- hybrid and soft materials
- dimensionally-constrained materials and phenomena
- magnetic and electronic materials

Soft Materials Engineering and Characterization (327-1207-00, autumn semester) •
In this course, we discuss engineering aspects of soft materials. First, we cover different classes of soft matter systems, e.g. suspensions, gels, emulsion and foams, and introduce scaling principles to design their structural, mechanical and functional properties. Second, we cover essential characterisation techniques to interrogate the structure-property relations in soft materials, which include rheology, advanced optical microscopies, static and dynamic scattering and techniques for liquid interfaces.

Biological and Bio-Inspired Materials (327-1221-00, autumn semester) •
This course explores the molecular and microstructural design principles present in biological materials, and how these principles can be incorporated into synthetic materials to improve targeted functions. The first part discusses the mechanisms that govern the adaptive functions of out-of-equilibrium systems in living organisms at the molecular scale. The second part covers the microstructural design principles of biological materials at a larger length scale. Throughout the course, we will also explore how these mechanisms can be adapted and applied to synthetic systems.

Chemistry of Soft Materials (327-1206-00, 5 ECTS, spring semester) •
This course will cover the basic links between organic and polymer chemistry, state-of-the-art polymerization methods in industry and academia (e.g., materials each method can synthesize), the synthesis of complex materials, chemical recycling of polymeric materials (chemistry, engineering and thermodynamics), polymeric nanoparticles (effect of shape on properties and applications and polymer electronics.

Synthesis and Assembly of Building Blocks (327-1203-00, 5 ECTS, spring semester) •
Introduction to commonly used wet chemistry methods for the synthesis of inorganic and polymeric particles of defined sizes and shapes, and concepts for assembling these building blocks into larger structures of varying complexity over multiple length scales.

Transport Phenomena: A modern approach to coupled transport problems (327-1201-00, 6 ECTS, spring semester) •
This course starts with the rigorous vectorial/tensorial formulation of the balance equations for mass, local species mass (including charged species), momentum, and energy, including simple constitutive equations for the fluxes (Fick, Fourier, Newton). Some selected example introduce you to scaling analysis, analytical and (hands on) numerical solution methods, which aim to bring physical intuition. Then the focus is shifted to problems where the different transport phenomena occur simultaneously and coupling between the different transport phenomena occurs. Thermodynamic considerations are used to understand which couplings can occur, and arguments will be given to evaluate the importance of the different phenomena in material science and engineering applications.

Surfaces and Interfaces I: Fundamentals, Analytics and Applications (327-0505-00, autumn semester) ■
The course first covers the physical/chemical properties of surfaces and interfaces, including a detailed discussion of adsorption and surface forces, followed by a presentation of a range of analytical techniques use to characterize surface chemistry (XPS, SIMS and IR spectroscopy) and their topography and mechanics (AFM). The student is then introduced to the practical relevance of surfaces and interfaces in phenomena such as wetting, lubrication and phoresis together with their applications.

Thin Film Technology – From Fundamentals to Oxide Electronics (327-2210-00, autumn semester) ■
We will give an introduction to thin films deposition techniques and applications with a focus on the growth of multifunctional oxide thin films. The leading deposition routes (PVD and CVD techniques) and characterization techniques for application-relevant thin films will be discussed. Emerging oxide electronics, materials selection and energy efficient device concepts will be introduced.

Electron Microscopy in Materials Science (327-0703-00, autumn semester) ■
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Surfaces and Interfaces II: Materials-related Electrochemistry, Chemical Reactivity and Applications (327-0505-00, 5 ECTS, spring semester) ■
Introduction to fundamentals of (electro)chemical surface processes on conducting materials: reactivity, degradation, functionalizing and deposition. Relevant corrosion/oxidation mechanisms are presented along with suitable characterizations (focus: electrochemical & surface analytical methods) and practical data analysis. Growth and characterization of (thin film) metal oxides are also addressed.

Size Effects in Materials (327-2202-00, 5 ECTS, spring semester) ■
The core of this course explains how the behavior of materials changes, when their external dimensions become small (usually on the micro- to nanometer length scale) until quantum effects become dominant. This is illustrated by examples from all materials classes and further substantiated by case studies of applications ranging from micro- and nanoelectronics to optoelectronics.

Introduction to Magnetism (402-0535-00, autumn semester) ♦
Atomic paramagnetism and diamagnetism, intinerant and local-moment interatomic coupling, magnetic order at finite temperature, spin precession, approach to equilibrium through thermal and quantum dynamics, dipolar interaction in solids.

Order in Materials (327-2208-00, autumn semester) ♦
It is the aim of this course to give an overview of the different ordering phenomena that occur in materials and that can be magnetic, electrical or structural in nature. Special emphasis will be placed on "novel" forms of order, such as multiferroicity. Their exploration and the new material functionalities we can derive from these are a topic of particular interest to our department.

Disorder in Materials (327-2209-00, 5 ECTS, spring semester) ♦
Part 1 focuses on the synthesis and processing of amorphous materials. The relationships between the structure of glassy metals and other disordered materials and their resulting mechanical, thermophysical, biomedical and electronic properties are discussed. Part 2 will cover materials that contain both ordered and disordered aspects, such as magnetic spin ices and

chemically disordered crystals. These are particularly easy to analyze analytically and thus provide insights into the physics of more complex amorphous solids. We will also cover the practical applications of such crystals.

Computational Multi-Scale Modeling of Solids (327-2143-00, 5 ECTS, spring semester) ♦
This course considers the multi-scale computational modeling of hard-matter systems, with an emphasis on the physical phenomena of matter transport and emergent macroscopic mechanical properties, and how their microscopic origin is coarse grained to the engineering scale of a material component.

Materials at Work I (327-1204-00, course is offered for the last time in HS 2023)
This course attempts to prepare the student for a job as a materials engineer in industry. The gap between fundamental materials science and the materials engineering of products should be bridged. The focus lies on the practical application of fundamental knowledge allowing the students to experience application related materials concepts with a strong emphasis on case-study mediated learning.