begins with a revision of basic topics in the theory of nucleation, growth and electrostatic stabilization of particulate materials. Following this the challenges and solutions to the problem of metal, oxide, semiconductor and polymer particle synthesis will be discussed. The second half of the course will concern the characterization, properties and application of disperse systems. In addition to understanding the measurement of particle and agglomerate size and shape, the factors affecting the electronic, magnetic, optical and catalytic properties will be covered. Particles are often applied as part of a hierarchical system e.g. in a device, functional coating, drug delivery system. The use of self-assembly and printing/patterning techniques to achieve these goals will be presented with reference to work carried out within the Erlangen Cluster of Excellence "Engineering of Advanced Materials - Hierarchical Structure Formation for Functional Devices". For the associated "Exercises" participants of the course will be required to explore the literature and give a 10 minute presentation regarding recent developments in a specific aspect of disperse systems or nanoparticle research.

Self-Assembly on Surfaces:

The lecture introduces with fundamentals of physisorption, chemisorption, growing modes, chemistry of surface binding via different motifs, analytical method for surface characterization, and nano-phase-separation. We will discuss weak intermolecular and surface interactions (van-der-Waals und dipoles), the mobility of nano-objects on surfaces and their use in 2D and 3D assembly. Medium interaction motifs (H-bonding, other non-covalent motifs) as driving forces. Main task will be the techniques and processes for self-terminating growth, 2D-superstructures according to the substrate and the chemistry. Strong interaction motifs (Coulomb, covalent) will be discussed in terms of stability, the possibility of exchange reactions on surfaces. Finally we will discuss methods to achieve hierarchical structure formation (layer-by-layer, complex layers structures, gradients, patterned structures and self-assembly on complex inner structures. We will conclude with classification and examples of self-assembled systems of 2. - 5. order.

Mechanical Properties and Structures of Advanced Materials:

The mechanical properties play an important role for all kinds of application of advanced and nanostructured materials. Therefore, in this lecture the different aspects of mechanical properties (i.e. strength, fracture, fatigue, creep. . .) with an emphasis on effects at the nanoscale including the properties of thin films will be discussed. The mechanical properties are closely related with the crystallographic structure and also the microstructure. New advanced materials as bulk metallic glasses and quasicrystals show an interesting mechanical behavior which will be discussed also including other advanced nanomaterials. The lecture will cover the following topics

- mechanical properties of engineering materials
- plasticity and hardening in metals / Strengthening mechanisms
- fundamentals of fatigue
- measuring mechanical properties at the micro- and nanoscale / Nanoindentation
- size effects - thin films and small volumes / Testing at small scales
- deformation and structure of structurally complex materials
- quasicrystals
- bulk Metallic Glasses
- mechanical properties of other advanced materials (e.g. Advanced steels, Metallic nanomaterials)

Preparation principles and production processes of advanced materials:
-inorganic-technical principles of synthesis and preparation methods of porous materials

- aspects of synthesis and technical processes for the production of zeolite materials
- description of hydrothermal crystallization
- crystallization techniques and technical processes
- characterization of porous solids
- manufacturing of amorphous silica gels and porous glasses
- classical high-alumina and high silica zeolites
- aluminophosphates (AlPO's) - new materials with interesting pore structures and applications
- mesoporous materials - products with pore sizes in new dimensions
- layered Materials - basis for 3-D network materials
- specialties - designing material properties by special crystallization techniques and new materials (MOF's: COF's,. . .)
- supported crystallization
- post synthesis methods - tuning of properties
- forming - an important part of the process before the application of the product

Nanopolymers:

- basic Introduction to Polymeric Nanocomposites
- different kinds of nanofiller
- production of Nanocomposites - Dispersing methods and machines
- characterization of Nanocomposites - Morphological and mechanical
- fatigue crack growth behavior of nanocomposites and nanostructured polymers
- innovative applications for nanoparticle filled polymer

Lernziele und Kompetenzen:

Nanotechnology and Disperse Systems:

- students review key themes of nanoparticle research and application as well as the underlying fundamentals

Self-Assembly on Surfaces:

- students will develop a key competence in structure-property-relations of self-assembly
- students gain knowledge in surface analytic, surface chemistry and processes
- students determine fundamental applications of the self-assembly process and resulting materials

Mechanical properties and structure of advanced materials: The students

- assess the effects of crystal structure and microstructure on the deformation behavior of materials on different length scales, from the atomic scale of the crystal lattice over the constraining effects in microscale devices to bulk deformation
- apply experimental techniques involved, with a guide as to how mechanical properties can be measured at the micro- and nanoscale and on the role of size effects

Preparation principles and production processes of advanced materials:
The students:

- realize the importance of porous system in general
- explain the formation principles of porous materials
- explain the construction principles of porous materials

- correlate properties and application potentials
- understand compare the design options
- summarise the resulting technical processes

Nanopolymers: The students:

- examine the world of polymer nanocomposites, reviewing different types of nanofillers and their relevant characteristics
- discuss different dispersion technologies in terms of operating principle and specialties with a key focus on parameters influencing the dispersion and which dispersion technology fits best for a special polymernanofiller combination
- explore important methods to characterize the nanocomposite morphology e.g. TEM, WAXS, NMR, μ-CT.
- critically evaluate different test methods and applications of nanocomposites (in the last section of the lecture dealing with the property improvement realized by using nanocomposites in produced components)
- decide if nanocomposites are suitable for a given application and which challenges have to be solved before using nanocomposites

Literatur:

- Everett, D.H. Basic Principles of Colloid Science, Cambridge, Royal Society of Chemistry 2007
- Vollath, Dieter, Nanoparticles, nanocomposites, nanomaterials. Weinheim, Wiley-VCH, 2013
- Nogi, Kiyoshi, Naito, Makio, and Yokoyama, Toyokazu. Nanoparticle Technology Handbook , Amsterdam, Elsevier 2012
- Pelton, Matthew, and Bryant, Garnett W. Introduction to Metal-Nanoparticle Plasmonics. Somerset, NJ, USA: John Wiley & Sons, 2013
- Gubin, Sergei. Magnetic Nanoparticles. Weinheim, Wiley-VCH, 2009
- Script Self-assembly, and included literature

Studien-/Prüfungsleistungen:

Nanomaterials and Nanotechnology 1: Nanoparticles, Structures and Self Assembly (Prüfungsnummer: 1816)
(englische Bezeichnung: Nanomaterials and Nanotechnology 1: Nanoparticles, Structures and Self Assembly)

Prüfungsleistung, Klausur, Dauer (in Minuten): 120
Anteil an der Berechnung der Modulnote: 50%
weitere Erläuterungen:
alternative (according to the corona satzung!) as 45 minute digital oral exam.
Prüfungssprache: Englisch

Erstablegung: SS 2020, 1. Wdh.: WS 2020/2021
1. Prüfer: Robin N. Klupp Taylor

Nanomaterials and Nanotechnology 2: Properties and Production of Advanced Nano Materials (Prüfungsnummer: 1817)
(englische Bezeichnung: Nanomaterials and Nanotechnology 2: Properties and Production of Advanced Nano Materials)

Prüfungsleistung, mündliche Prüfung, Dauer (in Minuten): 45
Anteil an der Berechnung der Modulnote: 50% Prüfungssprache: Englisch

Erstablegung: WS 2020/2021, 1. Wdh.: SS 2021
1. Prüfer: Mathias Göken
